TWENTIETH REPORT

OF THE

STATE ENTOMOLOGIST

ON THE

NOXIOUS AND BENEFICIAL INSECTS

OF THE

STATE OF ILLINOIS.

NINTH REPORT OF S. A. FORBES

FOR THE YEARS 1895 AND 1896.

SPRINGFIELD, ILL.
PHILLIPS BROS., STATE PRINTERS.
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INTRODUCTORY NOTE.

The following report presents the results of a part of the work done by myself and my assistants during the years 1895 and 1896, with the exception of the first paper, which has been revised to include material obtained to October 15, 1897.

The work of the office has been determined largely by the leading entomological conditions of the biennial period. The most notable features of the situation have been the extension of an outbreak of the chinch-bug northward, quite beyond the usual limits of serious ravage by that insect; the substantial disappearance or considerable diminution of chinch-bug attack over a large part of Southern Illinois previously heavily infested; the discovery of the San José scale in various parts of the State in 1896, and a minor outbreak of the army worm early in that year throughout a large part of Central Illinois. A local phenomenon of special interest was the occurrence in a part of Christian county and adjoining counties of extensive and extraordinary injury by white grubs. Articles on all these topics are included in this report.

The organization of my office staff during this time has not differed essentially from that of previous years, the association of the Entomologist's office with the State Laboratory of Natural History under one management continuing, as before, under conditions such that the assistants of that Laboratory have been available, as needed, for entomological work. Acknowledgments are due especially to the following assistants and others for services in connection with the work here reported: To Mr. C. A. Hart, many years Systematic Entomologist of the Laboratory, for entomological determinations and a variety of indispensable miscellaneous services; to Miss Lydia M. Hart, Artist of the Laboratory, for most of the drawings used in illustration of the report; to Messrs. W. G. Johnson, W. A. Snow, C. C. Adams and H. O. Woodworth for field and laboratory observations and experiments; to J. C. Blair, of the Horticultural Department of the University, to R. W. Braucher, to Prof. H. E. Summers and to Ernest B. Forbes for field work on the San José scale; and to Mr. B. M. Duggar, especially engaged during the year ending June 30, 1896, for a study of the contagious diseases of insects. Especial mention should be made, in addition to the various references in the body of the report, to the services of Mr. Johnson in conducting most of the experiments described in my article on "Miscellaneous Experiments with Chinch-bugs."

— b. E

I also had the advantage, during the holiday vacation period of 1896, of the volunteer service of a number of advanced students of the Agricultural Department of the University, who inspected orchards and nurseries in the vicinity of their homes in connection with our work on the San José scale.

THE SAN JOSÉ SCALE IN ILLINOIS.

(*Aspidiotus perniciosus* COMSTOCK.)*

The San José scale is the injurious insect of the hour in the United States. Its appearance on the Pacific Coast about 1870 and its insidious spread throughout the country, until it now infests at least twenty-one states, have caused an excitement among those economically concerned which recalls that attending the invasion of the potato fields by the Colorado potato beetle and the American advent and rapid distribution of the European cabbage butterfly. It seems, indeed, to be in many respects a much more serious pest than either of these, infesting a greater number of valuable plants, making its way from point to point more secretly, although more slowly, and being much more difficult to detect in its first appearances. Its recognition and arrest are, in fact, at present quite beyond the knowledge and powers of observation of the ordinary fruit grower or commercial nurseryman, and it is not surprising that the alarmed and helpless owners of property liable to destruction by it should have turned very generally to their state and national legislatures for protection and relief.

FOOD PLANTS.

Unlike the other leading scale insects of the orchard, this scale is almost equally at home on a large number of our most valuable fruiting trees and shrubs, very few of those thriving in our temperate climate being safe from its attack. No experiments have been made to determine the possible variety of its food plants, but it has been found occurring spontaneously on the apple, pear, peach, apricot, plum, cherry, quince, grape, raspberry, blackberry, gooseberry, currant, and persimmon among our fruits; on the hickory, pecan, the English walnut, and the almond among the nut-bearing trees; on the oak, basswood, elm, chestnut, birch, and willow among our shade and forest trees; and on a large miscellaneous list of trees and shrubs, including the rose, thorn-apple (Crataegus), crab-apple, wahoo, spirea, loquat, cotoneaster, flowering quince, flowering currant, acacia, alder, and sumach. It also seriously infests the osage orange, spreading with the greatest facility through the thick growth of the wayside hedge.

*The San José scale was first discovered in Illinois in September, 1896, and little opportunity has since been afforded for independent investigation of it. The main dependence in the preparation of this paper has consequently been a special Bulletin on that insect prepared by Messrs. Howard and Marlatt in 1896, and Professor John B. Smith's description of his observations in California and New Jersey, printed in his Report for 1896 as Entomologist of the New Jersey Agricultural College Experiment Station. Although written originally to cover only the work of 1896, this article has since been revised to include field observations made up to October 15, 1897.

INJURIES BY THE SCALE.

All exposed parts of the foregoing trees and shrubs, including bark, leaf, and in many cases even the fruit, may afford it lodgment and food. Upon the bark of twig, branch, or trunk it may form, when abundant, a continuous crust, completely concealing the surface with a dusky or grayish scurfy deposit of closely packed scales, so small and so nearly flat that even the observant horticulturist is little likely to recognize them as scale insects. A tree so infested is readily seen to be in an unthrifty condition, but when special information is lacking it is commonly classed simply as diseased. If the surface be rubbed or scraped, however, it will have a peculiar greasy feeling under the finger, and a yellowish liquid may be detected, produced by crushing bodies of the insects still living beneath the scales.

"Examined under a hand lens during the summer, numbers of little orange-colored larvæ will be seen running about, and the snowy white young scale will be interspersed with old blackened mature scales. Very frequently the scale has a marked tendency to infest the extremities of the branches and twigs. This is particularly noticeable with pear. As usually found on peach, the scale is massed often more densely on the older growth, and works out more slowly toward the new wood.

"The San José scale was formerly supposed to differ from all others in the peculiar reddening effect which it produces upon the skin of the fruit and of tender twigs. This, however, sometimes occurs with other scales, but is a particularly characteristic feature of this insect, and renders it easy to distinguish. The encircling band of reddish discoloration around the margin of each female scale is very noticeable on fruit, especially pears. Fruit severely attacked becomes distorted, rough, and pitted, frequently cracking, and may eventually fall prematurely or at least become unmarketable.

"The cambium layer of young twigs where the scales are massed together is usually stained deep red or purplish, and when the scale is only scatteringly present the distinctive purplish ring surrounding each is almost as noticeable on young twigs as on fruit, and is of the greatest service in facilitating the inspection of trees which have been subject to possible contagion. The almost microscopic young scale might easily elude the most careful search, but the striking circling ring makes them comparatively conspicuous objects without the aid of a glass.

"If the tree survives the attack the infested wood eventually becomes knotty and irregular, partly from the sapping of the juices by the insect and also, without doubt, largely from the poisoning of the sap of the cambium layer by the punctures of the insect, as indicated by the discoloration. Young peach trees will ordinarily survive the scale only two or three years. Pears are sometimes killed outright, but generally maintain a feeble, sickly existence, making little or no growth for a somewhat longer period."*

* "The San José Scale; its Occurrences in the United States, with a Full Account of its Life History and the Remedies to be used against it." Bull. No. 3, N. S., U. S. Dept. Agr., Div. Ent., p. 15.

According to Prof. J. B. Smith,* "Peach-trees suffer most severely, and succumb in two or three years. Other thin-barked trees come next, and suffer as they are young, or offer the insects opportunity to reach the inner bark layers on the trunk and main branches. Pear-trees suffer worse than apples, but even young trees may live on under scale attack for several years, though without making much growth. The tree gradually becomes hide-bound, the bark wrinkles and splits or cracks, and in that event the tree dies down from the top. The leaves also become infested and the scales range themselves by preference on each side of the midrib, causing a stoppage in growth, and a purplish discoloration. Scales attached to fallen leaves are doomed to death, because they have no power of motion and must starve as the leaf dries or decays. Fruit when badly infested becomes distorted, and does not attain its full growth."

EXTENSION OF RANGE AND DIMINUTION OF NUMBERS.

When first introduced into a new locality, although commonly attacked early by certain insect enemies, this scale spreads slowly but without interruption, more or less rapidly killing the fruit trees it attacks, continuing for several years at least a course of unmitigated destruction. The effect of this slow spread combined with its rapid rate of multiplication and the consequent concentration of vast numbers of the scale upon a gradually enlarging area is to cause a gradual but complete destruction, progressing from the first infested center outwards over all fruit trees and other plants especially subject to its attack. An entire orchard, no matter how great its size, may thus be completely ruined as by an incurable disease. It is possible that the young scale may be conveyed to considerable distances by flying or running insects or by birds; ordinarily, however, such scattering of the young scale will have no permanent effect, since females distributed here and there, one in a place, would be little likely to be fertilized, and in most cases would perish without reproduction. I have lately received, however, from Professor J. M. Stedman, of Missouri, an interesting item of information touching upon the agency of birds in the distribution of this scale. In the vicinity of infested orchards in Missouri Professor Stedman noticed that wherever a bird's nest was seen the San José scale had commonly established itself, sometimes, indeed, being confined to the branch bearing the nest, in other cases having distributed itself more generally over the tree. Evidently the frequent passage of birds between the nest and the infested orchard had resulted in the frequent transfer of the young, probably including males and females both, and in the establishment of colonies in condition to perpetuate themselves and to serve as further centers of distribution. On the other hand, its extension and multiplication are sometimes checked by natural causes, which will be more fully discussed under another head. In the southern part of its range in California—that is from San Francisco southward—it has more or less completely disappeared from regions formerly seriously infested, the cause of

* Rep. Ent., N. J. Agr. Coll. Exper. Station, for 1896, p. 546.

this disappearance being generally in dispute at the present time. North of San Francisco, however, according to Professor Smith,* it has nowhere disappeared naturally, a fact which seems to indicate sensibility to climatic conditions, and a preference for a temperate, somewhat moist climate, free especially from the intense dry summer heat of the southern parts of the Pacific states. There is as yet no recorded notice of any such spontaneous disappearance or diminution of its numbers in any eastern locality, either from climatic conditions or from the natural multiplication of parasites. So far as at present known to us, consequently, relief from its ravages is dependent entirely upon artificial measures.

It should be clearly understood, however, that these artificial measures are now so well developed and have been so thoroughly tested that there is no longer any question of the ability of the fruit grower to control this pest on his own premises, and to raise fruit year after year in spite of it, provided only that the necessary insecticide applications are regularly and intelligently made.

ORIGIN AND DISPERSAL.

In the United States. The original home of the San José scale has not yet been certainly ascertained. It has been found in Australia, Hawaii, and Japan, but seems to have been first recorded from Chili in 1872, where it was noticed on pears which had been introduced from the United States. By 1873 it had become a serious pest in the San José Valley, California, on the premises of Mr. James Lick, the founder of the Lick Observatory. It is probable, consequently, that it had established itself at this place at least as early as 1870. There is, indeed, some reason to suppose that this is a native American species, perhaps occurring originally, as suggested by Professor Smith, in the northern Pacific states upon some one or more of the many wild fruiting trees and shrubs which it is now known to infest. Mr. Cockerell, however, gives considerable indirect evidence of a Japanese origin of the species in a recently published bulletin of the United States Department of Agriculture.†

So far as its actual distribution has been placed on record, Arizona seems to have become infested by 1884, New Jersey in 1886 or 1887, Maryland in 1887, Florida in 1889, Washington, Ohio, Pennsylvania and Virginia in 1890, Idaho, Georgia, Louisiana, Indiana and Illinois by 1891, New Mexico and New York by 1892, Alabama,‡ Delaware, Massachusetts and Michigan by 1893, British Columbia and Missouri by 1894, and West Virginia by 1895. Doubtless in some of these states the first actual invasion was of earlier date, and in many of them it has been several times introduced and from various infested localities. Idaho was apparently infested from Washington, and

* l. c., p. 504.

† The San José Scale and its nearest Allies. Bull. No. 6, Tech. Ser., U. S. Dept. Agr., p. 15.

‡ "In reference to the San José Scale and its introduction into Alabama, it was first introduced into the state in the spring of 1893. We purchased some fruit trees from a nursery in New Jersey."—J. W. HOFFMAN, *Director, Agricultural Department, South Carolina College.*

Louisiana from Idaho. It came to New Jersey from California, in 1886 or 1887, and from the former State was most widely distributed throughout the East, in the shipment of infested nursery stock. The states now reported to have become infested from this center of dispersal are New York, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Georgia, Ohio, Indiana, Illinois and Michigan.

In Illinois.—The earliest ascertained introduction of the San José scale into Illinois was not earlier than 1886 nor later than 1891. Mr. J. B. Hayer, a fruit grower at Sparta, in the southwest part of the State, whose premises are now very badly infested, imported miscellaneous nursery stock from an infested New Jersey nursery at various intervals between these years, stopping with the last. It was imported again to Sparta from New Jersey in 1892 and in 1894, and to Mt. Carmel at some time not now ascertainable. The scale was also brought from the same New Jersey district to Richview, in Washington county, and to Auburn, in Sangamon county, in 1891. These four localities are now much the most seriously and generally infested of all in this State, the Sparta neighborhood much the worst of all.

In 1893 it was introduced at Collinsville, in Madison county, and in 1893 or 1894 at Monroe Center, in Ogle county. In this latter year, 1894, it was repeatedly brought into Illinois: to Quincy and Paloma, in Adams county; to Tremont, in Tazewell county; to West Salem, in Edwards county; to Ernst, in Clark county; to a farm in the eastern edge of Edgar county; and to Villa Ridge, in Pulaski county. This was the year of its discovery and recognition in the East, since which time it has been brought into the State of Illinois, so far as we now know, but once—to Herrick, in the southern part of Shelby county, in 1895—again from an Ohio dealer. The dates of its introduction at New City, Tower Hill, Mascoutah, and Mt. Carmel are, however, unknown to me.

Of the twenty-one colonies thus far detected in Illinois fourteen were certainly imported from New Jersey; three came directly from a dealer in eastern Ohio who does not grow his stock; and one was shipped on an order filled by a nurseryman at Rochester, New York. The origin of those remaining is not certainly known. Those from eastern Ohio were on one or two trees in each case, obtained from dealers in nursery stock and not grown at the localities from which they were shipped into Illinois. That from Rochester was imported to Illinois on currant bushes said by the nurseryman from whom they were bought to have been obtained from a New Jersey grower whose stock is now known to have been infested at the time. We thus see that the only infested districts from which it is now clearly ascertained that the San José scale has been introduced into Illinois are the above-mentioned New Jersey nurseries. The facts concerning the New Jersey outbreak have been so often rehearsed in entomological bulletins from several states and from the United States

Department of Agriculture that the following brief summary of them, taken from Howard and Marlatt's Bulletin* will serve the purposes of this report.

"The two nurseries responsible for the original eastern introduction of the scale are near Burlington, N. J., and Little Silver, N. J., the one on the Delaware River and the other near the Atlantic coast. The scale was introduced into these two nurseries in the same way. Either in 1886 or 1887, in the endeavor to secure a thorough curculio-proof plum, both of these nurseries introduced from California an improved Japanese variety, the Kelsey, obtained from the San José district. We have the statement from the proprietors of one of the nurseries that the plum-trees in question were secured in the spring of 1887 from San José, California, and were shipped through the agency of the Missouri Nursery Company, which acted in this instance apparently as a mere transmitting agent. The trees were unquestionably thoroughly infested when received, did not thrive, and in both cases most of them were ultimately taken out and destroyed. The stock, however, had been multiplied by nursery methods, and from the original stock and that subsequently obtained the scale spread more or less completely throughout both of the nurseries in question.

"In the case of one of the nurseries the scale spread to bearing pear-trees, and from these had spread yearly to neighboring nursery trees. In the other nursery, fruit growing is quite an important feature, and the scales had spread early from the introduced plum-trees to bearing fruit trees, and also infested low shrubs and plants, particularly currants of both the black and white varieties. It spread finally more or less thoroughly throughout large blocks of nursery stock. Both of these firms, when the nature of the infestation was brought to their attention and the seriousness of the damage they were doing was made apparent to them, undertook measures to exterminate the scale. One of the nursery companies was particularly prompt and thorough in its efforts in this direction, and deserves great credit for the manner in which it undertook the work; the other was for a time dilatory and seemingly indifferent, but was forced by the necessities of its business and by public opinion to adopt similar remedial measures."

DISCOVERY IN ILLINOIS.

The first hint of the presence of the San José scale in Illinois was received August 29, 1896, from Mr. Chittenden, an assistant in Dr. Howard's entomological office in Washington, in charge of the office during the absence of his Chief, who wrote enclosing a letter from Dr. G. G. Groff, of Lewisburg, Penn., reporting that he had just received from Mr. Valentine J. Kiem, of Quincy, Ill., the San José scale "in its worst form," and asking that the Entomologist of this State be

* U. S. Dept. Agr., Div. Ent., Bull. No. 3, pp. 36 and 37.

notified. I later learned from Mr. Kiem that this report was based on specimens sent by him, with a request for information, to Meehan's "Gardeners' Monthly."

I immediately wrote to Mr. Kiem for specimens cut from the injured trees, and September 4 received from him pieces of twigs completely incrusted with the San José scale. The fact of the occurrence of this insect in Illinois being thus established, I sent my most experienced entomological assistant, Mr. C. A. Hart, to Quincy with instructions to inspect the infested premises thoroughly, and to extend his search into all orchards, nurseries and fruit gardens for two or three miles around. According to his report, made September 9, the Quincy attack was limited to about a dozen peach and apple-trees received from a New Jersey nurseryman in the spring of 1894, and set in an isolated orchard of five hundred trees (peach, apple, pear and cherry) some three miles out of town.

INSPECTION OF ILLINOIS ORCHARDS.

Learning from Mr. Kiem that other trees had to his knowledge been received from New Jersey by his neighbors at about the same time as his own, I decided to appeal to the public spirit of these outside nurserymen known to have distributed stock at a time when their own premises were infested and before this fact had been ascertained by them, in the hope of securing from them lists of their Illinois customers to whom this suspected stock had been sent out. By correspondence with Professor J. B. Smith, the Experiment Station Entomologist of New Jersey, I secured the names of all nurserymen in that state whose premises had at any time been infested with the San José scale and who had an outside trade in nursery stock. To my great pleasure, these gentlemen were good enough to send me lists of purchasers in Illinois to whom it seemed to them possible that infested trees or shrubs had at any time been sent. The total number of Illinois localities given on these lists was one hundred and nineteen, and the number of persons receiving stock from these suspected localities was one hundred and forty-six in all. These localities were well distributed throughout the State, from Waukegan and Scales Mound on the north to Villa Ridge on the south, and from Paris and Danville on the east to Moline, Quincy and Alton on the west. To all persons who had imported this suspected stock a letter of warning and advice was sent from my office October 22, with a request that careful inspection of this material should be made, and that specimens should be sent me if anything of a suspicious character was found. General notice of the facts was also published through the agricultural press of the State and through the Associated Press.

October 20 I began to visit, either personally or through competent assistants, the places on our lists, with the intention of looking up and inspecting critically every lot of imported stock which we had reason to believe might possibly harbor the scale. As a result of these visits eighteen points in Illinois are now known to be infested by the San José scale. At one of these we found three

independently imported lots of trees which were infested, and at another two, making twenty-one such importations thus far found in Illinois. These infested localities are as follows, beginning at the north part of the State: Monroe Center, in Ogle county; Tremont, in Tazewell county; Quincy and Paloma, in Adams county; Auburn and New City, in Sangamon county; Tower Hill and Herrick, in Shelby county; Ernst, in Clark county; Vermilion, in southeastern Edgar county, and a farm in the same vicinity; Collinsville, in Madison county; Mascoutah, in St. Clair county; West Salem, in Edwards county; Mt. Carmel, in Wabash county; Richview, in Washington county; Sparta, in Randolph county, and Villa Ridge, in Pulaski county.

CONDITIONS AT INFESTED LOCALITIES.

The exact condition of affairs with respect to this scale reported by my inspectors for each of the orchards now known to be infested by it is as follows:

At Monroe Center, in Ogle county, one pear-tree in a small fruit patch was found badly infested with the scale, the other trees in the lot being, so far as could be seen, entirely free from it. This infested tree had come from a New Jersey nursery in 1893 or 1894. To my letter of October 22, asking him to inspect his imported trees and to report the results, the owner had replied that he had carefully examined all his New Jersey stock, and that it was free from scale. I mention this as evidence of the fact that the fruit grower's own inspection can not be depended on with safety in matters of this importance.

Three miles south of Tremont, in Tazewell county, my inspector found that Mr. Jacob Winzeler had purchased from New Jersey in the springs of 1894 and 1895 a considerable number and a large variety of trees, mostly pears, but including also a few apples, plums and cherries, and some currant bushes. In this orchard six Japanese golden russet pears were quite badly infested by the scale. As these were set alternately with trees of other varieties which showed no sign of the scale it is practically certain that they were infested when received, and it is probable that the scale has not begun to spread. The owner has promised to burn these trees, but we have no present assurance that the remainder of the orchard will be sprayed.

The Quincy case has already been described. The other Adams county locality at which the scale was found was Paloma, a small town on the Wabash railroad. Among some forty or fifty New Jersey trees on the premises of Thomas P. Ogle at this place only one was found infested with the scale, and that a pear which stood by itself on the lawn. This was dug up and burned by Mr. Blair, of the Horticultural Department of the University, and the owner of the orchard has promised to disinfect the remainder of his trees. As these are all small, it can be done at very slight expense.

At New City, in Sangamon county, twelve miles south of Springfield, three plum-trees and thirteen pears (Clapp's favorite and Garber) belonging to Mr. Henry Archer were badly infested with the

scale. These trees were said by the owner to be grafts from a nursery at Louisiana, Mo., but as he had received many trees from New Jersey whose location he was not sure of, it seems probable, on the whole, that this was the source of the scale. The owner promised to root up and burn the trees marked for destruction by Mr. Blair, but did not feel that he could afford to disinfect his entire two-acre orchard with whale-oil soap.

At Auburn, in this same county, nineteen miles south of Springfield, we found five acres of fruit trees belonging to Mr. I. N. Lowe, among which two plum-trees, eight apple-, eight pear-, and eleven peach-trees, all imported from New Jersey about five years ago, were found so badly infested by the San José scale that the owner was advised to dig them up and burn them. The osage orange hedge beside this orchard plot was also seriously attacked. It would probably require six hundred pounds of whale-oil soap to destroy the scale on these premises, together with a good force-pump, twenty feet of hose, and other appliances not now in Mr. Lowe's possession. To raise the fifty dollars or so which a thorough disinfection of this orchard would require, the owner assured us that he would have to haul corn to market at thirteen cents a bushel.

Two and a half miles east of Tower Hill, in Shelby County, we found two hundred New Jersey pear-trees and eight hundred others, together with apples, blackberries, etc., mostly from Illinois. Five of the New Jersey trees were badly infested by the scale, and three others slightly so. The owner, Mr. G. W. Grisso, promised to burn the infested trees.

Near Herrick, in the southern part of Shelby county, two small trees were found, four or five feet in height, completely incrusted with the San José scale. They were in a small fruit plantation belonging to Mr. S. W. Buchanan, between two and three miles north of the town. They were obtained in 1895 from an Ohio dealer who does not raise trees himself. Adjacent stock, consisting of pear-trees, grape vines, apricots, red and black raspberries, and also an apple orchard but a little distance removed, were all inspected carefully by an Assistant of the office, Mr. Braucher, September 7, 1897, but without further discovery of the scale.

From Ernst, in Clark county, twigs from a dwarf Duchess pear-tree bought in the spring of 1894 from a Bridgeport, O., nursery, were sent me early in December, 1896, by Mr. William C. Hammerly with the request that I would identify the scale upon them, which had lately attracted his attention. These twigs were thoroughly incrusted with the San José scale, although a dozen dwarf pears bought at the same time, and fifty more received from the same source in the spring of 1895, together with a number of peach-, cherry-, and quince-trees, were reported to be perfectly clean. The infested tree, however, was incrusted from the surface of the ground almost to the tips of the twigs. Advised of the presence of the San José scale by my reply, Mr. Hammerly wrote me on the 10th of December that he had cut the tree down, sprayed it thoroughly with kerosene, and burned it. As this tree came from a source not previously known

to be infested by this scale, some correspondence followed, from which I learned that the tree came to this State through a jobber or dealer in trees who had no nursery of his own, but who had bought it with a quantity of others from a New York nurseryman on whose grounds the scale has never been known to occur. On a subsequent careful inspection of this entire neighborhood no other infested trees were found.

On a farm near Sanford, Ind., but across the Illinois line, in Edgar county, Ill., in a small plantation of about two thousand currant bushes, a considerable number were found by the owner infested by a scale which proved on examination at my office to be the San José species. The infested bushes were all of the "red Dutch" variety, "cherry" currants mixed with them not showing the scale. These infested bushes had been obtained in 1893 from a nursery company at Rochester, N. Y. Mr. Howard had about fifteen acres of fruit, but found the scale on nothing but the currants mentioned. He promised to burn all the currant bushes in this acre field, plow it up, and plant it to corn. As the infested patch was not immediately connected with any other fruit plot, it is possible that there had been no extension of this imported colony.

From Mr. Howard's premises the scale was transferred by sale of currant bushes to those of Mr. A. H. Evinger at Vermilion, in the same county but about five miles away.

At Collinsville, in Madison county, in an orchard of about five acres belonging to Charles Eckert, five or six large trees (apricot and plum) were found slightly infested at one end of the orchard, and a small apple-tree near the center of it was extensively attacked by the San José scale and other orchard scales. The latter tree had been received from New Jersey three years before, and had been noticed by the owner as unthrifty from the beginning.

At Mascoutah, in St. Clair county, about ten trees were found infested with the San José scale in one corner of a neglected fruit plot on a town lot. The infested trees were peach, apple and cherry. These had been imported originally from New Jersey by John Baisch. The property has since changed hands.

In a ten-acre orchard at West Salem, Edwards county, belonging to Mr. Augustus Fischel, several Nevada pear-trees originally obtained from a New Jersey nursery were found badly infested with the San José scale, one of the trees having, in fact, died from its effects. An apricot was also conspicuously covered, and a few peach trees near by were slightly contaminated.

At Mt. Carmel, in Wabash county, a single infested plum-tree was first found by Dr. J. Schneck, specimens of which he sent to the office, but subsequent visits of assistants discovered the fact that a large number of fruit trees, dispersed over at least six city blocks, were infested with the scale, many of them badly so, and that the introduction of the pest must date back several years. The number of owners of infested premises and the great variety of sources from which trees had been obtained by them make it now impracticable

to trace the original importation to its source. Peach-, apple-, pear-, cherry-, quince-, and plum-trees, rose bushes, and currant bushes were all infested at this place.

At Richview, in Washington county, in a young eight-acre orchard, nearly all pears, belonging to Dr. J. W. Stanton, a large number of trees were found dead and completely covered with the San José scale, the greater part of the others in this plot being also more or less infested. A few scales were found even on the Kieffer pears, although none of these trees were seriously affected. A part at least of the infested trees were originally from New Jersey. From this place the scale has spread into an old orchard adjoining, belonging to Mr. Rice. A few San José scales were also found in a small pear orchard belonging to Jasper Willgus on stock from the same source as the preceding.

Much the most serious condition of affairs with respect to the San José scale thus far found by us is that disclosed by letters from Mr. J. B. Hayer, at Sparta, Randolph county, and by the subsequent reports of inspectors from my office who have visited this place repeatedly since last December. Mr. Hayer's New Jersey importations were made at various times from five to ten years ago, and since that period he has lost about a thousand bearing apple-, peach- and pear-trees from this scale. He has now about seven hundred trees on his farm, all of which except his Kieffer pears are badly infested with the scale, many of them being completely incrusted. The same scale was found on this farm on elm trees, wild crab-apples and rose bushes, and on osage orange hedges beside the orchard. It has also spread to three other orchards adjoining on the north, west and south, and has been transferred by budding to the orchard of a son-in-law of Mr. Hayer, Mr. Mann, living some four miles from town. Mr. Hayer has applied various insecticides from time to time, some of them with moderate success, but has practically given up trying to raise peaches and apples and buys now only the Kieffer pear. Two other fruit-growers near this town, Mr. John Robinson and Mr. W. H. Grant, have also imported the scale from the same New Jersey situation, and have it now in their orchards near this town.

From Villa Ridge, in Pulaski county, Mr. C. C. Spaulding sent me, the first of March, pieces of twigs from a Transcendent crab-apple tree obtained from a tree dealer in Ohio in the fall of 1894, the condition of which had attracted his attention sufficiently to lead to his treating it with pure kerosene. An examination of these specimens showed that they were thickly covered with the San José scale. Further search by Mr. Spaulding, made upon the receipt of this information, resulted in the sending of several additional specimens bearing scale insects, none of which, however, were of this species; but a subsequent inspection made by Mr. R. W. Braucher, an Assistant of the office, showed that one large and ten smaller peach-trees growing in the immediate neighborhood of the tree originally worst infested also bore the scale in comparatively small numbers. An inspection of the other trees and shrubs in the vicinity was made with only negative results.

It will be seen that these twenty-one Illinois colonies of the San José scale are all in orchards or small fruit plots, and none of them in nurseries. In every case thus far detected the original importation of the scale was made directly from the East by the owner of the orchard, and not through any Illinois nursery. On the other hand, it is much to be regretted that although our local nurserymen have frequently dealt with proprietors of eastern nursery grounds which are now known to have been at one time infested, my inspectors have rarely been able to trace any stock so received beyond the Illinois nursery through which it has passed to Illinois customers; it is consequently possible that some cases of the occurrence of the scale will thus escape our search.

DISINFECTION OF QUINCY ORCHARD.

At a meeting of the Executive Board of the State Horticultural Society held in September, 1896, the facts with regard to this orchard were reported to this Board, who thereupon passed a resolution requesting the State Entomologist to undertake the extermination of the scale at this place, and making an appropriation (not to exceed $150) from the funds of the Horticultural Society for the expenses of this procedure.

On a personal visit to Mr. Kiem's place, made a few days later, I came to an agreement with him that he should permit nothing to leave his premises which could possibly convey the scale to any other locality, and that he should do all the work and provide all the assistance necessary to a thorough insecticide treatment of everything on his farm which could harbor the scale, on condition that the work should be supervised from my office and that the insecticide should be furnished him at our expense. As the female scales were still giving birth to young at this time, I decided to postpone operations until it was certain that all the scales in the orchard were established in fixed position on the trees. There was an additional advantage in waiting until the leaves had fallen, as a smaller quantity of insecticide would then be required for a thorough treatment of the trees, shrubs and hedges on this place.

As Mr. J. C. Blair, of the University Department of Horticulture, has had extensive practical experience with spraying methods in the orchard, I gladly availed myself of his kind offer to superintend this operation for us, and sent him November 10 on a general trip of inspection through western Illinois, with full instructions as to the disinfection of the Quincy orchard. The insecticide used was whale-oil soap obtained from Leggett & Brother, 301 Pearl street, New York City, at a cost of four cents per pound by the barrel. This soap was applied in a hot solution of two pounds to the gallon of water. In the operation a large iron pot holding about sixty gallons was mounted in the field near the orchard, and in it water was heated and the soap dissolved. This soap solution was taken from the pot boiling hot and placed in a barrel on a wagon provided with an ordinary orchard spray pump and twenty-five feet of hose with a good spray nozzle. Three men were required for the work; one

heating the water, one driving the team and pumping, and the third handling the hose. Nine of the infested trees had been rooted up and burned by the owner, but everything else in the orchard was thoroughly drenched. Care was taken that every twig of every tree was thoroughly soaked with this hot solution, which was, however, doubtless cold by the time it struck the bark. The trees were carefully examined the next day after spraying, and all parts which the liquid had not certainly reached were sprayed again. Patches of raspberry canes adjoining and all the osage orange hedge in the vicinity were similarly treated. Five hundred and ninety-five pounds of whale-oil soap were thus used, or a total of two hundred and ninety-eight gallons of fluid for the five hundred trees. The one and two-year old stock required but little of the solution, but for trees four to eight years old an average of two and a half quarts was used. For some of the larger trees in the older part of the orchard two gallons each were necessary. Mr. Blair found it expedient to direct the spray himself, not wishing to trust to the thoroughness of persons not familiar with this sort of work. The cost of material for this single treatment was $23.80. For the larger trees it was, as will be seen, eight cents per tree for the soap alone.

The second treatment of this orchard with the soap-suds spray was begun under Mr. Blair's supervision March 27, and finished by the owner of the premises, Mr. Kiem, March 29. The method differed from that of the first treatment only in the use of an extension rod to carry the spray nozzle along the larger limbs.

To test the effect of this treatment, the scales remaining upon the twigs, portions of branches, and cuttings from the bark of the trunks of various trees were examined in early spring as sent in by the owner. All the specimens of the San José scale which were thus critically scrutinized were dead.

To determine more exactly the effect of this treatment, an Assistant, Mr. R. W. Braucher, was sent to Quincy in July, 1897, with instructions to make a critical examination of every infested tree in the orchard, and, if necessary, of the hedge and other vegetation in the vicinity liable to attack by the scale. At this season of the year the presence of living scales was of course more easily recognized than in early spring, since the season of reproduction was at its height, and young scales of all ages would be found wherever any were still alive. The following statement is drawn up from his report made August 2.

Of the twenty-six trees in the orchard which had evidently been infested, living scales were found upon seven, generally in crevices or holes in the bark, where they were protected from the soap solution, but in several cases upon the exposed surface, where they had doubtless been covered by a mass of scales so thick that the soap-suds did not reach them.

The worst infested tree remaining in the orchard was an apple-tree which had been left as an experiment when others in similar condition had been destroyed. The trunk and larger limbs had been thoroughly incrusted, although most of the scales had now disap-

peared. In protected places which the rains could not reach, the dead scales could still be picked off several layers deep. Mr. Kiem reported that in the early part of the spring a handful of them could be got in a short time by scratching the bark with the finger nail. This tree had been sprayed five times, while the other trees were sprayed but twice. A few living scales were still to be found on the trunk and limbs, a part of them in holes or crevices of the bark, and others on the smooth surface of the limbs. In picking off the masses of dead scales packed into crevices in the bark, sometimes one, and occasionally two living scales were found at the bottom of the mass, but in most cases every one was killed. The effect of the treatment in permitting the revival of this originally thrifty tree was very conspicuous. The old bark had been generally killed, but the tree had made a fine growth this summer, cracking the dead bark, which was beginning to peel off, leaving a young clean bark beneath. This condition of things was also noticed on other apple-trees, wherever the scales had been very abundant.

It is thus made evident that an originally healthy tree, in the complete possession of the scale, may sometimes be saved by a destruction of the insects themselves. If the surface of the trunk and larger branches of this tree had been scraped and brushed to remove the incrusting scales and the rough dead bark before spraying with whale-oil soap, it is quite probable that not a single scale would have survived.

A large peach-tree, six years old, the worst infested of those left standing, and still thickly coated with the dead scales on the trunk and larger limbs, was also thoroughly examined. No living scales were found on the trunk or on the larger limbs near their origin, but a considerable number were seen on both the upper and under surfaces of the smooth bark of the limbs in the middle of the tree. According to Mr. Blair's report this tree was less thoroughly sprayed than many because of the large amount of fine brush in the top, which made it very difficult to distribute the spray to all parts of the tree. This difficulty would have been removed if the tree had been vigorously trimmed before spraying. Although badly infested with borers, it had made a very good growth during the season, like most of the other peach-trees treated.

Two or three living scales were found on the trunk of another apple-tree, the bark of which was rough and peeling off in patches. It had not been very badly infested, and was now making an excellent growth and bearing several sound apples.

Upon the trunk of still another apple-tree, more thickly infested and with rougher bark, one or two living scales were found. On three other apple-trees, three or four years younger than the foregoing, a few living scales remained at the base of the trunk, either under the protection of the ragged bark or under masses of scales. When these trees were sprayed in spring the ground was covered with a mulch of manure, about two or three inches deep around the trees, which possibly protected the base of the trunk in part from the action of the spray. One of these three apple-trees was the

worst infested at this time of any tree in the orchard. The living scales were quite numerous near the ground, and were also distributed sparsely over the trunk and larger limbs. Immature scales were found on all three of these trees, established under pieces of bark which had recently cracked away from the deeper layers. Two mature females were noticed on these trees, each with a number of young beneath the maternal scale.

It is commonly supposed that a spray of whale-oil soap of the strength used in these treatments is destructive to the fruit buds, but the general appearance of this little orchard would suggest rather that the treatment which it had received was immediately beneficial in all respects, at least to the apple-trees. These not only blossomed freely but set a very good crop of fruit, which the owner was sure was much less wormy than that in neighboring orchards. Plum-trees also were in bearing, with no evidence of a diminution of their crop. The peach blossoms in this region were all killed by frost. Raspberries and blackberries, sprayed both in fall and spring, were fruiting abundantly.

As a general conclusion concerning the results of this experiment, it was Mr. Braucher's judgment that ninety-nine per cent. of the scales in this orchard were killed, and that the remainder would probably have been destroyed if the surfaces of the trunks and larger limbs had received a suitable preliminary treatment with a scraper and brush. It is very evident, however, that the treatment ordinarily recommended at the present time for the extermination of the scale, namely, two sprayings in the year (in fall and spring respectively) with a strong solution of whale-oil soap, cannot be relied upon to do more than to keep the attack in check. As likely to be applied by the ordinary orchard owner or the employés of the nurserymen it would almost certainly fail much more conspicuously than in the case here described. This Quincy orchard will be treated again next fall and, if necessary, the following spring, in the light of our experience at the time.

DESCRIPTION.

The small size and inconspicuous appearance of the San José scale as compared with other orchard scales with which fruit growers are more or less familiar, make it difficult of recognition even as a scale insect of any sort, and when identified as such its positive determination as the San José scale is greatly embarrassed by the fact that we have, commonly and widely distributed, three or even four other species* of its genus which so closely resemble it that they are not to be distinguished from it by ordinary observation. Indeed, even the practiced entomologist will often resort to the compound microscope and a study of a mounted slide to satisfy himself in doubtful cases. These kindred species are but little known, and their economic importance is not well understood. Our own observations in Illinois go, on the whole, to support the view that they

* *Aspidiotus obscurus*, *A. ancylus*, *A. forbesi*, and *A. howardi*.

are of no extraordinary interest to the fruit grower, none of them being either as abundant or as destructive when present as the commonest of the native orchard scales, the so-called scurfy scale of the apple, *Chionaspis furfurus*. It often becomes, consequently, a matter of special interest and importance that this most destructive San José scale should be positively distinguished from the others, and to this end I have had prepared by my Assistant, Mr. C. A. Hart, the following comparison of characters, both superficial and minute.

Besides the San José scale there are a few other kinds of Aspidiotus infesting fruits, most of which closely resemble the San José species, and are scarcely to be distinguished from it without a microscopic examination of prepared specimens of the female, mounted on microscope slides. The case is quite different, however, with regard to the other common fruit scale insects, such as the oyster-shell, the scurfy scale, and the rose scale, which are often supposed to be the San José, but which are easily distinguished from it at sight, as the mode of growth of their scales is on quite a different plan. In the San José scale and its allies of the same genus (Aspidiotus) the starting point of growth—the larval scale—is usually near the center of each scale, marked by a minute papilla or nipple encircled by a tiny impressed ring. This mark is usually quite evident except when rubbed off from the older scales. Around this point the scale grows by concentric additions. That of the female always maintains a nearly circular form, but the male scale when about half grown begins to enlarge mostly in one direction, assuming an oblong or oval shape. In the oyster-shell and scurfy scales (Mytilaspis, Chionaspis), on the other hand, the starting point is indicated by a minute dark-colored cast skin at one end, from which growth progresses by successive additions in one direction only, as in the shell of an oyster.

The fruit-infesting species of the first group (Aspidiotus) most likely to be confused with the San José scale are the minor fruit-scale, a common species in Illinois (*Aspidiotus forbesi*)*, Putnam's scale (*A. ancylus*)†, the obscure scale (*A. obscurus*)‡, and Howard's scale (*A. howardi*)§. The minor fruit scale seems to be distinctly whiter than the San José scale, the younger scales especially so, and never dark-colored as in the imported species. I have seen unusually light colored specimens of the San José on currant stems, but in the many examples of apple twigs infested by both species examined at this office, the difference was always quite evident. Howard's scale, found on the plum in Colorado, resembles the San José scale, but lacks the nipple and ring. Putnam's scale is also similar to the San José in external appearance, but has a darker color, and brighter or deeper red spots in the center of the older scales, and the nipple and ring are not well developed.

* Johnson, Bull. Ill. State Lab. Nat. Hist., Vol. IV., Art. XIII., p. 380, Pl. XXIX.

† Comstock, Rep. U. S. Ent., 1880, p. 292, Pl. XIV., Fig. 3; Pl. XXI., Fig. 4.

‡ Ibid, p. 303, Pl. XII., Fig. 4; Pl. XIII., Fig. 4.

§ Cockerell, Can. Ent., Vol. XXVII., p. 16; Gillette, Bull. 38, Col. Agr. Exper. Station, p. 37.

As has been already stated, in order to separate the above species it is necessary that specimens of the female be examined microscopically. If some of the larger female scales are carefully lifted, a very flat, rounded, reddish object may be seen underneath. These are the female scale insects. Remove a few of these and boil them briefly in a five per cent. solution of caustic potash, in order to soften and clean them. They may then be transferred to a drop of water on a glass slide, and carefully covered by a microscope cover-glass. When this temporary preparation is examined under a moderately high power of the microscope, the female appears as a semitransparent yellowish disc, the margins of which are smooth and unmarked, except about the posterior extremity, which forms a slight angle, with a number of marginal lobes, incisions, spines, teeth, and "plates," symmetrically arranged on each side of the tip. Under favorable circumstances a number of groups of small "spinning glands" will be seen about the genital orifice, which lies a short distance in front of the posterior extremity. The glands are wanting in the San José scale only. On each side of the deep median incision at the apex of the posterior extremity in the San José scale is a rounded lobe, notched outwardly near its tip, and beyond these is a second pair of similar lobes. Exterior to each of these four lobes is a shallow incision with thickened sides, making five incisions in all. Four small spines or setæ will be noted in the margin, the third just exterior to the outer incision, and the fourth about as far beyond it as the distance between the first and third. Near the third spine, exterior to the outermost incision, the margin bears three projecting teeth, each ending in two or three points. These sometimes become so transparent that they are not very conspicuous. The middle pair of lobes are well separated, not closely approaching at their inner apical angles. In the minor fruit scale, these lobes closely approach each other at their inner apical angles, greatly narrowing the central incision, and the margin exterior to the outer incision is finely crenulated or entire, and nearly straight, bearing only the usual spines. In Putnam's scale the second pair of lobes are wanting, and there is nothing resembling the three teeth of the San José scale. This species occurs on a variety of trees, including the pear and plum, but especially on maple. Howard's scale has been found infesting the tender bark of the twigs and the fruit of the plum in Colorado. It is similar to Putnam's scale, but has traces of a second lobe. The obscure scale has been described from oak, but it also infests fruit trees. It is one half larger than the other species here compared, and the female is quite different. There are three pairs of lobes and a third rather broad and shallow pair of incisions, just beyond which on each side is a short tooth or projecting angle; and beyond this, at a little distance, are two or three similar low teeth.

LIFE HISTORY.

It should be clearly understood that the San José scale occurs in three widely different forms; namely, the minute, active, six-legged larva, recently hatched from the egg or born alive from the body of

the mother; the fixed and motionless scale insect, male or female—the form commonly seen upon the tree, and the active two-winged male, which emerges from the so-called male scale after a period of development to which nothing in the life history of the other sex corresponds. As seen during the winter months, the male and female scales of various ages—most of them, however, nearly or quite full-grown—are mingled in the same incrusting group or colony.

The male scales give origin early in spring to the winged male, which, flying about, fertilizes the female sheltered beneath their separate scales, and from these, living young are born—from the first of May to early in June in Illinois according to the part of the State and the weather of the season. The active young scale retains its power of locomotion, at least under ordinary conditions, only a few hours, when it slowly pushes its long and very slender beak through the bark into the living tissue of the tree, contracts into a nearly circular form, and emits delicate waxy filaments from special glands, which form first a matted covering and then, by fusion of the filaments, a smooth waxy scale. Under this scale the insect lives and grows, and presently sheds its crust or skin, without escaping, however, from its protective covering. With successive molts the males go through their special metamorphoses, forming wing-pads within which the wings develop, while the female simply grows and becomes sexually mature. Four successive generations were observed at Washington in a single season, with some indications of a fifth. The period from birth to maturity was from thirty-three to forty days.

The number of young produced by a single female under observation has risen as high as five hundred and eighty-six, four hundred and sixty-four of which were females. Howard estimates two hundred females as a general average of the different generations of the year, according to which the product of a single individual from spring to fall might conceivably amount to a billion and a half of female scales, or to three and a quarter billions of both sexes. "It is not to be expected, of course," says Mr. Howard, "that all the individuals from a scale survive and perform their function in life, but under favorable conditions, or in the case of a tree newly infested or not heavily incrusted, the vast majority undoubtedly go through their existence without accident. Neither the rapidity with which trees become infested nor the fatal effect which so early follows the appearance of this scale insect is therefore to be wondered at."

NATURAL CHECKS ON MULTIPLICATION.

The economic history of the San José scale in California, where it has been longest known (for twenty-five years), is involved in great confusion, contradiction, and uncertainty, owing primarily to the fact that it has not been continuously followed for any considerable time at any one point by even one expert investigator. A great quantity of evidence concerning it collected there from local sources in 1896 by Professor John B. Smith, of New Jersey, is very largely a mass of conflicting views and mutually destructive interpretations of facts

themselves but imperfectly ascertained, and Professor Smith's own observations extended over too brief a time to serve as satisfactory clues to the labyrinth.

It is safe to conclude, however, that the San José scale has largely diminished in numbers, or even almost wholly disappeared, in some parts of California where it was formerly widespread, excessively numerous, and exceedingly destructive. Even at San José Professor Smith says that it is not now injurious, although it was plentifully scattered on abandoned trees and occurred in moderate numbers in several cultivated orchards. It also seems clear that this apparently spontaneous disappearance has been most general and complete in southern California; that it is confined, in fact, to points from San José southward. Some of its causes are manifest, but some assumed causes are doubtful or obscure, and the share of each in the effect produced it is impossible to estimate definitely. Unfavorable climatic conditions, insect enemies, either predaceous or parasitic, and fungus diseases are the agencies known or suspected.

Climatic Checks.—It is a fair inference from reported observations that the scale does not thrive permanently in a very hot and dry climate, or even in one subject to a long period of midsummer heat and drouth. It has been sometimes surmised that very cold weather is unfavorable to its continuance. It is reported by Professor Smith to have survived in New Jersey a zero temperature and its continuance for four years on a single tree in Ogle county, near the northern line of the State of Illinois, is still more convincing evidence of its capacity to withstand low temperatures. From reports of the U. S. Weather Bureau, kindly sent me by Mr. Charles E. Linney, Observer in Chicago, it appears that the temperature record in Oregon, Ogle county, reached 20° below zero (Fahrenheit) in 1894, 26° below zero in 1895, and 15° below zero in 1896. Indeed, the entire "month from the 20th of January, 1895, to the 20th of February following was a period of extreme cold, probably lower than any like period since systematic records have been kept within the State." This fact further goes to show that the supposed limitation of the distribution of this scale to the austral zone cannot be depended upon, since a climate such as that indicated by the above temperature records would exclude the Ogle county situation from this zone.

Entomological Enemies.—The recognized species of predaceous insect enemies of this scale are six in number, and the recorded parasitic insect species are five. Only three of these are worthy of present attention as highly destructive enemies of the scale, one a parasite (*Aphelinus fuscipennis*) and two predaceous enemies (*Chilocorus bivulnerus* and *Smilia misella*). These three are native American species, occur throughout the United States from the Atlantic Ocean to the Pacific, and live on scale insects generally. It seems quite likely, as suggested by Professor Smith, that other insect enemies of our coccids may attack the San José species, if they have opportunity, as freely as they do our native orchard scales. There is evidently a wide and promising field for experiment here, one in which work can be carried on readily and at small expense.

The parasitic enemy (Aphelinus) spoken of belongs to the hymenopterous family Chalcididæ, and is said by Howard to be a common parasite of the armored scales. As described by Professor Smith: "It is very minute, hardly as long as an ordinary San José scale, and of a somewhat straw-yellow color. The eyes are dark, and as they contrast in color, appear rather prominent. The antennæ are rather short and a little thickened at the tip, and are kept in constant motion while the insect is moving among the scales. The wings are ordinarily laid upon the back, and when the little creature is seen on an infested tree, it will be found walking or hopping, rather than flying, over the scales, and testing them with its antennæ, seeking a suitable one in which to lay an egg. In California it is easy to find specimens on any infested tree at any time of the year. In New Jersey they are much more rare, and in many places the trees do not show the slightest signs of the presence of the parasite. We have not yet seen them in Illinois. A single egg is laid in each scale, and the parasitic larva feeds upon the insect beneath. When ready to emerge, the parasite cuts a small round hole in the scale, through which it makes its exit into the open air. It is easy, therefore, to determine the part that has been played by this insect in lessening the number of scales, and there is no sort of doubt that in California it is extremely effective, particularly in the southern portions of the state."

The two-spotted ladybird (*Chilocorus bivulnerus*), although a common insect in this region and throughout the East, has not as yet been seen to feed upon the San José scale except in the Pacific states. There is scarcely any question, however, that if it were colonized in our infested orchards it would serve the same useful purpose here that it does in California.

"It is black in color, shining, almost hemispherical in shape, and on each wing cover, a little before the middle, there is quite a large, dull, orange or blood-red spot, from which the insect derives its common name. In size it varies from an eighth to three sixteenths of an inch in length, and as increased length is also accompanied by increased breadth and thickness, the largest specimen seems more than double the size of the smallest. The eggs are bright yellow in color, and quite large in proportion to the size of the beetle. They are elongate-oval in shape, set on end in little groups, something like those of the potato beetle, and in a general way resemble the eggs of other ladybirds, which are not uncommonly found on leaves infested by plant-lice. The larvæ are very dark gray or blackish, spiny, and with a more or less well-marked whitish or yellowish transverse band across the middle of the body. This mark is quite characteristic and makes it possible to recognize the insect in this stage with great certainty. These insects may be found active at all seasons of the year, and they feed upon armored scales in preference, on the Pacific coast generally preferring the pernicious scale to almost anything else. The beetle hibernates and appears towards the beginning of May. It lays eggs, from which larvæ hatch about the tenth of that month or a little later, and sometimes in July a second brood of beetles makes its appearance from these larvæ. In

August the second brood of larvæ has been observed, and beetles, apparently just issued, were found in September. The larvæ feed preferably upon active young or recently set scales, and where they are at all numerous undoubtedly destroy a great number. When full grown, the beetle larva attaches itself to the bark by the anal extremity, suspends itself head down, the skin splits, and the pupa wriggles partially out of it. In this condition it remains for a few days, until ready to transform to an adult. This beetle I believe to be the most effective enemy of the San José scale in California. Combined with Aphelinus, it has done most effective work in the southern counties, and is, I believe, largely responsible for the decrease of the scale in that part of the country."*

The third of the notably helpful species (*Smilia misella*) is a very minute ladybird, smaller than the San José scale itself, shining black and broadly oval in outline. It was abundant in September in the Quincy orchard, in this State, feeding freely upon the San José scale there and breeding actively. It is comparatively little known in California, where it has, indeed, only recently been ascertained to occur as a native insect. It is apparently the most active enemy of the San José scale in our region, and must, I think, produce a marked effect upon the rate of multiplication of that species. Its life history, as given by Professor Smith, is highly favorable to this supposition, for it seems to breed here as early and almost as long as the scale itself, and has been found abundant in November and December. The beetles are said to prefer the full-grown female scales, but the larvæ feed actively on the younger individuals. We found this beetle abundant at Champaign April 10, 1889, on pine-trees heavily infested with the pine-leaf scale (*Chionaspis pinifoliæ*.) A dissection of specimens collected at the time showed that they were feeding upon the scales.†

Efficient as these insect enemies may prove to be as a means of checking the multiplication of the scale when left to itself, they have the disadvantage as an economic reliance that artificial measures for the destruction of the scale must destroy these parasitic and predaceous enemies also. Indeed, the fact is now well recognized that the economic uses of parasites and insecticides are usually antagonistic, and unless we are obliged to abandon the effort to exterminate the scale in Illinois, we can pay but little attention to the introduction and artificial multiplication of these entomological enemies of the species, which can never be expected to exterminate any insect, but can at best only reduce its average numbers to economic insignificance. In fact, in those parts of California the climate of which most nearly

* Prof. Smith's Report, pp. 521, 522.

† It is a source of frequent surprise to me that the dissection method of determining the food of insects is almost never resorted to by economic entomologists in this country, notwithstanding the abundant evidence which has been given of its usefulness in settling points left doubtful by observation, and even in discovering food habits not previously suspected. (See "Notes on Insectivorous Coleoptera," and "The Food Relations of the Carabidæ and Coccinellidæ." Bull. Ill. State Lab. Nat. Hist., Vol. I., Art. 3., pp. 153-158, and Art. 6, pp. 33-59). Even pinned insects which have been dried for years may be readily dissected after boiling for a little time in dilute potash solution, and will then disclose the nature of the last food taken on an examination of the contents of the alimentary canal displayed upon a slide in glycerine under a compound microscope.

resembles that of Illinois, the San José scale has never been controlled by natural enemies, but it is there closely watched by all careful fruit growers, who rely always upon their own efforts to keep it in check.*

Determined efforts have been made to introduce into California from Australia and other western countries large numbers of species of the natural enemies of scale insects, but thus far with only two conspicuously successful results. There is no question that the importation of *Vedalia cardinalis* has brought about a very great reduction in numbers, amounting to the practical extermination for the time, at least, of the scale upon which it feeds exclusively, namely, the *Icerya purchasi* of the orange; and another predaceous enemy of this scale (*Novius koebeli*), seems also to have been successfully established; but of the forty to sixty other species whose introduction has been attempted, it appears from Professor Smith's Report, so often quoted, that only one enemy of the San José scale (*Rhizobius lophanthæ*), has finally established itself and become widely distributed in that State. Even this species, however, has not been recognized as an effective enemy of the San José scale. It appears, indeed, to be nowhere very abundant, and promises but little as a means of checking the multiplication of this destructive orchard insect.

Fungus Diseases.—Several writers have indulged in slightly founded surmises with reference to the occurrence in California of fungus diseases of the pernicious scale, but no really tangible evidence of the occurrence of such disease has yet been presented from that State. The only certainly recognized fungus parasite of this scale is one whose occurrence on it was first detected by Prof. P. H. Rolfs, of Lake City, Florida, who at this writing is about to bring to a conclusion an extensive study of its life history and economic character. Professor Rolfs has been kind enough to send to me a large quantity of material in the form of coccids dead from the disease produced by this fungus, and also cultures of the fungus itself. The coccids in question were *Aspidiotus obscurus* (on water oak) and the San José scale, the latter infected by Professor Rolfs by means of artificial cultures of the fungus parasite. From these an assistant has made pure cultures successfully, and is now extending them in fruit-jar cultures on corn-meal saturated with milk, for the purpose of obtaining a sufficient quantity for experimental use in the laboratory and in the field. Prof. Roland Thaxter, to whom some specimens have been referred, somewhat doubtfully confirms its determination—made at this office—as *Sphærostilbe flammea* Tulasne.† Further particulars are withheld, awaiting the publication of Prof. Rolfs' report of his investigation. This experiment has, however,

* See Prof. Smith's Report, p. 508.

† Referring to some specimens from Prof. Rolfs determined by him (Thaxter) as *S. coccophila*, he says: "The material which you send is far more luxuriant, and if one is to separate *S. coccophila* from *S. flammea* on a basis of spore measurements, I should say that what you send is *flammea* without much hesitation. The material formerly sent me contained spores which correspond to the exsiccati specimens of *S. coccophila* in Ravenel and Rabenhorst, but it is also true that they correspond to our copy of Ravenel's *S. flammea* var. *minor*. * * * Tulasne remarks that the two are very closely allied, but does not make it plain that they may be distinguished unless by the spore measurements, which seem not very reliable.

already gone far enough to encourage strong hopes that this fungus parasite will serve as a permanently useful and highly efficient ally in the destruction of this scale, and very likely of other injurious scales as well.

PRECAUTIONARY AND REMEDIAL MEASURES.

The obscure character of the San José scale and the difficulty of ridding premises of it when once infested, make general and precautionary measures the main reliance against its ravages. The following suggestions are made in a form to apply both to the business of the nurseryman and to the protection and disinfection of the premises of his customers.

1. Great care should be used in selecting stock. With the numerous possible sources of contamination now scattered throughout the country, no fruit grower is really safe who does not first assure himself that the premises from which his young stock may be obtained are themselves free from this insect, and who does not also critically inspect every portion of every tree and shrub liable to attack by this scale which comes to his premises. The best evidence of the absence of the scale from any nursery is the high reputation of the nurseryman for care, business method, and scrupulous honesty. Stock from such a nurseryman in a district known to have been infested by the scale in the past, is perhaps a safer investment than indiscriminate purchases made from less reliable men in regions where this scale has not yet been detected. Confirmation of this view is given by the fact that among the numerous importations from eastern nurseries examined by us during the last few months, only one importation made *after the discovery of this scale* in those nurseries has yet been found infested.

2. A very important additional safeguard is a certificate of inspection, issued by some official expert, certifying to the freedom of the stock in question from injurious insects and fungus diseases. The time seems rapidly approaching when official inspection and certificates will be a necessity of the trade. Too much reliance must not be placed, however, upon the absolute value of an inspector's certificate to the absence of the San José scale on any suspected premises or from any lot of inspected stock. It is a physical impossibility to assure one's self beyond all possible doubt that not so much as a single fertilized scale is present on even a single tree, and one such scale, if overlooked, may give rise within a very brief time to a destructive colony. Indeed, no critically careful inspector will issue unqualified certificates of freedom from injurious insects or fungus diseases. It is further to be remembered, that an inspection of the premises of a nursery and a certificate of freedom from the scale, are not a guarantee of all stock which may be shipped out by the owner, since a large percentage of that sold by most nurserymen originates elsewhere. The rearing of nursery stock has now become largely specialized in localities, to the great advantage, indeed, both of the dealer and his customer. The certificate referred to should consequently apply immediately to the entire lot of stock purchased; or, if it is a certificate of inspection of premises only, it

should be accompanied by a statement from the nurseryman to the effect that the stock sold was grown on the premises inspected, giving also the date of such inspection and the time when the stock was taken up. If a growing season or any part of such a season has intervened between these dates, the value of the certificate is thereby impaired.

3. The nurseryman should fumigate all suspected stock with hydrocyanic acid gas before sending it out. This is a simple, convenient, and comparatively inexpensive process, and the most effective known means of securing a complete destruction of living insects, including the San José scale. For this purpose the stock may be piled up closely and covered with a large sheet, beneath which the gas is generated by putting into a glazed earthenware vessel first three ounces of water, next one ounce of commercial sulphuric acid, and finally one ounce of fused potassium cyanide (98 per cent.) The vessel should then be placed at once under the sheet and left for at least an hour. The above quantity should be used for every hundred cubic feet of space. For large nurseries permanent provision for disinfection may profitably be made in the form of a small, tight building, conveniently arranged for the reception of large lots of stock, and for the introduction and removal of the insecticide ingredients.

A cloudy day is best for the work if done in the open air, or, if this cannot be had, the stock should be fumigated after sunset. Dormant nursery stock is not easily affected by the gas, and there is no danger to exposed roots. Sulphuric acid and the potassium cyanide are deadly poisons, and the greatest care should be taken not to inhale any of the gas emitted by the mixture, as it is deadly to man and other animals as well as to insects.

4. Where the above fumigation method is impracticable, as in the case of the ordinary purchaser, reliance may be placed upon thoroughly saturating the surface of suspected trees and shrubs with a solution of whale-oil soap, two pounds to the gallon of hot water.

5. All stock sent out by the nurseryman should bear the name of the nursery and, if practicable, a copy of a certificate of inspection containing the information mentioned under 2.

6. Examples of all stock suspected to bear this scale should be sent at once to the address of the State Entomologist, at Urbana, Ill., with a request for examination and report.

7. Whenever the fact is established that any trees or shrubs planted out are infested by this scale, all such fruit plants should be destroyed by fire if practicable. The loss thus incurred will commonly be trivial compared with that which will be likely to follow if less radical measures are taken. This is particularly incumbent upon the owner when the scale has been lately introduced and is as yet confined to a small number of trees, especially if these are isolated.

8. When such destruction is impracticable, the infested trees or bushes should be trimmed closely in fall, after the leaves have dropped, scraped to remove loose bark, and sprayed very thoroughly

twice (once in fall or winter and once in early spring), and repeatedly thereafter if necessary, with a solution of whale-oil soap, two pounds to the gallon, as described in the Quincy experiment, an account of which is given in this paper.

9. As a secondary precaution, all trees in an orchard any part of which has been infested should be whitewashed occasionally throughout the summer so as to keep the trunks and branches as thoroughly covered with lime as possible.

"We wish particularly to impress upon the minds of fruit growers that as soon as this insect is found to occur in an orchard the most strenuous measures must be taken to stamp it out. No half-way steps will suffice. The individual must remember that not only are his own interests vitally at stake but those of the whole community in which he resides. He may think that he can not bear the loss, but the loss in consequence of the slightest neglect will be much greater. The fact, too, that there is a community of interests among fruit growers in this matter must not be lost sight of. Fruit growers must be mutually helpful in an emergency like this."*

* From "The San José scale, its Occurrences in the United States, with a Full Account of its Life History and the Remedies to be used against it." (Bull. No. 3, U. S. Dept. Agr., Div. Ent. p. 66.)

FIELD OBSERVATIONS ON THE WHITE GRUBS.

Since the preparation of an article on the white grubs in a discussion of insect injuries to the seed and roots of Indian corn, published in my Seventh Report,* an unusual opportunity has presented itself for a study of an extraordinary outbreak of this insect pest in Central Illinois. In the years 1894 and 1895 white grubs became so abundant in the vicinity of Taylorville, in Christian county, as to have caused, according to the most intelligent estimates at my command, a damage of not less than twenty to thirty thousand dollars in a single township. This damage was chiefly manifest in grass lands and in fields of corn, although beans, strawberries, potatoes and other garden vegetables, and also an occasional field of wheat or oats suffered considerably.

Desirous of improving as fully as the exigencies of other work at the office would permit the chance thus given me to study the relation of agricultural conditions and management to injuries of this insect, I sent three assistants in succession to Taylorville in the fall of 1895, and later distributed a circular of inquiry to more than a hundred farmers whose crops were known to have been injured by the grubs. From the reports of assistants and replies from eighty farmers the data were collected which are presented and discussed in this article.

My first notice of the local outbreak was in the form of a description of an injury to a timothy meadow sent me September 11, 1894, by Mr. Wm. T. Vandeveer, a banker at Taylorville and large land owner in Christian county. The injury was not great, but patches of grass were killed here and there in this meadow, weeds growing in these spots the following year. The extraordinary character of the occurrence is shown by Mr. Vandeveer's statement that, although long a resident there, insect injury of this description was new to him.

The situation became much more serious in 1895, the grass in the meadow just mentioned, for example, being completely killed that year. In response to earnest representations made to the office early in September, Mr. C. A. Hart went to Taylorville September 6 for an examination of the situation with special reference to the species of white grubs principally responsible for the damage. On the 26th of the same month another assistant of the State Laboratory, Mr. B. M. Duggar, engaged at the time upon the study of the diseases of insects, was sent to Taylorville to make observations with special

* Pp. 109-144.

reference to the occurrence of contagious disease among these grubs. A third trip was made October 5 by Mr. W. G. Johnson, one of my entomological Assistants, his special errand being a study of the situation with reference to the crops, soil, surroundings, and agricultural history of the fields worst injured. Both Mr. Duggar and Mr. Johnson were particularly charged to make observations upon the relation of the white grubs to clover sod, the opinion being quite prevalent both among farmers and economic entomologists that the clover plant is but little liable to injury by grubs, and that it offers but little attraction to the adult beetle in search of a place of deposit for her eggs.

In November a blank was distributed, as already mentioned, and as shown on page 28, with a circular request for full and precise information with respect to the history of infested fields from 1891 to 1895.

The information obtained by means of this blank is exhibited in summary form in the "outlines" following, on pages 29 and 30.

Outline of History of Fields Infested by White Grubs during Summer of 1895.

	Crop this year	Percentage of damage by grubs.	Crop in 1894.	Crop in 1893.	Crop in 1892.	Crop in 1891.	Remarks.
Field No. 1...							
" 2...							
" 3...							
" 4...							
" 5...							
" 6...							
" 7...							
" 8...							
" 9...							
" 10...							

Signature.....

Post-office.....

Date.....

Outline of History of Christian County Fields Infested by White Grubs during Summer of 1895.

		Crop in 1895.	Percentage of damage by grubs.	Crop of 1894.	Crop of 1893.	Crop of 1892.	Crop of 1891.	Remarks.
Field No.	1	Corn	Light	Wheat				Black prairie.
"	2	"	.10	"	Oats			
"	3	"	Light	Corn				
"	4	"	.05	"	Grass	Grass	Grass	Bottom land.. Timber in 1890.
"	5	"	.75	Grass	"	"	"	
"	6	Pasture	.10	"	"	"	"	Upland
"	7	Corn	.50	Wheat	Wheat	Oats	Corn	
"	8	"	.20	Corn	Corn	Grass	Grass	
"	9	"	10	"	"	Clover	Clover	
"	10	Grass	.60	Grass	Grass	Grass	Grass	
"	11	Corn	.75	Wheat	Corn	Clover	Clover	Those nearest timber the worst damaged.
"	12	"	.20	"	"	Corn	Corn	
"	13	Tim. & clover	.20	Grass	Grass	Grass	Grass	
"	14	Corn	.25	Corn	Oats	Corn	Wheat	
"	15	"	.50	Grass	Grass	Grass	Grass	
"	16	"	1.00	"	"	"	"	Young grubs. Grass 25 years.
"	17	Grass	1.00	"	Oats	Rye	Wheat	
"	18	"	.75	"	Grass	Grass	Grass	No timber near grass. 40 years.
"	19	Vegetables	1.00	"	"	"	"	Large orchard adjoining.
"	20	Corn	.30	"	"	"	"	
"	21	Grass	.25	"	"	"	"	Orchard. Grass 10 or 12 years.
"	22	"	.50	"	"	"	"	Originally timber.
"	23	"	1.00	"	"	Rye	Corn	" "
"	24	Corn	.50	Corn	Corn	Corn	"	Part bottom; once timber.
"	25	Grass	Little	Grass	Grass	Wheat	Oats	Clay soil; once timber.
"	26	"	1.00	"	"	"	"	Half timber originally; light soil.
"	27	Onions & corn	.05	Potatoes	Raspberries	Raspberries	Raspberries	
"	28	Potatoes	.06	"	"	"	"	
"	29	Potatoes, etc.	.75	Raspberries	"	"	"	
"	30	Sw. potatoes	.05	Grass (failu'e)	Grass (failu'e)	Corn	Oats	
"	31	Potatoes	.75	Grass	Grass	Grass	Grass	Grass 12 years.
"	32	Grass	.60	"	"	"	"	Grass 25 years.
"	33	"	.50	"	"	"	"	Grass 15 years.
"	34	"	.25	"	"	"	"	Grass always... Prairie; 2 miles from timber.
"	35	"	12	"	"	"	"	Grass 21 years..
"	36	"	.50	"	"	"	"	Soil thin. Grass 22 years.
"	37	"	1.00	"	"	"	"	
"	38	Corn	.65	Wheat	Oats	Corn	Corn	
"	39	"	.50	Corn	Corn	"	Grass	
"	40	"	"Some"	Grass	Grass	Grass	"	Grass 20 years.
"	41	Grass	.20	"	"	"	"	Grass adjoining. In grass 15 years.
"	42	"	.90	"	"	"	"	Grass 8 years.

Outline of History of Christian County Fields, Etc.—Concluded.

	Crop of 1895.	Percentage of damage by grubs.	Crop of 1894.	Crop of 1893.	Crop of 1892.	Crop of 1891.	Remarks.
Field No.	43 Grass	10	Grass	Grass	Grass	Grass	Grass 25 years.
"	44 Corn	.90	Corn	"	"	"	
"	45 "	1.00	Grass	"	"	"	
"	46 "	.50	None	None	None	None	
"	47 "	.50	None—grass	None—grass	None—grass	None—grass	
"	48 Grass	1.00	Grass	Grass	Grass	Grass	Timber land.
"	49 "	.50	"	"	Wheat	Wheat & corn	Prairie beside timber.
"	50 Corn	1.00	"	"	Grass	Grass	" "
"	51 "	.33	"	"	"	"	Crab apple groves.
"	52 "	.50	Corn	Oats & corn	Corn	Corn	Black soil—prairie—tiled.
"	53 Oats	Slight	Wheat & corn	"	"	"	
"	54 Grass	.90	Grass	Grass	Wheat	Oats	
"	55 " & clov'r	.50	" & clov'r	" & clov'r	Grass & clov'r	Grass & clov'r	
"	56 Corn	.75	"	"	Grass	Grass	
"	57 Grass	75	"	"	"	"	
"	58 Corn	.33	Corn	"	"	"	Adjoining timber—bottom—timber land.
"	59 "	.25	Grass	"	"	"	Prairie; 3 miles from timber.
"	60 "	.20	Corn	Wheat	Wheat	Corn	
"	61 Wheat & corn	05	Grass	Grass	Grass	Grass	
"	62 Grass	.90	"	"	"	"	
"	63 Corn	.10	Corn & wheat	Clov'r & grass	Clov'r & grass	Clov'r & grass	
"	64 "	.30	Corn	Wheat & clov'r	Oats	Corn	
"	65 "	25	Grass	Grass	Grass	Grass	
"	66 "	.50	"	Corn	Corn	Corn	
"	67 Grass	Slight	Grass	Grass	Grass	Grass	
"	68 "	.75	"	"	"	"	Prairie—woods ¼ mile distant; in grass 25–30 years.

Injuries to Different Crops.—The region affected is one of varied character, comprising lands originally prairie and others from which the forest had been cleared, together with many remaining remnants of the forest tract more or less completely cleared of underbrush and used as woodland pastures. This forest soil differs of course from that of the prairies, and may itself be divided into upland and bottomland portions. The agriculture is but little diversified, corn and grass being the principal crops of the county. The area in each of these crops (including pastures) was not far from a hundred and ten thousand acres in 1895, while that in all of the small grains was only about half that amount. In other words, wheat and oats each occupied about one tenth the agricultural area of the county, and corn and grass about four tenths each. I have accounts from the various sources above mentioned of sixty-eight fields in Christian county in crops which were more or less injured by the white grub. Thirty-four of these fields were in corn, twenty-five were in grass (usually blue grass), two were a mixture of timothy and clover, one was in wheat and one in oats, and five were in potatoes and other vegetables. Thus only three per cent. of these injured fields reported were in small grain, while the general small grain acreage for the county was twenty per cent. of the whole additional evidence of the concentration of loss in corn and grass, as already mentioned.

The injury reported ranged from that characterized as little or slight to a total destruction of the entire crop, whole pastures being deadened, extensive meadows lying uncut, and no corn being gathered from fields of many acres. The general average of all the grades of injury on these sixty-eight reported fields was forty-six per cent.

As an example of extreme damage, mention may be made of a pasture tract of two hundred and twenty-five acres in sod for twenty years, the entire area of which was deadened except here and there a small patch. The roots of the grass were so thoroughly eaten away a little distance below the surface that the dead sod could anywhere be rolled up like a carpet. In another infested field twelve to fourteen grubs to the square foot were found, and in still another one hundred and twenty-seven were collected from twelve square feet. A dozen to fifteen were obtained from single hills of corn in a ninety-acre field, the crop on which was a total loss. Where injury to meadows and pastures was in comparatively limited patches, the grubs were of course the most abundant around the margins of such areas, where the grass was still partly alive.

Relations of Injury to Agricultural History of Land.—By a tabular arrangement and summarization of the facts reported it may be shown that the current supposition is correct that crops following upon grass are more liable to injury by the white grub than those on lands which have a different recent history. For example, on forty-two fields which had been in grass in 1894 the average injury by the white grub was reported at fifty-six per cent., while on nineteen fields which had been in grain in 1894 the average injury by the grub was twenty-eight per cent., or just half the above amount. On those which had been in grass for two years preceding, that is, for

1893 and 1894, the average injury was reported at fifty-five per cent., while on those fields where no grass had grown during these two years the crop injury by the grub was estimated at thirty-three per cent. Fields in grass and those not in grass for three years preceding (from 1892 to 1894) gave substantially the same percentages. The excessive tendency of the agriculture of this region to grass is illustrated by the fact that fourteen injured fields were reported by the owners to have been in grass for periods ranging from eight to forty years. These fourteen fields were damaged on an average to the extent of forty-eight per cent.

It has been a very common supposition among entomologists that the parent of the white grub lays its eggs mainly, if not altogether, in lands bearing pasture or meadow grasses, and that, consequently, crops on ground continuously in small grain or corn are not liable to this insect injury. It is now very evident, however, that under circumstances such as have lately prevailed in Christian county this supposition is erroneous. Seventeen of the fields reported to me had not been in grass since 1890, and yet damage to the crops of 1895 averaged in these fields, according to our reports, no less than thirty-five per cent. According to current accounts of the life history of the American white grubs, the oldest grubs in the ground in 1895 must have been hatched from eggs laid in the summer of 1893. Forty-two per cent. of the crops borne by three fields which were in small grain in 1893 and 1894 were destroyed by the grubs in 1895, while three fields in corn in these two years were reported injured in 1895 to the amount of twenty-seven per cent. The conclusion is thus unavoidable that where the beetles are excessively abundant, as in this badly infested region, they may, like the chinch-bug, multiply almost without reference to the crop on the surface at the time when the eggs are laid.

Clover and White-Grub Injury.—Interesting items concerning the relation of clover to the white grub are given in the notes of my assistants. In a pasture near Taylorville, where both clover and timothy were growing in the fall of 1895, the latter was very greatly damaged, but the clover presented no appearance of injury, this contrast being remarked on both the higher and the lower parts of the field. In some patches where the timothy was entirely killed, the clover was clearly unharmed, even the smallest roots being entire. Several clover fields in the vicinity gave no evidence of injury, although spots of blue grass in these clover meadows were often found infested with white grubs. In a town lot at Taylorville living clover plants were abundant in the smaller patches of dead blue grass, but in the larger areas the clover had been attacked and its roots cut off. This comparative immunity of clover is very probably due in large measure to the peculiar rooting habit of the plant. Even when the tap-root was girdled or eaten away, the smaller roots commonly remained uninjured, and served to maintain the plant.

Injuries as affected by Soil and Situation. It is quite apparent from the mass of the reports sent in that fields adjacent to woodlands, and especially woodland pastures themselves, were much more

generally and seriously damaged than those at a distance from forest trees. Indeed, there was considerable evidence to support the proposition that the intensity of the outbreak was in part to be accounted for by the unusual extent of woodland pasture grounds in this region, on which the grubs found always an abundant food in the turf, while the June beetles which give origin to them had likewise an abundance of food in the leaves of the forest trees still growing from the sod. Crops on high lands were, as usual, more subject to injury than those on low; and the loss was generally much more extensive and severe than it could otherwise have been because of a protracted midsummer drouth.

Species of Grubs Concerned.—The grubs collected by Mr. Hart on his visit to Taylorville and vicinity September 6, 1895, were apparently nearly all of the two extremely common species, *Lachnosterna fusca* and *L. hirticula*, the former commonest on lowland meadows, the latter on bluffy uplands. A few specimens of *L. gibbosa* were also seen.

Life History.—The life history of the white grubs as at present understood was given in my Seventh Report*, published in 1894, and no additional particulars of importance were obtained by the observations made in 1895. For the convenience of readers of this article, however, the statements in the report above referred to may here be summarized.

These insects hatch most commonly in grass lands (although frequently also in corn) from eggs laid there by various kinds of beetles, all commonly confused under the general name of "June beetles" or "May beetles" or "dor-bugs." These large, thick, short, snuff-brown beetles, a half inch to more than three fourths of an inch in length, nearly as thick from above downwards as they are wide, and about half as wide as long, are universally known because of their great abundance in May and June, during which months they fly at night, filling the air at dusk with their hoarse buzzing, and often invading lighted rooms in our houses, where they bump and bumble about, as awkward as frolicking cart horses. In this stage the insects are but short-lived, the males dying soon after the sexes pair, and the females living but a few days after they have laid their eggs in the ground.

The young grubs, hatching among the roots of grass or grass-like plants, commence to feed at once, and live in the earth in the larval stage for at least two years (so far as known), most of them changing to the dormant pupa from the middle of June to September of the second or third year after hatching, and becoming fully developed "June beetles" again, still in the earth, in August or in September of this same year. These beetles do not, as a rule, emerge from their earthen cells until the following spring, but spend the winter at rest, each in the underground cavity made originally by the grub while preparing to pupate. In May and June they come out and pair and lay their eggs as already related.

*Pages 109 and 115 to 122.

A single species (*Cyclocephala immaculata*) has a slightly different life history, the grub not pupating until spring.

The time and place of hibernation of the grubs have their special economic interest, since while in their usual winter quarters these insects are far beyond the reach of any agricultural operations. According to our most recent and general observations they begin to retreat from the surface in September, going gradually deeper with the advancement of the season, most of them being much below their usual feeding places before the advent of December. They bury themselves from a foot to a foot and a half,—and sometimes possibly deeper, remain here during the winter months, and come up from their winter quarters in March and April, the time of their movement varying.

Prevention and Remedy.—The simplest and most immediate measure for the prevention of injury by the white grubs is the pasturing of infested sod with pigs, a fact not by any means new, but substantiated abundantly by the observations of assistants and the statements of correspondents in the Christian county district. In badly infested fields herds of swine will fairly gorge themselves with grubs. One correspondent describes a field of blue grass and red top, divided by a fence for about three years preceding, on one side of which it had been pastured by hogs and cattle and on the other by sheep. No damage at all was done to the grass of the former plot, but upon the latter the pasture became worthless at harvest time, and about half the grass died, destroyed by immense numbers of grubs working about an inch below the surface. Chickens were also very active in destroying these insects, especially in small grassy lots near town.

It is clearly evident from the foregoing account that long continuance of the ground in grass is an invitation to agricultural injuries by the white grubs both to the sod and to the succeeding crops, whatever these may be. Especially is this true in woodland regions, where the beetles find an abundant food in the leaves of the trees, and the grubs an equally favorable supply in the adjacent sod. No natural or agricultural arrangement could be found or devised more favorable to the maintenance of these insects, and it is not at all surprising, consequently, that they should now and then reach the limit of possible destructiveness when such conditions are present. We see further from the foregoing discussion that small grains in rotation are a better protection against subsequent white grub injury than is corn, since the eggs of the June beetles are most likely to be laid in grass, next in corn, and less likely on the whole in any of the small grains.

The Christian county observations strongly emphasize my recommendations, previously made,* of the general use of clover in the crop rotation as a substitute for grass in regions liable to injury by grubs.

For a fuller discussion of preventive and remedial agencies the reader is referred to pages 127 to 132 of my Seventh Report (eighteenth of the series).

*Eighteenth Rep. State Ent. Ill., p. 128.

MIDSUMMER MEASURES AGAINST THE CHINCH-BUG.

Well-considered and successful artificial measures for the destruction of injurious insects are most commonly based upon an exact knowledge of the life history and habits of the insects themselves. The case is rare indeed in which such knowledge does not reveal a weak point during the course of the year which puts the insect enemy more or less completely at our mercy. Such a weak point in the history of the chinch-bug is its preference in spring for growing wheat, rye, and barley as food plants, and the consequent concentration, more or less complete, of the new generation in such fields of grain at harvest time. Few of the bugs having by this time developed wings, the mass of them are unable to fly, and are compelled, with the ripening of the grain, to leave the fields in which they were bred, traveling on foot in search of food elsewhere, and making their way most commonly into oats or corn adjacent. These facts long ago suggested to farmers what indeed is the oldest of all methods of attack upon the chinch-bug—the making of dusty furrows, impassable by small insects on foot, around the infested field of wheat, rye, or barley, or at least between such fields and threatened fields of corn beside them. The common method has always been essentially the same as one often used against the army worm—the making of a shallow ditch or furrow in the dusty earth by dragging back and forth a log through the plowed ground, continuing this procedure to arrest and destroy the bugs as they seek to escape from the small grain. They are commonly killed in such furrows by exposure to the heat and dust, or are mechanically crushed by the log, and, at any rate, are prevented from entering the field, because they are unable to climb the dusty slopes of the furrow into which they have fallen. This method requires, however, the constant service of a man and horse, and it is rendered useless by even so much as a gentle shower of rain, which, by packing the dusty surface, permits the bugs to cross the furrow freely.

A modification of this method, in which the dusty furrow is replaced by coal-tar poured in a slender line along the ground or smeared upon fence boards set upon edge, was introduced many years ago, first in McLean county, in this State,* so far as I have been able to learn. In this method the bugs are trapped by digging post-holes at intervals along the belt of coal-tar, into which they fall as

* See Second Report of Dr. LeBaron as State Entomologist of Illinois, pp. 146 and 147.

they move up and down the line in search of passageway, and where they may be readily killed. This method is a somewhat expensive one, however, since the coal-tar, exposed to the heat of the sun, dries out rapidly, and in bright weather must be renewed two or three times a day.

Another measure of defense is based upon experiments made by myself in 1882,* which demonstrated the extreme susceptibility of the chinch-bug to destruction by dilute kerosene-emulsion, a very simple mechanical mixture of kerosene and soap suds containing from three to five per cent. of the former, by which the bugs may be very readily killed, as they concentrate upon the outer rows of corn in fields which they are entering on foot. This kerosene-emulsion method also is expensive of both labor and time, especially if depended on alone, since the insecticide must be applied again and again, as the corn becomes repeatedly covered by the invading host, and the outer rows will, after all, commonly be sacrificed to the bugs even if promptly and thoroughly treated.

A combination of these methods described in full and earnestly commended in my last entomological report, that for 1893 and 1894,† gives, in my judgment, the most successful defence against the chinch-bug which has yet been devised. It must be understood, however, that the most thoroughgoing possible application of this combination method by only one here and there in an infested region, will protect a field from invasion only temporarily. If the insects are allowed to escape from other fields without interference they will presently acquire wings and scatter everywhere, infesting from that time forward all fields indiscriminately. It is only on condition that the bugs are *generally* arrested and destroyed as they attempt to escape from fields of small grain that the full and permanent benefit of this method will be gained.

The recommendations in the above report were based on experiments made by myself and my assistants on the Agricultural Experiment Station Farm at the University of Illinois in July, 1894, as described in full in the article in my entomological report just mentioned.

In an address to the Illinois Farmer's Institute, delivered at Springfield, January 8, 1896,‡ this description and recommendation were repeated with some elaboration, and further supported there by a brief account of some field experiments made under my direction in Effingham county, Illinois, by an assistant of this office in June, 1895. Some parts of this method were also used with great success by a considerable number of farmers near Georgetown, in Vermilion county, Illinois, late in June, 1896, as described in the weekly "Danville News" for July 2 of that year.

Similar and equally successful work was done in Kansas in 1896 by an interesting modification of this trap and barrier method.§

* Twelfth Rep. State Ent. Ill., pp. 59-63.

† Pages 1-15.

‡ Rep. Ill. Farmers' Inst., 1896, pp. 108-110.

§ 5th Ann. Rep. Dir. Exper. Station, Univ. Kansas, pp. 45-47.

The great importance of making widely known to farmers the ascertained facts concerning the utility of this most valuable and reliable of all known measures of contest with the chinch-bug, and of substantiating the statements concerning it by detailed accounts of practical experiments, will justify still further discussion of it in the light of our latest experience.

My experiments in 1894, although made in the field, were on too small a scale to afford convincing evidence to all of the usefulness of this method as applied on the scale of ordinary farming operations. To find opportunities for a more extensive procedure it was necessary to go some distance from Urbana, since the amount of chinch-bug injury there was insufficient to permit a convincing test of measures for their destruction. On this account an Assistant of the office, Mr. W. G. Johnson, was sent in July, 1895, to Effingham county, Illinois, with instructions to select one of the worst infested fields of wheat in that badly infested region, and to carry on a continuous and energetic contest with the chinch-bug around the borders of this field by the trap and barrier method and by the use of kerosene emulsion to destroy such of the chinch-bugs as might escape to adjoining fields of corn. The barriers used were to be the dusty furrow, with post-holes dug at intervals as traps, and a coal-tar strip, similarly reinforced with post-holes.

After considerable search in the vicinity of Edgewood, a field was chosen June 4 which answered the conditions admirably, and arrangements were made for a commencement of operations. A twenty-acre field of winter wheat on the farm of William Quade, three miles northwest of Edgewood, had been so badly attacked by chinch-bugs that the wheat was already largely killed. South of it lay a field of corn four to six inches high, extending its whole length, but separated from it by a bare strip of mellow earth about two rods wide, on which Hungarian grass had failed owing to the drouth. North of the chosen field of wheat was a field of oats, east of it were oats and meadow grass, and west of it a country road. Both wheat and corn were free from grass and weeds.

The chinch-bugs in the wheat were nearly all young, in stages one to three. A few adults of the hibernating brood remained, and some of these were even yet engaged in laying their eggs, but most of them had perished, multitudes of their dead bodies being profusely covered with the so-called white muscardine fungus, *Sporotrichum globuliferum*.

Experimental operations were carried on here continuously from June 5—when the first furrows were made—until June 15. The weather of the season was extremely hot but somewhat variable, running June 3 to 104° Fahr. in the shade; and June 8, to 96° in the open air and 116° in dust exposed to the sun. On the 10th a temperature of 99 Fahr. in the shade was noted at four o'clock p. m.; and on the 11th, 92° at three o'clock p. m. Light rain fell June 4, and a heavy rain on the 11th, the latter wetting the earth about two inches deep. On the afternoon of the 12th a very heavy, dashing rain fell for three quarters of an hour, filling the field ditches, and

soaking the earth to a considerable depth. Except as the temperature was reduced by these rains there was no cool weather during the progress of the experiment.

The measures used in these fields were such as to determine quite fully, under these conditions of season, weather, and situation, the effect of the ordinary farmers' practice of hauling a log back and forth in the dusty earth, the value of a simple dusty furrow exposed to the sun as a protective and destructive agency, the conditions under which post-holes must be used with such a barrier, the usefulness of the coal-tar and post-hole barrier when the weather forbids the use of cheaper expedients, and the cost of field work with kerosene emulsion applied to infested hills of corn along the edges of a field. All these methods, it is true, had been provisionally tested by my experiments of 1894, already referred to, but this work of 1895 served to verify the results then reached by work in the field with methods and expedients available in ordinary farm practice.

Experimental Details. The following details of experimental work and results are abstracted from the field notes of the Assistant in charge of the Effingham county experiment.

By June 5 the bugs had begun to move on foot from the infested wheat across the fallow strip between that and the corn, and had already penetrated the latter in one place opposite a deadened patch of wheat, completely covering the young corn plants over a space four or five rods long and three corn rows deep. To arrest this movement the fallow strip was thoroughly harrowed and rolled, and a furrow was made in it by dragging a log, six inches through and six feet long, back and forth the whole length of the field, a distance of forty-eight rods. The dusty furrow thus made was kept in good condition by repeating this process once in four hours during the day, a single horse ridden by a boy furnishing the motive power. This method was tested by three days' use with very good results, few of the bugs crossing the barrier and many of them being killed.

June 8 the ground was more thoroughly pulverized by hauling over it a wooden sled turned bottom upward, and a more dusty furrow ten or twelve inches deep was made by using a block fourteen inches through. In this the now highly active young bugs rapidly collected in immense numbers, completely reddening the earth in the bottom and sides within a few minutes after the furrow was made. The heat of the sun on this dusty earth (116° Fahr.) was deadly to the young bugs, killing them after a few minutes' exposure, and not one of the myriads tumbling into the furrow was seen to escape from this deadly trap. They began to die, in fact, when the temperature of the dust reached 110° Fahr., an observation agreeing very closely with my own of the year preceding, when 108° was recorded as a fatal heat. This surface temperature was reached with the thermometer at 87½° in the air. (See Nineteenth Report, page 10.) At 119° surface heat young bugs in the first and second molts lived but a few seconds.

To prevent the escape of the chinch-bugs from the wheat in other directions similar furrows were made on the other three sides of the wheat field, with greater difficulty, however, than in the bare strip between the wheat and the corn, owing especially to the straw in the earth where the wheat was plowed under at the edge of the field. Fairly good furrows were finally made, and very few bugs escaped.

Owing to the intense dry heat of this period post-holes in the dusty furrow were of course unnecessary. They would, indeed, have been a disadvantage as affording a protection against the sun and giving the bugs accumulating in them a possible opportunity to escape in the cooler part of the day. When the temperature is lower, however, and the weather dry, post-holes or cans sunk in the furrow are indispensable as a means of accumulating the chinch-bugs where they can be killed by coal-tar or kerosene. These facts were well made out in 1894, and post-holes were used along the furrow in 1895 only after a light rain which partially destroyed the efficiency of the barrier previously made.

A very heavy rain having fallen on the afternoon of June 12, filling the ditches to overflowing and thoroughly soaking the earth, the bugs entered the field freely during the two following days, completely covering the corn to a depth of about four rods along the edge of the field, and penetrating in some places as far as ten or twelve rods from the border. June 15 a line of coal-tar was put upon the ground between the wheat and the corn from an ordinary garden sprinkling pot from which the sprinkler had been removed. The orifice of the spout was narrowed with a plug of wood until the tar came out in a stream about the size of the little finger, making a line upon the earth about three fourths of an inch in width. Post-holes were then sunk along this line on the side next to the wheat at intervals varying from ten to twenty feet. The barrier thus formed was practically complete. The chinch-bugs being unable to cross the coal-tar line, accumulated in vast numbers in the holes, where they were destroyed by pouring in a little tar. The further spread of the bugs in the corn was arrested by additional tar lines between the rows, the infested corn itself being presently cleared by the use of the kerosene emulsion. In this field the tar was run in a zigzag manner, the post-holes being dug in the angles of the line. This is an unnecessary addition to the expense, however, more tar being used than was required. A somewhat more economical procedure when time will permit would be to dig the line of post-holes first and to extend the coal-tar belt from one hole to another, running it a little over the edge at each side of the hole to prevent the passage of the bugs around the ends.

The general effect of the Effingham procedure above described was to protect the corn and other crops adjacent to the field of wheat (itself so badly infested as to have been completely destroyed) except so far as the corn was entered before the beginning of the experiment and at the time of the heavy rain of June 12, when the tar was not at hand for use. Even these infested portions of the field were saved by the kerosene emulsion, as described. By selecting an aver-

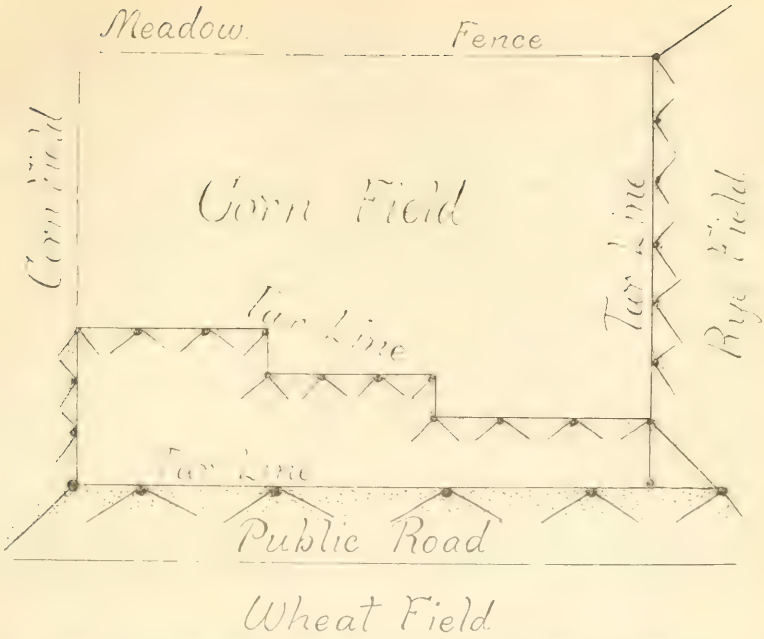
age part of the furrow around the field and carefully collecting and measuring all the chinch-bugs accumulated in it, it was determined that the entire mass of bugs killed in this ten days' contest would measure not less than twelve bushels. Taking into account the fact that these were the first generation of the year, and that if they had lived they would have bred a second generation in the corn, and the further fact that each female chinch-bug lays a hundred eggs or more, it will be seen that an important benefit to this farmer and to the owners of adjacent fields was done by this work. This place was, in fact, visited in the fall of 1895 by Professors Burrill and Davenport, of the University of Illinois, and by them the report was made that Mr. Quade grew a full crop of good corn in the protected field adjacent to this wheat, all of which he owed to our experimental operations, and that other corn fields on his place, not so protected but exposed to invasion by chinch-bugs from other fields of wheat, were almost completely destroyed, some of them averaging not more than two or three bushels per acre of very poor corn. It should further be said that the expense of the work done in and about this field of wheat in this contest with the chinch-bug was less than $5, omitting, of course, traveling expenses and the cost of materials not used, and taking no account of the value of the labor of the owner of the land. *In short, the success of this field experiment, tried under very difficult conditions, was substantially complete, and the value of this method of contest with the chinch-bug seems established beyond controversy.*

The Georgetown Campaign.—In the vicinity of Georgetown, in Vermilion county, in June, 1896, a number of farms were heavily infested with chinch-bugs which came out of the wheat and rye at harvest time and accumulated as usual upon the lower parts of the stalks of corn. The owners of these farms undertook a determined contest with their insect invaders for the preservation of their corn, using only the coal-tar and post-hole barrier, with some slight modifications. The ground was prepared for the coal-tar line by hitching a team to a heavy plank and running this over the ground once or twice, weighted with three or four men, until a smooth, hard surface had thus been made to receive the tar. Or, if the barrier was to be made in sod, a furrow was plowed and the plank was dragged in the bottom of the furrow to pack and smooth the earth. Either before or after the tar lines were run, post-holes, cans, or jars were sunk close to it at intervals of a few feet. Leaders or switch lines of coal-tar were in some instances laid to these holes or cans, as shown in the diagram on the next page.

The scene of these operations was visited by the editor of the "Danville News," from whose interesting report this account is condensed. "Care must be had," he says, "to the following details:"

"1. Make the ground smooth.

"2. Look over it often for breaks, or any blade or article that may fall across the line, or for cracks in the ground. The bugs cross even on a stalk of grass that lies across the tar line.



"3. See that jars and cans are a little below the surface of the ground and that dry dirt is kept around their edges and also around the edges of post-holes, for the bugs tumble in more rapidly on dry loose earth.

"4. See that bugs cannot go between holes, cans, or jars, and main tar line, but are forced to fall in as they crowd into the little angles.

"5. If cans or jars are used, fill a third full of coal oil and water mixed about half and half. Coal oil kills the bugs, but water will not.

"6. Those using the tar say that they freshen the lines about twice or thrice per day. The bugs crawl most from about 11 a. m. to 4 p. m.; if the sun is hot they crawl earlier.

"7. If you have not time to make post-holes or sink cans, you can dig holes two or three inches deep along the lines with spade or hoe, and not run any angles from them, and they will soon fill with bugs. Destroy these by sprinkling with coal oil, using a little broom or brush of broom-straw or grass.

"8. If you use post-holes, part of the bugs will crawl out unless you cut a little trench around the hole about half way from bottom and fill trench with tar. When holes fill up to tar in that trench pour coal oil on them. You needn't burn them in holes, as the coal oil kills them."

The general reports of the result of this procedure were highly favorable. On one farm of two hundred and fifty acres a coal-tar line ninety rods long was renewed once a day, and killed daily about

eight gallons of bugs. The corn adjacent was doing very well indeed. Four men were employed in laying out the lines; and a man and a boy were sufficient to keep them in working order and to kill the chinch-bugs. On another farm near by several gallons of bugs were being killed every day. One farmer in this neighborhood had three hundred rods of the tar lines, with post-holes, cans, etc., trapping by this means about ten bushels of bugs—a six-gallon jar full—in less than half a day at one point on the line. Although he freshened his lines from one to three times a day he did not use a barrel of tar. Another, who had one hundred and twenty rods of coal-tar line, which he renewed three times a day where necessary, did not lose a hill of corn, although he caught chinch-bugs by the bushel. He used about a third of a barrel of tar.

A modification of the method described in this article is the placing of the coal-tar line on a ridge made by throwing two furrows together and packing with a roller. This has the advantage over a trench that rain does not wash the dirt down and cover the tar.

Kansas Method.—The following is a description of the barrier method of arresting the progress of the chinch-bug and destroying it at the borders of the field. It is taken from the Fifth Annual Report of the Director of the Experimental Station of the University of Kansas, pages 45–47.

"The plan found most effective was that of turning a double furrow with a plow and thus forming a ridge and putting the tar, etc., on top of this ridge. On the side of the ridge next to the small grain, post-holes were dug, broadening toward the bottom, about 100 feet apart. The bugs were retarded in their march by the ridge, and being repelled by the tar, etc., would swarm along the ridge, and in so doing would crowd each other into the post-holes. In some cases, when the holes were nearly filled with bugs, dirt was thrown in and packed down; in others a little petroleum was poured. Both methods were effective in killing the bugs. It was found that where the holes were deep the bugs died without any special effort to destroy them.

"After the ridges are thrown by the plow it is best to smooth and pack down the top and sides somewhat, in order to keep the tar, etc., from sinking in deeply and to protect the ridge from too great washing away by rains. This process was necessarily slow and tedious by hand, and to obviate this a drag with a concave bottom of the form of the ridge was made, and when weighted with rocks or dirt and drawn by horses over the ridge it did very effective service, saving a vast amount of time and doing the work better than could be done by hand. The bottom of the drag was found to scour much better when covered with sheet zinc.

"Coal-tar as it comes from the gas works, crude petroleum as taken from the oil well, and kerosene oil mixed with salt* were used on the ridges. These substances are offensive to the bugs, and they seldom attempt to cross them or even to come close enough to touch

* This mixture was found ineffective as a check to chinch-bug movements in some experiments tried at my office and described on page 43 of this report.

them, but on approaching these offensive substances the bugs turn and run along the ridge in the evident hope of finding a gap through which they may pass.

"Coal-tar is the best of the substances named in that it stands on the surface better and is not so readily washed away by rains. However, crude petroleum and kerosene are very efficient and are more generally available than the coal-tar. The coal-tar can be easily applied by means of an old tea-kettle, sprinkler, or coffee-pot. The stream poured upon the ridge need not be more than half an inch in diameter, and when of this size the operator should walk rather rapidly in applying it. * * *

"It would be well to form the ridge for the barrier a week or two before it is needed. (Ridges formed last summer by Mr. Marcy's drag were in excellent condition after having withstood the heavy, beating rains of July and August.) Then the tar, kerosene, etc., may be spread at a moment's notice and the post-holes dug. After the barrier is formed, it should be inspected daily and kept in good repair. This will not require much time, and should not be omitted. Perhaps no other repair will be necessary than the addition of a small amount of tar, kerosene, etc. If the small grain has been harvested and the bugs are all moving at once into the corn they may be trapped and the necessity for vigilance is soon over; but if they are coming more slowly from the ripening grain the barriers must be kept up a few days longer.

"The results of this method of combating chinch bugs were well shown by experiments in the wheat field. The bugs were noticed early in this wheat, and just before harvest and before the bugs had migrated to the corn, the ridge was thrown up, coal-tar was applied, and the post-holes dug. The bugs which collected and died in the first few holes were taken out and piled near the holes in great quantities. Only a few bugs escaped, and no damage was done to the corn.

"In another case, the bugs had left the wheat and had advanced about fifty rows in the corn, destroying it utterly as they advanced. * * * Then the ridge was thrown up, tar was put on, and post-holes dug. The result was that the bugs were caught and died in the holes, so that the corn suffered no further injury. These two instances demonstrate the value of the barrier method described above. * * * If the ridge is not formed and the offensive substances are simply spread upon the ground, the bugs, when in great numbers, crowd each other across the barrier, those in front being unwillingly carried forward by those behind; or, if the post-holes are omitted, the bugs are not destroyed, and manage finally to struggle into the corn field after the barrier has become damaged by the weather.

"The barrier method has the advantage of not being dependent upon a complexity of conditions for its success, and of giving immediate results. It has the disadvantage of being only applicable at the very short time when the bugs are migrating from one field to another. It cannot be used upon bugs already scattered through the small

grain or corn fields. But this disadvantage is largely done away with if the farmer is provided with the necessary material, and watches his fields so as to be able to make the barrier at the critical time. The wisdom of using the barrier hardly needs argument. When the farmer has worked two or three months on his corn field, he would hardly grudge two or three days' labor to save the profits of his season's work from being wiped out by chinch-bugs."

EXPERIMENT WITH KEROSENE AND SALT, AND OTHER REPELLANTS.

In the Kansas report above quoted, and in letters likewise from my correspondents, recommendations have been made of common salt saturated with kerosene and of crude petroleum as materials suitable for use in place of coal-tar in the construction of barriers against the movements of chinch-bugs. Desirous to test these recommendations experimentally, I made arrangements in June, 1895, for a field experiment with them on the Agricultural Experiment Station farm at the University of Illinois. June 27, twelve and a half pounds of salt were saturated with a quart of kerosene, and the mixture was scattered along the ground between the field of wheat and corn immediately adjacent just after the wheat was cut. About four pounds of salt were used to the rod, making a ridge two inches wide at the base. The same quantity of salt without kerosene was used in the same manner, and crude petroleum was put upon the surface of the ground on another place, making a line about two inches wide. On still another portion of the boundary line between these fields coal ashes mixed with a little dry earth were saturated with crude petroleum and used to form a ridge about two inches wide and three rods long at the edge of the wheat field. The chinch-bugs passing from the wheat to the corn paid not the slightest attention to any of these barriers except the kerosene and salt, running across them without hesitation and without injury. Concerning the salt and kerosene mixture the assistant in charge of the experiment (Mr. Johnson) says: "The chinch-bugs were running in all directions and the salt and kerosene at first seemed to check them, but they ran into it and over it, some seeking shelter under lumps that were lying on the ground. I could not see that it was any more of a barrier than a similar ridge of hard earth. The kerosene, no doubt, is not altogether agreeable to them, but does not form a barrier that will check their advance."

A STUDY OF THE CAUSES OF THE DISAPPEARANCE OF A CHINCH-BUG OUTBREAK.

One of the most strongly marked and important features of the economy of the chinch-bug is the enormous variation in its numbers in any given locality from year to year. Increasing in a maximum ratio of over one hundred per cent. in each of its two annual generations, its injuries may rise in three or four years, under favorable conditions, from utter insignificance to the proportions of an agricultural calamity. Such outbreaks commonly disappear, however, more rapidly than they develop, the wave of increase sometimes receding, as in Southern Illinois in 1887, from its highest to its lowest level in a single year. The causes of this rapid decline in the numbers of a destructive chinch-bug horde are too little known as yet to permit us to recognize them with certainty when they appear, and this irregular variation in numbers makes the farmer uncertain what to expect from the chinch-bug in any year, thus, preventing, as a rule, all intelligent adjustment of plans and methods to the probabilities of the season. If the damage done by this insect were equally distributed in time, or if its periods of increase and decrease had any calculable regularity, or if either the rise or fall of the wave were commonly preceded by any recognizable sign of the event, preventive measures might be very generally taken; but, as it is, the average farmer in the region most liable to attack prefers to speculate on the uncertainties of the future, taking his chances year after year with about the same procedure which he would use if there were no chinch-bugs in existence. The final loss thus falls upon him and upon the agriculture of the State almost without mitigation, for remedies effective after an attack has begun are very few and but little used. It is a matter of considerable consequence, therefore, that the causes of the recession of this wave-like movement of chinch-bug reproduction be thoroughly investigated, at least so long as there is any hope remaining that a full knowledge of them would enable us to foresee with some definiteness the probabilities of the season or of the coming year. So long, furthermore, as we can believe that there is the least chance that any of the natural checks upon the increase of this insect may be brought under our control, and used at will for the reduction of a destructive outbreak, or for the local defense of endangered crops, we are not at liberty to abandon investigation as hopeless, or to remit in the least our efforts to learn the full and precise truth.

For the purpose of getting precise evidence with respect to the causes of the natural and normal destruction of chinch-bugs leading to the disappearance of an outbreak, I set on foot in 1896 a considerable series of field observations and laboratory experiments. The field observations were to be made at frequent intervals throughout the entire season in several localities where the chinch-bug was suffering diminution of numbers from natural causes, and the laboratory experiments were planned to test the precise action of such causes as were already known or suspected to operate, as well as any others which might be suggested in the course of observations in the field.

The known or supposed natural causes of a considerable destruction of chinch-bugs are midsummer heat, exposure to winter cold, wet weather, scarcity or unsuitable character of food, and contagious or epidemic disease. Insect parasites and other animal enemies are not here taken into account, because in all the observations upon this insect made during a hundred years, nothing has been seen to warrant the supposition that these animal agencies have any effect of agricultural importance upon the numbers of chinch-bugs.

An investigation into the causes of these phenomena is really a study in the field of entomological œcology; that is, in the relations of insects to nature and the effects upon their economy produced by natural agencies. It is a much more extensive and complicated subject than would at first appear, as may be seen from the following list of subordinate problems requiring solution.

The destructive effect of wet summer weather has been known almost from the beginning of knowledge on this subject, but the method of its action has never been made out with any precision.

1. Does it destroy chinch-bugs directly or indirectly? If directly, does it take equal effect upon bugs of all ages, and how does it affect the egg?

2. What kind of rainfall is most destructive: brief but violent storms, or slow, soaking, long-continued rain?

3. Does the temperature at the time of the rainfall have anything to do with such destructive effect of wet weather?

4. Are the chinch-bugs drowned by rain, or are they merely washed from their food, imprisoned in the mud, etc.?

5. Is it possible that they are sometimes simply dispersed and scattered by flooding rains, thus giving a fallacious appearance of destruction?

6. If wet weather acts wholly or in part as an indirect agent, does it serve to stimulate or occasion disease, and is such disease contagious or not?

7. If it promotes the appearance and spread of epidemic or contagious disease, then what disease does it so promote, and what other conditions, if any, conspire with it to produce or intensify this effect?

8. Does it possibly act, to any important degree, by checking the multiplication of chinch-bugs, either by preventing the re-

peated copulations which seem necessary to the fertilization of the eggs, or by checking or preventing the development of eggs in the ovary?

9. May it possibly act in part by diluting the sap of the food plants, rendering this sap comparatively innutritious and thus reducing the vigor of the bugs in a way and to an extent to diminish their reproductive capacity or to make them more likely to succumb to the attacks of fungus parasites and other causes of disease?

10. Is a wet winter unfavorable to chinch-bugs, and, if so, why?

11. Are the bugs ever killed in the field by heat, and does a moist heat act more or less efficiently than an equal temperature when the air and earth are comparatively dry?

12. May a midsummer drouth become so intense and long-continued as to affect the chinch-bug unfavorably, and, if so, how is the unfavorable effect brought about?

13. What is the limit to midsummer heat, moist and dry, to which the chinch-bug is actually exposed? That is, what is the maximum temperature of the surface on which it is found in the hottest weather of the year, both in times of drouth and shortly after rains?

14. Do the bugs live equally long and lay equal numbers of fertile eggs whatever may be the food plant to which they are limited? Do they live as long and breed as rapidly on oats and grass, for example, as on wheat and corn?

15. Are there any conditions of the food plant, such as thrifty growth or the reverse, which affect the longevity or reproductive activity of the chinch-bug?

16. Are any of the efficient causes made out to be finally traced back to peculiarities of soil or climate or agricultural management; or does the complicated assemblage of causes and conditions which govern the geographical distribution of insects have any important bearing upon our problem?

17. What are the known contagious diseases of the chinch-bug, and how is their presence to be recognized by the expert and by the ordinary observer?

18. What are their relative values as agents of destruction?

19. What observations have been made pointing to the existence of other diseases not yet certainly known?

20. To what parasitic organism are the known diseases to be respectively attributed, and what are the life histories of such organisms?

21. Are they completely parasitic in habit, or only partially and occasionally so; that is, are they true or "facultative" parasites?

22. If true parasites, are they always injurious, or do they become so only under special conditions?

23. Are they capable of artificial cultivation on inanimate substances and under conditions which make artificial cultures economically available for their distribution to insects?

24. Does repeated artificial cultivation in any way diminish their virulence as parasites?

25. Are all stages of the insect equally subject to their action, particularly, may they infest the egg?

26. What are the conditions, favorable and unfavorable (maximum, minimum and optimum temperatures, and the like) to their propagation and continuance among chinch-bugs?

27. How are they propagated in nature, and how and where are they preserved under unfavorable external conditions, or during intervals of quiescence of the disease?

28. Is it possible that the spread of these diseases in the field may be arrested by heavy flooding rains which may have the effect to carry away the spores and to bury dead and fungus-covered bugs in the earth?

This is an illustrative, but not by any means exhaustive list of the questions which press upon the attention of the serious student of the relations of this insect pest to the agriculture of interior North America, answers to most or all of which are necessary before we can say finally and with the authority of positive knowledge what can or can not be done by way of relief.

A number of these questions have been answered partially or fully in my earlier Reports, beginning with the first (the Twelfth from this office, published for 1882). In the various articles of these Reports information will be found showing the unequal effect of wet weather upon chinch-bugs of various stages, including the egg; the effect of violent and flooding rains to scatter and disperse these insects; the effect of rains to promote contagious diseases, especially those due to Entomophthora and Sporotrichum; the injurious effect of intense and protracted summer heat on bugs of all ages; the occasional injurious effect of long protracted midsummer drouth; the effect upon the numbers of these insects of various schemes of cropping and methods of agricultural management; together with a considerable mass of matter relating to all known contagious diseases of the chinch-bug and their practical application in the field. It must be said, however, that the data for complete and conclusive answers to scarcely any of the foregoing questions as yet exist. Field observations of a close, continuous, and thoroughly intelligent character, and field experiments likewise, carried out by the precise and persistent methods of our best agricultural experiment stations, are especially to be desired, and can hardly fail to contribute to knowledge in whatever direction they may be made.

The field observations of 1896 here reported and discussed were made by three regular Assistants of the State Laboratory of Natural History, B. M. Duggar, W. G. Johnson, and W. A. Snow, and by H. O. Woodworth, temporarily engaged for the purpose. The labora-

tory experiments were made chiefly by Mr. Snow and myself. Notwithstanding the number of persons engaged upon this work, its unity and uniformity throughout the season were very well maintained by precise directions to each observer and by a systematic supervision of its progress.

The regular observations and collections, beginning April 14 and ceasing October 5, were distributed over selected points in five counties, all on the line of the Illinois Central railroad from Champaign southward; and the same points—in most cases the same fields—were visited on each trip. These stations of observation were Tamaroa, in Perry county; Odin, in Marion county; Edgewood, in Effingham county; Mattoon, in Coles county; and Urbana and Mahomet, in Champaign county, the extreme stations of the series being about one hundred and fifty miles apart from north to south. This selection proved fortunate, on the whole, as the different stations resembled each other closely enough to make it possible to compare results to advantage, and yet each had a distinctive character of some importance to our purposes. Tamaroa, Odin, and Edgewood are all in the agricultural region commonly known as Southern Illinois, but differ considerably in soil and surroundings. The country about each was originally prairie, with a light-colored soil containing much clay and comparatively little vegetable mold, and winter wheat is a leading crop. Mattoon and Urbana are in the black paririe region of Central Illinois, and little wheat and much corn are raised in their vicinity; while Mahomet, although in Champaign county, is in a district of clay soils, originally woodland, near the Sangamon River, where winter wheat is much raised. At the four wheat-growing points, the chinch-bug was very much more abundant than at the other two, and in all it was almost completely concentrated in early spring in fields of growing wheat and rye.

The weather of the season was rather unusually wet throughout the whole district, and in very marked contrast to the extreme drouth of the years just preceding; but the rains fell in showers and in rather violent storms of comparatively short period, sometimes with intervals of considerable drouth between. For detailed accounts of the rainfall and temperature at the points visited which are embodied in this paper, I am indebted to Mr. Charles E. Linney, Observer and Section Director of the Illinois Section of the Climate and Crop Service of the Weather Bureau of the United States Department of Agriculture.

The field observers were instructed to search the selected fields carefully on each trip, and to make full notes on the weather at the time; on the number and distribution of the bugs; on the relative number in each age or stage; on evidences of contagious diseases in the fields and on the ages of the bugs principally affected by them; on the direct action of weather, and particularly of rain, in the destruction of bugs, young or old; and on the comparative numbers of the various ages as observed on successive trips to the same place. They were also expected to bring to the laboratory collections of dead and

living chinch-bugs in considerable number, the former for careful examination with reference to the possible causes of death, and the latter for continuous observation at the laboratory and for experimental use in determining the rate of death, the causes thereof, the stages in which deaths were occurring, and other matters of kindred interest.

The living specimens thus brought in from time to time were kept under conditions as nearly normal as many years' experience enabled us to supply, and the dead were removed from each collection day by day, those whose bodies gave no obvious clue to the cause of death being commonly placed on moist sand under conditions to promote the external development of any infesting fungus to whose attacks they might have succumbed. It scarcely need be said that these collections were carefully watched and laboriously searched with the microscope for evidences of disease other than the two contagious diseases definitely known to prevail among these insects.

THE DISTRICT AS A WHOLE.

Taking the district under observation as a whole, it appears from the data herewith presented that the bugs began to leave their winter quarters about the middle of April, and were generally distributed to their breeding and feeding grounds—mainly in wheat and rye—by the end of that month, laying of eggs beginning before the first of May. The eggs began to hatch about the middle of that month, by which time also the hibernating adults were dying (most of them probably in the normal course of events). In some cases by the end of May, and in others not till the middle of June, these old adults had practically all disappeared. Deaths in winter quarters varied greatly, from twenty-five per cent., as at Urbana, to almost nothing, as at Odin.

The common fungus of white muscardine was everywhere present in winter quarters and among the earliest bugs to infest the wheat, in small quantity, it is true, but apparently always sufficient to furnish a start for the rapid development of this fungus if conditions, meteorological and other, should become favorable to its germination and growth. The green muscardine, on the other hand, was not observed in winter quarters anywhere, and appeared in the fields later than the other, usually not until June. At Urbana, however, both first appeared together about the middle of May. Both these fungus parasites were powerfully affected by the weather, evidently requiring a moist atmosphere for their growth. I saw nothing in our observations and experiments to indicate that one is any more virulent as a parasite than the other,* although we have no evidence that the fungus of green muscardine (Entomophthora) will take its start upon the insect body already dead. The white fungus, on the other hand, grows much more readily on the freshly killed chinch-bug than on the living. Both muscardines were most abundant in the fields, with the exception of the Mahomet neighborhood, where the adults of the

* See here especially the dissections reported under *Odin*, July 6.

hibernating generation were generally perishing. The only extensive and important epidemic of contagious disease observed was that at Mahomet, where the green muscardine affected for a time in July fully ninety per cent. of the chinch-bugs in the field. Observations made in that month also hint at, but do not demonstrate, the presence of a bacterial malady.

There is no doubt of the destruction of a large number of young chinch-bugs by violent flooding rains, especially such as may wash them down into the mud. Eggs are probably thus destroyed in even greater numbers, the young hatching from them in the mud being unable to make their escape; and the facts justify the suspicion that very wet weather tends in some way to diminish the reproductive activity of the adults. Death by immediate drowning, even by long-continued rains, was not clearly proved by these observations. On the other hand, it was not disproved, but it is rendered practically certain by laboratory experiments described in my Eighth Report as State Entomologist, that for 1893 and 1894 (pages 178 and 183), by which it was shown that newly hatched chinch-bugs cannot withstand submersion much over two hours as a rule; that those of the second molt may begin to die within five hours and will practically all perish within nine; that even pupæ may be drowned by eight hours' submersion, others living for at least thirteen hours, and that some adults at least will be killed by twelve hours' continuous submersion, although some may survive nearly twenty-four

Fuller details of our observations and experiments are herewith given, first under a summary statement for each observing station, and, following this, in a detailed abstract of field and laboratory notes.

SUMMARY STATEMENT FOR EACH OBSERVING STATION.

At Tamaroa the chinch-bugs were already out of their winter quarters by April 27, and concentrated mainly in fields of wheat, in which they were very abundant. The ground here was well stocked with eggs, but few or no young had yet appeared. The common fungus of white muscardine (Sporotrichum) was everywhere present in small quantity on chinch-bugs and other dead insects. Repeated heavy rains in May and June were followed by some increase in the number of these fungus-covered chinch-bugs, and green muscardine (Entomophthora) also appeared among them in a small way early in June. The number of eggs and young was very much smaller as the season progressed than the heavy attack upon the wheat in spring gave reason to expect. Some of the young were certainly killed directly by the rain, which washed them off their food plants and imbedded them in the mud, and doubtless a very considerable proportion of both young and eggs were thus effectually disposed of A few adults of the hibernating generation were still alive and breeding May 28.

The number appearing upon the outer rows of corn after wheat harvest was here so small as to indicate an enormous destruction of the progeny of the hibernating generation, or a very general diminu-

tion of reproduction by the adults at the time of the heavy rains. In fact, the number of dead actually seen by the observers in this district seems insufficient to account, even on the most liberal interpretation of the facts, for all this apparent diminution.

Certainly there was no good reason to suppose that contagious diseases had any very important share in the destruction of the chinch-bug at this place. This was shown not merely by field observations, but likewise by our laboratory experiments, in which a hundred and five dead bugs placed under conditions to develop the fungi of muscardine gave only one case of a fungus parasite (*Entomophthora aphidis*). An attempt to infect chinch-bugs' eggs with this fungus failed completely.

July was rather dry until the 19th. Among a thousand dead placed at this time on moist sand, less than fifty exhibited any parasitic fungus growth, those with white muscardine (Sporotrichum) being three times as abundant as those with green (Entomophthora). On the other hand, a very large number of these chinch-bugs when so treated underwent a peculiar decomposition, indicating beyond doubt the presence of a bacterial infection—whether septic or pathogenic originally it is impossible to say. In a collection of such insects taken from an observation box at the same time (all of which had died within twenty-four hours) and placed on moist sand together in a Petri dish, a large percentage became swollen and soft, with whitish or greenish abdomens which presently burst, exuding a creamy or slightly discolored fluid swarming with various forms of bacteria. Most of the others remained without notable change.

A considerable amount of microscopic study of the decomposing specimens resulted in no discovery of any common character of the fluids, or of any single bacterial species which could be even hypothetically connected with their death, and the meaning of these phenomena consequently remains obscure. They doubtless deserve further investigation. In this connection I may refer to the dissection of a dead chinch-bug from Tamaroa, made July 8, and described under that date in the detailed abstract of field and laboratory notes, on another page.

A still further marked diminution in the number of chinch-bugs followed upon very heavy rains July 19 and 20, many freshly dead adults being noticed at this time between leaves and stalks of corn. Only a few of these were clearly dead with fungus disease, and the cause of death of the others was not apparent. They were quite possibly killed by drowning.

The condition of these fields in August was not materially changed. Chinch-bugs continued to die, adults predominating, some exhibiting growths of white muscardine after death, but the greater number not.

At Odin the situation and the succession of events were not materially different from those at Tamaroa, except that some of the fields regularly visited were those in which muscardine experiments

had been conducted the previous year, and where there was consequently a considerable presumption that this disease would be pronounced in 1896.

At the middle of April chinch-bugs were still in their winter quarters, with only a little early scattering to wheat. Very few had died in hibernation, a condition in quite decided contrast with that found at Urbana in March. Traces of white muscardine occurred in these hibernation resorts and also in the latter part of the month among the bugs in wheat and rye, to which by this time they were generally distributed. By the end of May the hibernating adults were largely dead, and many of them were covered with Sporotrichum which was clearly more prevalent here than at Tamaroa under similar conditions. A few dead young were also noticed here imbedded in mud after rains. There was no very great number of chinch-bugs in June either in oats or corn, and only a small amount of Sporotrichum and Entomophthora was demonstrated by laboratory experiments with collections brought in. Of one hundred and five dead specimens placed on moist sand for a development of their fungus parasites, three grew Sporotrichum and four Entomophthora, and ninety-seven gave no evidence of parasitism. Entomophthora apparently increased somewhat, however, in the early part of July, both that and Sporotrichum, but especially the latter, during the latter part of this month. Thus of the ninety-three dead specimens placed on damp sand, twelve developed Entomophthora and twenty Sporotrichum within one to four days. Extremely heavy rains July 19 seemed greatly to reduce the number of bugs in the corn, and this without any apparent increase, but a diminution rather, of the muscardines. A few dead young were seen later in this month covered with white muscardine fungus, but with the dry weather of August all signs of contagious disease disappeared from this field. The chinch-bugs in the meantime had not increased in number, and no great harm was done by them at this point.

At Edgewood, during the last week in April, conditions in wheat and rye and in the winter quarters of the bugs were essentially like those at Odin and Tamaroa, a sufficient amount of muscardine fungus (Sporotrichum) occurring everywhere in the field and appearing in laboratory experiments to indicate its general distribution. The adults of the hibernating generation died in wheat and rye during the latter part of May, as at other points below, and were usually covered with Sporotrichum after death. A few died from Entomophthora, which was more abundant here than at Tamaroa or at Odin. Extremely heavy rains at this time destroyed great numbers of the young, and a few of them exhibited the fungus of white muscardine early in June. By the latter part of that month green muscardine appeared here also, and early in July became decidedly prevalent in the field and was demonstrated in more than usual abundance in the laboratory experiments.

Under these losses and the effect of the late July rains the chinch-bugs became clearly less abundant as the month advanced; but they were nevertheless common enough to breed large numbers of young

of the generation following in the corn. Both adults and young continued to die with Sporotrichum at least until about the middle of August, but Entomophthora seemed to have completely disappeared.

At Mattoon, in May, the chinch-bugs were mostly in the wheat—little of which was raised here—though about equally abundant in rye. Oats were considerably infested, but much less so than these other grains. Adults had already begun to die May 5, with evidences of white muscardine. Green muscardine also appeared among them early in June, becoming somewhat prevalent by the latter part of the month. They continued later here, however, than further south, some living on until the middle of June. As usual, the amount of muscardine fell off to insignificance with the disappearance of this hibernating generation. As the relatively small number of bugs maturing at this point dispersed themselves after harvest, their numbers became so inconspicuous in the fields that further observations of value were impracticable.

At Urbana a search of winter quarters made the middle of March showed that about twenty-five per cent. of the hibernating bugs were dead, none of them apparently from any contagious disease. They began to leave their hibernating quarters about a month later, and by the last week in April were flying in swarms. The first eggs were detected April 26 in the field, and the first young May 15. Heavy rains the middle of May had no apparent effect upon the old bugs except in the development of Sporotrichum and Entomophthora, both of which appeared in the fields at this time, the latter predominating. Dead young in the field were occasionally observed, sometimes imbedded in the mud and occasionally with a growth of Entomophthora, and the multiplication of the species was evidently checked, although no wholesale destruction of either old or young was at any time observed. Similar conditions prevailed throughout June, green muscardine continuing common into July. Field observations at this point were interrupted by the general dispersal of the now mature bugs.

In the wheat district near Mahomet, the wheat fields were very much more heavily attacked, and the invasion of corn at wheat harvest was very much more manifest. The situation here was rendered peculiarly interesting by a destructive outbreak of green muscardine in early July and a considerable, although much inferior development of white muscardine also. The former disease was so prevalent that ninety out of one hundred dead from one of these fields grew Entomophthora within two days. Indeed, a third of a large collection brought in alive were dead with this disease in a day; but as the rains ceased both diseases disappeared in the fields, and only small indications of them were obtained in the observation boxes. The bacterial decomposition already described became quite prevalent in June. After very heavy flooding rains late in July few

bugs were to be found in the neighborhood under observation, although many dead covered with Sporotrichum were present under corn stalks and other rubbish.

FIELD AND LABORATORY NOTES IN DETAIL.

Seasonal History at Tamaroa, Perry County.—April 27.— In a small wheat field in the outskirts of the town, bugs were very abundant under the stools of wheat, but during an hour's search only four dead were seen, two of which were covered with *Sporotrichum globuliferum.* In a number of other fields carefully examined, traces of this muscardine fungus were discoverable, in every case except one in the form of a few dead chinch-bugs or other insects covered with it, usually in the moister parts of the field or along adjacent fences. Eggs were everywhere abundant in the wheat. The weather of the month had been dry until the day preceding this visit according to the records at the DuQuoin Station of the Weather Bureau. April 26, .7 of an inch of rain had fallen, the only other preceding rainfall in April being .18 of an inch on the 9th. The temperature had ranged from 31° to 89°, the mean for the month being 64.9°. Dead bugs from above collection placed April 29 on damp sand at laboratory for the purpose of ascertaining whether they might have died from fungous disease developed a recognizable growth of *Sporotrichum globuliferum* May 6.

May 4. A good rain (.68 inch) accompanied by hail in this region May 1, following upon an inch and a half of heavy rain with thunder and lightning April 28 and 29. Fields in about the same condition as on previous visit, some showing serious damage to crops notwithstanding the rain, and others, on comparatively low ground presenting a very thrifty appearance. A small number of chinch-bugs dead and covered with Sporotrichum under the stools of wheat, half a dozen found in fifteen minutes' search in the field where bugs were most abundant. Many chinch-bugs copulating and a great number of eggs observed.

May 6. Three separate lots of dead chinch-bugs from above collection placed on damp sand were presently imbedded in *Sporotrichum globuliferum.*

May 21. Nearly a week of rain preceding this visit. Conditions little changed. Very few dead bugs imbedded in Sporotrichum; these most abundant on low ground.

May 28. Heavy driving rain preceding night, accompanied with strong wind. All the fields visited were very wet. Small grains in excellent condition; wheat beginning to ripen. Chinch-bugs everywhere present, but doing no evident injury; mostly adults, newly hatched young, and in first and second stages; those of first and second stages most abundant. A few adult bugs still pairing, but very few eggs seen. Bugs clearly scarce in this locality as com-

pared with preceding year, being mostly confined to stems close to the ground and behind sheaths of the leaves. A careful search of six fields of wheat and one of rye discovered only one chinch-bug with Sporotrichum. Search of dead furrows between drill rows and in low spots receiving the wash of the field, brought to light always young bugs imbedded in the mud. Dead young in very small numbers on the hard surface of the ground between drill rows, but most abundant where pools of standing water had disappeared. Young chinch-bugs rarely seen still swimming on the surface of standing water. A few of those fastened in the mud were still feebly alive, but about eighty per cent. of them were dead. Number of dead actually seen was small compared with those still living in the fields, but doubtless a large proportion of those actually killed were overlooked.

June 4. Rain nearly every day for about a week, and fields too wet to plow. The latter part of the month of May had in fact been unusually wet, rain falling on nine days after the 10th at the adjacent station, (DuQuoin) according to the Weather Bureau reports, the rainfall for the month of May reaching the extraordinary total of 8.8 inches. The temperature had also been unusually high for the season, reaching a maximum of 94° and a minimum of 58°, with a mean for the month of 73.9°. Chinch-bugs still quite abundant, a few adults remaining, and a few of the young in the pupa stage. Occasionally a full-grown bug seen on the wing. Apparently not less abundant than the week preceding. A small number found dead on the ground covered with Sporotrichum, and an occasional specimen with *Entomophthora aphidis*. Harvest of wheat and rye begun.

June 12. Bugs escaping from the wheat, many fields of which have now been harvested. Not very numerous in corn except along the outer rows adjacent to fields of infested grain, where a teaspoonful might have been collected from each hill. Scarcely any as yet in the oats, which were still green.

June 23. Continued rain all night of the 22d and 23d (.8 of an inch at DuQuoin); fields quite muddy, making examination difficult. But few bugs in wheat, oats, or corn, except in single field of corn adjacent to infested wheat, where a teaspoonful could have been taken, on an average, for each hill. No dead bugs seen. The temperature of this month had ranged from 60° to 94°, with a mean of 75.5°.

June 24. Collections of live chinch-bugs brought in from these fields were placed in a breeding-box under normal conditions and fed each day with freshly cut corn for the purpose of studying the causes of such mortality as might appear among them. The specimens dead each day were removed and placed upon moist sand (in a shallow glass tray with an overhanging glass cover) with a view to obtaining a free development of any fungus parasite which might

have caused their death. June 27, ten specimens removed; July 2, no appearance of muscardine. June 29, forty dead specimens put on moist sand; July 2, no evidence of muscardine or other mold. June 30, thirty specimens put on moist sand; July 2, no muscardine or other mold. June 30, another lot of twenty-five specimens placed on moist sand; July 2, one imbedded in a growth of *Entomophthora aphidis*; no Sporotrichum. July 2, no appearance of muscardine. Total, 105 dead examined; one example of Entomophthora, none of Sporotrichum.

July 8. Examined by dissection a dead pupa from the above lot while plump and fresh, with no appearance of decomposition or *post-mortem* change of any kind. No trace of fungous affection found. The cellular structure of the intestinal cœca had, however, disappeared, and these organs were full of fat globules of different sizes, evidently originating in the disorganized contents of the epithelial cells, and were also crammed with the usual *Bacillus insectorum* of the chinch-bug. No nuclei, cell walls, or definite structures in these cœca. The cellular structure was also obscure in other parts of the food canal, but there was no fatty degeneration there and there were no bacteria. If the cœca were crushed, clouds of bacteria escaped, but if other portions of the alimentary canal were similarly crushed, only spherical granules of various sizes appeared in the fluids. Cause of death obscure, but presumptive evidence of injurious action of cœcal bacteria, causing degeneration and disorganization of cœcal epithelium as at least a feature of the condition.

July 27, 1896, I dissected two young chinch-bugs, hatched from the egg within two or three days previous in my laboratory, for the purpose of determining the condition of the alimentary cœca at the time, and especially to ascertain whether these organs contained bacteria from the egg. These young bugs had hatched from eggs enclosed in a Petri dish, in which they had since been kept, and they consequently had no opportunity to feed. I found the cœca developed in both, though most satisfactorily shown, by the dissection, in one of them, where they were well and completely displayed. In this there were ten cœca, two of which were much longer than the others. The eight shorter ones were scarcely longer than broad, and consisted of an external basement membrane of flattened cells with small flat nuclei, and within this a single series of large spherical cells with no intercellular spaces except a sufficiently conspicuous lumen. They were given off as blunt, broad appendages from a somewhat enlarged portion of the alimentary canal, in front of which were two distinct enlargements, one corresponding evidently to the anterior stomach of the adult bug, and the other representing apparently both the second and third stomachs. There were no bacteria in any of these appendages, or in any other part of either of these bugs. Careful study was made of the contents of the organs while still entire, and of the fluids escaping from them after crushing them in water. It consequently

seems likely that the characteristic bacterial parasites of these insects always found infesting the alimentary cœca in adults and in active young, are acquired after hatching, and perhaps after the bug has begun to feed.

In other dead specimens examined at this time vast numbers of oval protoplasmic particles—evidently cells of indefinite shape and apparently in normal condition—were found covering the muscle fibers, fatty bodies, etc., and occurring in small masses elsewhere. These were possibly Sporozoa. No trace of fungous affection in four pupæ examined.

As materials for a study of causes of death a large collection of living chinch-bugs was brought in *July 13* from Tamaroa and placed under normal conditions, five or six hundred of them being kept in an open box and supplied with green corn stalks daily. These bugs were very nearly all adults and many of them were *in copula*, and many eggs had been laid in transit.

July 14. Ten dead bugs removed to damp sand in covered glass dish. July 16, 18, and 19, no noticeable change; July 20, observation discontinued.

July 15. Eleven removed to damp sand. July 16, two covered with *Entomophthora aphidis*. July 18, no further development of fungus; several bugs undergoing bacterial decomposition. July 19, no change; July 20, discontinued.

July 16. Fifteen dead specimens removed. July 16, p. m., two exhibited Entomophthora; July 18, one case of Sporotrichum, several cases of bacterial decay. July 20, no change; Sporotrichum fruiting. July 23, 25, 27, no change. July 29, discontinued.

July 17. Eighteen specimens removed. July 18, four with Entomophthora; July 19, no change. July 20, Entomophthora deliquescent; one bug completely imbedded in Sporotrichum; several examples of bacterial decay. July 23, 25, 27, no change. July 29, discontinued.

July 18. Eight specimens removed. July 19, one with Entomophthora; July 20, a second with Entomophthora and three with Sporotrichum. July 23, 25, and 27, no change.

July 20. Twenty-four specimens removed. July 23, five with Sporotrichum (three covered with well-developed fungus and two with immature); several specimens undergoing bacterial decay. July 25, immature Sporotrichum developed. July 27, no change; July 29, discontinued.

July 21. Twelve specimens removed. July 23, one case of Sporotrichum. July 25, bacterial decay in a few examples. July 27, no change.

July 22. Six specimens removed. July 23, two cases of Sporotrichum. July 27, no change; July 29, discontinued.

July 23. Fresh supply of living bugs from collection made at Tamaroa July 20 was added to the box. Two hundred specimens removed on this date. July 29, a few cases of Sporotrichum developed, none of Entomophthora. Many dead bugs rotting.

July 24. Two hundred removed. July 25, four cases of Entomophthora and one of Sporotrichum.

July 25. Two to three hundred removed. Bugs dying rapidly in box. July 27, two cases of Sporotrichum; none of Entomophthora. Large numbers decomposing. July 29, two more cases of Sporotrichum; none of Entomophthora; much bacterial decomposition.

July 27. About two hundred removed. July 29, no muscardine among these specimens; much bacterial decomposition.

Total dead examined, 1,004; 9 cases of Entomophthora; those of Sporotrichum, 23+ "a few."

July 20. The heaviest rain of the season began at eleven o'clock p. m., July 19. Intermittent showers on the 20th, 3.4 inches of rain having fallen in all at DuQuoin. Weather preceding this rain had been dry enough to affect the growth of corn, only two light showers having occurred in July and these early in the month. Railroad traffic interrupted by a "wash-out." Bugs in corn next to oats quite as abundant as on visit of July 10. Now a hundred to two hundred bugs on a single stalk along the edges of the field. Adults active, a great many *in copula.* Many young just hatched. Very few dead ones, beating rain seeming to have produced no marked effect. A few freshly dead adults were seen at the bases of the leaves next the stalks. Ground carefully examined for dead bugs killed by the rain but without result. None seen floating on the water between rows of corn.

July 31. Weather extremely hot, with bright sun. No rain since last visit, but a marked diminution in number of bugs. Adults still pairing. Very many freshly dead adults between leaves and stalks of corn in the field. Only a few of these, however, showed Sporotrichum, and none Entomophthora. Most of the young in apparently healthy condition, although a few were found dead with Sporotrichum.

August 2. From a collection of chinch-bugs brought in from Tamaroa July 31, all dead, individuals were selected comprising fifty-one adults and about fifteen young, with two more adults and one young in a dying condition. Twenty adults were placed on damp sand under cover, the remainder being retained for microscopic examination. One of the two dying adults lay on its back perfectly helpless, but with all its appendages in constant tremor. The other crawled very feebly about. This collection was in strong contrast with those made at the same time at Odin, Edgewood, and Mattoon in respect especially to the large number of dead adults in the Tamaroa lot. August 3, two of the twenty bugs removed to damp sand exhibited a growth of *Sporotrichum globuliferum.* But one additional dead adult in breeding-box. August 6, no significant change

August 11. Weather very dry, roads extremely dusty. Found very few nearly dead adults and a few dead young, all covered with Sporotrichum. No change of interest for this locality.

Odin, Marion County.—April 14. Several fields on various farms near Odin, and between that town and the next railroad station north (Tonti) were examined with reference to the numbers, location, and condition of the chinch-bugs just emerging from their hibernating period. Collections were also brought to the laboratory from these fields for observation in confinement, with a view to ascertaining whether the occurrence of contagious disease in any form might be detected among them at this season. This last inquiry was especially interesting because some of the fields examined were those in which the so-called white muscardine of the chinch-bug had been quite prevalent the preceding autumn. The weather at the time of this visit had been somewhat stormy for several days, with light rain and considerable wind. This rain had been preceded by snow, and this again by a warm spell during which a few old bugs had been noticed on the wing. The bugs were still mostly in their winter quarters under leaves and hedges and rails lying upon the ground, among roots of blue grass and timothy at the borders of fields, around stumps in a meadow, in corn fields, and occasionally in the shocks of corn, and once found in an old wheat field at the base of the stubble of the preceding year. They were most abundant at this season along a rail fence bordering a woodland and in the grass about the fallen rails. A few were seen upon the wing. But very few dead bugs were found in these winter quarters, although search for these was one of the principal objects of the trip. Along the fence above mentioned, for example, where the old bugs were present in millions, not one dead specimen was found. Only three exhibiting the muscardine fungus were reported for this trip, and there was of course no assurance that these had been killed by the fungus parasite. Four lots of specimens were kept for some days at the laboratory under conditions to demonstrate the occurrence of fungous disease among them if present. Three of these lots gave no definite evidence of its occurrence, while in the fourth white muscardine appeared.

April 28. Fence rows and other hibernating quarters had been abandoned by the bugs, and wheat fields were already badly infested. No diseased bugs of any kind were found in these fields and only one specimen of white muscardine was detected in the winter quarters; but a collection brought to the laboratory April 29 and kept in confinement there, exhibited white muscardine May 6.

Heavy rains prevented observations at this place *May 22.*

May 28. Young bugs of the first and second stages were now extremely abundant in young wheat, reddening the stems and dwarfing and killing the plants. The adults were still pairing in small numbers and a very few eggs were seen. A considerable number of adults were also noticed covered with Sporotrichum, most abundantly at the bases of the plants. A few dead bugs were seen after a rain in dead furrows and other places which had received the wash of the field, but no fungous growth except on dead adults.

June 12. Mr. Woodworth reported that but few bugs occurred in the oats and not many more in the wheat: most abundant in the latter where the wheat was green. Numbers here estimated at fifty to the square inch of surface. Had already begun to invade fields of corn adjoining wheat, but no dead whatever were seen.

June 24. The same observer reported that fields of oats and corn not adjacent to wheat contained scarcely any chinch-bugs, but that oats in fields adjoining wheat were commonly killed for a distance of fifteen feet from the boundary, and that corn in a similar situation was usually considerably infested along the edges of the field at an average estimated rate of a teaspoonful of bugs to each hill. Live bugs taken from oats were brought to the laboratory for experimental use.

They were placed in a box, provided with food, and kept under normal conditions for several days. As they died their bodies were placed on moist sand in glass Petri dishes for the purpose of determining whether or not muscardine fungi would develop, giving evidence of the presence of these fungi as cause of death. Five successive lots of dead specimens were thus treated. In the first, transferred to moist sand June 27, and containing thirty specimens, two were well covered with Sporotrichum July 2, but all the remainder were free from this infection. In the second lot (twenty-eight specimens), transferred at the same time as the first and examined July 2, one was found to exhibit Entomophthora and the others were free from parasitic infection. In lot No. 3, containing about twenty bugs placed on moist sand June 29, one gave an evident growth of Sporotrichum and one of Entomophthora, the others exhibiting only common molds. In a lot of twenty-four, removed June 30, one showed Entomophthora July 2 and the others were free. In the last lot, of three specimens only, taken July 1, one was well covered with Entomophthora and the others gave no appearance of fungous disease. Taking the several lots together, of one hundred and five specimens dead in confinement under normal conditions and placed in circumstances to demonstrate death by fungous disease, seven individuals gave this evidence and the remainder not. Three of these seven were infested with Sporotrichum and four with *Entomophthora aphidis*.

July 2. The conditions at this place but little changed. In the corn a few dead bugs were seen, however, and in the oats many had been killed by Entomophthora, and a few were noticed dead without visible evidence of the cause of death.

July 6. A dead bug of the fourth stage—the so-called pupa—perfectly fresh and flexible and evidently very recently dead, was taken from the box from among the living specimens brought in from this trip and dissected with a view to determining microscopically the cause of death. There was no external fungous growth or appearance of fungous affection, even of a microscopical character, but the viscera were well invested by an intestinal mycelium, evidently that of Sporotrichum. This ramified upon the surface of the organs and branched freely in the perivisceral spaces, forming there a more or less dense felt, but not penetrating anywhere the substance of the viscera them-

selves. These, with the exception of the fatty bodies, distinctly retained their cellular structure and the main features at least of their normal appearance.

A second specimen of the same lot in the same condition and having an identical look, also in the so-called pupal stage, was found on inspection to be profusely infested by Entomophthora, the conidia of which were abundant in the fluids, more or less contorted, sometimes divided once or even twice, and sometimes with short rounded branches. Although lying on the surface of the viscera, or even adhering slightly to them, these seemed to be entirely free from penetration by the Entomophthora, which was evidently developing only in the blood. The food canal from the œsophagus to and including the cæca, had its normal structure. This bug, like the preceding, was actually dead when selected, but was still fresh and flexible. These precise observations throw considerable light on the question raised by superficial observers as to the parasitic character of Sporotrichum and as to its precise effect on immature chinch-bugs. That Entomophthora is a true parasite no one can doubt, and it is quite certain that this and Sporotrichum were undergoing precisely similar development in the same parts of the body of chinch-bugs exactly similar as to condition, age, and circumstances. If one was parasitic in this case the other was also.

July 11. A large number of living specimens brought in at this time were placed in a dry wooden box without cover, but chalked at the upper edge inside to prevent escape of the bugs. Green corn stalks were furnished them as food, and changed as necessary. The conditions were carefully kept as near the normal field experience of the chinch-bug as practicable, differing little, if at all, except in the fact that the bugs were screened from the sun and that the food furnished them was the sap of cut corn instead of that of the growing plant. This box was overhauled daily, all of the dead bugs being carefully transferred to covered glass dishes of moist sand. Later experience showed, however, that the amount of care used in handling the bugs and their food was not sufficient, and some deaths were doubtless to be attributed to small injuries thus received.

Beginning July 14, seven dead bugs were removed to a covered glass dish, two of which were covered with Entomophthora on the next day, after which there was no change.

July 15, twelve were removed, one of which showed Entomophthora on the 16th, but no further development up to the 29th.

July 16, three were removed. Two days later one was covered with Entomophthora and one with Sporotrichum. The third remained unchanged until attacked by common molds on the 25th.

July 17, four were removed, one of which showed Entomophthora the next day. Observations were discontinued on the 29th, with no further changes.

July 18, three were removed. The next day one was decaying with a seemingly bacterial affection. The others remained unchanged until the 29th. Observation discontinued.

July 20, fourteen were removed, one of which bore fruiting Entomophthora by the afternoon of the same day. On the 23d three were covered with Sporotrichum. The remainder continued unchanged until the 29th.

July 21, ten were removed. July 23, one was covered with Sporotrichum and one with Entomophthora. Thenceforth no change, except the appearance of common molds, until the 29th. Discontinued.

July 22, six dead bugs removed. July 23, one was infested with Sporotrichum and one with Entomophthora. The remainder unchanged until the 29th.

July 23, fourteen were removed. On the 25th two bore Entomophthora, and on the 27th eight were imbedded in a growth of Sporotrichum.

July 25, thirty removed. July 27, two with Entomophthora and six with Sporotrichum; the remainder free.

Summarizing the results of these experiments, it will be seen that ninety-three dead specimens were taken out of this box, none dead more than twenty-four hours when so removed and transferred to moist sand, where twelve of them developed Entomophthora and twenty Sporotrichum, all within four days after death. It is to be observed that during the two weeks of experiment the number of dead specimens developing Entomophthora continued very nearly uniform throughout the period, being at the most one or two each day, but that the number exhibiting Sporotrichum increased towards the last with the increased number of deaths. I see nothing in these observations to indicate that parasitism by *Sporotrichum globuliferum* had not as much to do with the death of these bugs as that by *Entomophthora aphidis*. Its recognizable occurrence as an external growth, often within twenty-four hours, at farthest, of the death of the insect—a *post-mortem* appearance on the whole very nearly as prompt as that of the acknowledged pure parasite Entomophthora, seems to admit of no other interpretation.

July 21. The heaviest rain of the season had fallen here, beginning on the afternoon of July 19 and continuing with great violence and almost without interruption for several hours at a time. Mr. Snow, who reported the observations of this trip, thought five inches of rainfall a conservative estimate. Streams were over the banks everywhere, in some places endangering the wooden bridges. Roads were flooded in many places, roadside ditches were running over and water was standing in the fields. Moderate rain was still falling when fields at this place were examined.

According to a careful comparison of the number of chinch-bugs in a selected field with those observed by Mr. Snow in the same fields previously, no more than twenty-five per cent. of the bugs remained in the corn. Eggs and newly hatched young were found, though not in great numbers. Except for the immediate effect of the weather the causes of this diminution were obscure. Evidences of contagious disease were but slight, a dead bug covered with a fresh growth of either Sporotrichum or Entomophthora being only rarely found.

Evidence was seen, says Mr. Snow, that bugs had actually been killed by the rain, but, on the other hand, the chinch-bugs were active, often *in copula*, and the newly hatched young seemed little affected by the floods that had fallen upon them. In other fields examined here chinch-bugs were almost invariably less numerous than at the preceding visit.

July 31. Frequent rains had occurred here since the last trip, and the weather was now very hot. The old bugs were still more numerous than on the 21st and the young more abundant. One or two pairs of adults *in copula*. A few dead young covered with Sporotrichum. No Entomophthora seen.

August 11. Weather dry since last visit; corn suffering from hot sun; the roads very dusty. Little change in visited fields. Adults fewer—a few still pairing—and young consequently in larger proportion, but not alarmingly abundant. No signs of contagious disease.

Edgewood, Effingham County.—April 28. Wheat and rye fields for several miles west of this station were examined, and bugs were found in great abundance in every one, injury to wheat being considerable. The weather was dry, and dead bugs were very rarely found. No Sporotrichum except along hedge rows, under boards, etc. Dead specimens found in this locality (obtained in two lots from wheat and rye) and placed on damp sand in my office April 29, developed *Sporotrichum globuliferum* by May 6.

May 11. Weather dry. Same fields visited as on preceding trip. Entomological conditions substantially as before.

May 23. Many dead bugs in rye field visited, and some also in wheat and oats; all are covered with Sporotrichum.

May 29. The heaviest rain for two or three years had fallen here May 27—two and three fourths inches according to a local observer—and the fields were still very muddy. Old bugs seen only occasionally, and some of these pairing, but young just hatched and those in first and second stages were everywhere abundant, reddening the stems of wheat in many places. This crop was good on the whole, however, and corn and oats were excellent, there being very few bugs at this time in the oats. Many young bugs washed away from their food plant and thousands of them could be found fast in the dirt in low, damp places; none of them with Sporotrichum or Entomophthora. In one field visited old bugs dead and covered with a profuse growth of Sporotrichum were very abundant throughout the entire field, half a dozen to fifty or sixty to every stool of wheat. In oats adjacent a few young bugs were seen, but none dead. Also quite abundant in field of rye, some of the adults being dead with Sporotrichum. Many found in this region dead with Entomophthora also. Much more abundant here than in the Tamaroa region.

June 3. One and three fourths inches of rain here May 31, and a fourth of an inch June 3. Chinch-bugs very abundant in wheat fields visited, damaging them so badly that grain will hardly be worth cutting. Mostly young of first and second stages, with a very few adults. Many of the latter on the ground, covered with *Sporotrichum*

globuliferum. A few young bugs dead also and covered with fresh growth of this fungus parasite—less than two per cent. of those in the field, according to the estimate reported. No Entomophthora seen at this time.

June 13. No old bugs seen and but comparatively few of any age. Wheat and rye mostly cut and some fields plowed. Grass on roadsides adjacent to fields formerly infested, fairly well covered with bugs. No dead observed.

June 24. More numerous here than at points farther south, but less so than at Mattoon. A few dead covered with Entomophthora.

June 27. Specimens from collection made on the above trip of June 24 at Edgewood were kept for study of development of disease and causes of death. July 2, twenty-three specimens placed on moist sand in Petri dish; no muscardine detected, but common mold.

June 30. Twenty-six specimens removed. July 2, no muscardine of any kind. Another lot of fifty specimens placed on damp sand on this date. July 2, one with Entomopathora; no Sporotrichum.

July 1. Four specimens removed. July 2, no appearance of muscardine.

July 2. Same fields visited as on trip of June 24. Entomological conditions unchanged except that about two per cent. of bugs seem to have been killed by Entomophthora and a few from causes not apparent.

July 11. Trip made by Mr. Snow, detailed notes of which are not on file. *Entomophthora aphidis* abundant in fields at this time, more so than on any other visit by this observer up to that date. Live bugs were secured for the laboratory

July 13. Experimental box for study of causes of death stocked from collections made at Edgewood July 11. Unlike those for preceding experiments of this character, these were mostly in the so-called pupal stage.

July 14. Twenty dead removed and placed on moist sand. Three dead with Entomophthora by afternoon of same day, one with swollen abdomen, indicating bacterial decay. July 15, five more dead with Entomophthora. July 16, two dead with Sporotrichum; several undergoing bacterial decay. July 18, one more exhibited Sporotrichum. July 20, no further change; discontinued.

July 15. Twenty dead removed. July 16, no parasitic fungus, but two or three decaying, with abdominal distention. July 18, one bug with Sporotrichum. July 20, no change except the ripening of this fungus; discontinued.

July 16. Twenty removed. One dead with Entomophthora on afternoon of same day; three others with swollen abdomens, indicating bacterial decay. July 18 and 20, no significant change. July 23 Entomophthora disappeared. July 25, no new development; experiment discontinued.

July 17. Twenty removed. July 20, 23, and 25, no evidence of infection. Experiment discontinued.

July 18. Sixteen removed. July 19 and 20, no evidence of infection. July 23, one bug with Sporotrichum; many of the remainder rotting. July 25 and 29, no special change. Observation discontinued.

July 20. Twenty-four removed. One dead with Entomophthora afternoon of same day. July 23, two dead with Sporotrichum and one more with Entomophthora; a few decaying July 25 and 29, no change. Experiment discontinued.

July 21. Forty removed. July 23, one dead with Sporotrichum; many others with soft and swollen bodies, indicating bacterial decay. July 25, one more covered with Sporotrichum. July 29, no change; experiment discontinued.

July 22. Twelve removed. July 23, two dead with Entomophthora and one with Sporotrichum. July 25, Entomophthora poorly developed, Sporotrichum profusely. July 29, no change; discontinued.

July 23. Fresh supply of living bugs added from same field as original stock, but collected at Edgewood July 22.

July 24. Seventeen removed. July 25, six dead, with an extraordinary growth of Entomophthora; others unchanged. July 29, no new development; discontinued.

July 25. Number removed not recorded. July 29, two exhibited Sporotrichum.

July 28. Number removed not recorded. July 29, five dead with Sporotrichum in this lot.

The total number of dead bugs removed to damp sand from this lot was something over two hundred. Sporotrichum appeared on twenty of these, and Entomophthora on sixteen.

July 22. Had rained a greater part of the three preceding days, including the night of the 21st, but not so heavily as at Odin and Tamaroa. Live bugs distinctly less numerous than on July 11. Occasionally found in considerable numbers upon prostrate stalks of corn, but commonly to be taken only singly or in pairs. Mostly adults, but some in the pupal and even younger stages still to be found. No young of the second brood and no eggs were seen. Fresh growths of either Sporotrichum or Entomophthora extremely rare.

July 30. Second brood of young just emerging from egg in great numbers. Adults less numerous than on previous visit, some of them still pairing. No Entomophthora seen and but few bugs with fresh growth of Sporotrichum.

August 10. Notwithstanding great rains of three weeks before (there had been no rain since July 23), crops now showed effects of drouth, and the dust was ankle deep in the roads. According to weather record of a local observer, the average maximum temperature of the seven preceding days was 99° in the shade. Field of "ninety-day" corn noticed, the owner of which was cutting and

shocking it. Stalks dead and dry for half their length, partly with drouth and partly from chinch-bug attack. Adult chinch-bugs diminished in number, a few still copulating, and a few others dead, with a fresh coat of Sporotrichum. Young in all stages excessively abundant, a single stalk of corn bearing as many as five to seven thousand. A very few young found dead with Sporotrichum, but no Entomophthora seen.

Mattoon, Coles County. May 5. This locality was peculiar as compared with those farther south, in the fact that but little wheat or rye was to be found in the region, and the chinch-bugs were consequently largely compelled to resort to oats and grass in spring for the deposition of their eggs and for their own earliest food. A single field of wheat visited May 5, was growing luxuriantly, with here and there a spot dry and unthrifty. Chinch-bugs were much more abundant here than in oats, and were doing a considerable amount of damage, least, of course, in the lower, damper portions of the field. They were not only clustered about the roots, but scattered far up on the growing plant. Rye fields were usually about equally infested with the wheat. In the oats a comparatively small number of bugs were on or in the earth upon the roots of the plants. Eggs were abundant everywhere, and scattered dead adults were found in all the fields, usually covered with *Sporotrichum globuliferum*. There had been a good rain (.17 in.) May 1.

Dead specimens obtained in two lots from oats and wheat and placed on damp sand in my office May 6, grew Sporotrichum at some subsequent date not recorded.

May 21. Wheat field visited contained a large number of chinch-bugs and crop was entirely destroyed, in large part, however, by the Hessian fly. There were but few bugs in the oats, and the air was full of flying adults. A few dead specimens taken which were covered with Sporotrichum. Repeated rains during the middle part of the month on seven days from May 11 to the date of this visit—a total of 4.23 inches.

May 29. Good rains May 24 and 27, but roads and fields were now dry. Bugs very abundant in two wheat fields visited, and flying freely. Those on the ground were running actively about among the wheat, and many were dead in the ditch by the roadside adjacent. Young just hatched and in the first and second stages were very abundant, reddening the wheat, which was worse infested than in fields further south—probably because small acreage of wheat led to closer concentration. Many of the bugs were dead with Sporotrichum but none seen with Entomophthora, and no dead young were found.

June 4. Good rains May 31 (.47 in.) and June 3 (.06 in.) and ground quite damp. Fields of wheat, rye, and oats examined. Adults becoming scarce, but more abundant than further south. A great many dead and covered with Sporotrichum, and a few with *Entomophthora aphidis*. Farmers report that adult chinch-bugs have been seen flying frequently all the spring. The young were

quite abundant, but no dead were found. The number seemed small, however, compared with the promise of the earlier part of the season.

June 13. Light rains on two preceding days, amounting to .17 in. Bugs very abundant in wheat about the base of the plants, reddening the ground when the stalks were shaken. Also more in oats than in other places visited. Dead bugs found in oats and wheat.

June 22. Rain on three days preceding—an inch and a quarter. Oats and corn generally free from bugs or containing very few except adjacent to infested wheat which had been partly harvested. From this bugs had scattered to oats and meadow grass, but had concentrated especially upon the outer hills of the corn to a depth of about twenty-five rows, averaging according to the observer's estimate a measured ounce to each hill. Had gone into oats about fifteen feet, killing a strip ten feet in average width. Many dead found in both wheat and oats, several at the base of each stool in the wheat, and so abundant in the oats that in moist places they were scattered at an average distance of an inch apart. In the wheat stubble dead were also found, together with scattered young. A large number were collected from corn at this place and brought to my laboratory for the usual observation and experiment to determine cause of death.

June 27. From the above collection, thirty specimens removed. July 2, a single specimen well covered with Sporotrichum, others only with common molds.

June 29. Thirty specimens removed. July 2, an abundant growth of Sporotrichum on one; the remainder without evidence of muscardine.

June 30. Thirty dead removed and placed on moist sand in Petri dish. July 2, no muscardine. Another lot of twenty-four specimens removed June 30, likewise gave no evidence of muscardine on the 2d of July.

June 30. Last rains June 25 to 27 (1.15 in.) General conditions about as on preceding visit, but chinch-bugs more scattered generally in corn and oats, in the former about fifty to a hill. A strip of dead oats ten feet wide at the preceding visit has now increased to thirty feet. Large number dead with Entomophthora, and now and then one with Sporotrichum. Other dead found giving no evidence of fungus affection.

July 22. Specimens obtained from Mattoon corn field on this date were placed in observation box with usual arrangements. July 23, eight dead were removed and placed on damp sand, and July 25 three more. Two more were taken out on the 27th, one of these with a profuse growth of Sporotrichum. Four were dead on the 28th, but, with the single exception mentioned, none of these gave any evidence of contagious disease.

July 30. Weather extremely hot and bright; hard rain two days before and fields very wet. Rains on six successive days, from the 18th to the 24th, giving total rainfall of 5.56 inches. On three of these days the rain fell in very heavy thunder showers, 1.52 inches, 1.65, and 1.41, respectively. Chinch-bugs generally extremely scarce, averaging not more than one to a corn stalk. No young seen, and but very few eggs Bugs long since dead were found between leaves and stalks of corn. No Entomophthora, and only an occasional example of Sporotrichum seen.

August 10. No change of note. Young hatching in very small numbers only. Weather very hot and ground thoroughly moist, although no rainfall had been reported since July 24.

Champaign County, Urbana.—March 14, an assistant was sent to the fields to search the winter quarters of the chinch-bugs and to make extensive collections with a view to determining the condition in which they had come through the winter, especially with reference to the percentage of survival. Specimens were obtained from orchard sod, from timothy and blue grass by the roadside, from grass on headlands near a forest plantation, and under boards, logs, bark, etc., in the same vicinity. Brought to the laboratory and carefully examined, about twenty-five per cent. were dead, none of them exhibiting any external trace of contagious disease. Indeed the temperature at the time was much below the minimum for the germination and growth of the disease-producing fungi of the chinch-bug, having been below the freezing point every day of the month.

March 26, numbers of these dead bugs were placed on moist sand in Petri dishes for the purpose of ascertaining whether any of them might have died of fungous disease, notwithstanding the absence of external parasitic growths. Three such lots so treated gave no growth of fungus parasite.

Chinch-bugs were first seen on the wing at Champaign April 16, but almost daily thereafter until April 27, swarming abundantly from the 24th to the 27th. There was no change of weather recorded at this time, the temperature being about the same as at the middle of the month, and no rainfall occurring except .14 of an inch on the 23d and a mere trace on the 26th. They were found quite abundantly on the wheat on the Experiment Station farm April 18, and were noticed pairing there on April 24. The first eggs in the field were detected April 26. By May 5 the eggs had become very abundant, and the bugs were pairing in great numbers in this wheat, but no young were detected. The first young chinch-bug was seen in the field May 15, at which time large numbers of eggs were evidently about to hatch. Two more young were found on the 17th in the same field of wheat, and still a few more on the following day. Heavy rains occurring on the 16th, 17th, 18th, and 19th (2.22 in.) had no apparent effect upon the old bugs, but notes on the 20th and 21st show that the young were not appearing as rapidly as might have been expected, some washing away and burying of newly hatched young by these successive rains is consequently probable. Both Sporotrichum and Entomophthora had appeared by this time in the field, the first

in a wheat field May 15, where the ground was rather wet, and the second May 19 in the same field. Entomophthora was observed again on the 20th and 22d and Sporotrichum on the 22d. The Entomophthora became rapidly more abundant on old bugs, but neither this nor the Sporotrichum were seen on young. Dead specimens with Entomophthora were not uncommon on the ground, on leaves and stems of wheat, oats, and grass, on weeds, and under rubbish.* Several pairs were seen *in copula*, both dead with this infection. This condition of things continued for several days, the weather meantime remaining wet. May 27 a few dead young were found on low, damp places, many of them more or less buried in the mud. A good many old bugs dead with Entomophthora and a few with Sporotrichum June 1. Young were also observed on the surface of the ground dead with *Entomophthora aphidis*. Conditions continued about as above, the young not increasing very rapidly in number, and heavy rains continuing. The observer's notes mention from time to time to June 15 the occurrence of a few dead young in the field, but there was at no time any visible wholesale destruction of either old or young on these premises. Heavy rains had fallen May 21 (1.18 inches), May 30 (.53 inches), and June 8 (1.78 inches), together with several lighter rains.

June 18. There were now but very few bugs in oats on the Experiment Station farm, but they had been sufficiently abundant in the wheat to have made their way into corn adjacent a distance of six or seven rows to the number of about half a teacupful to each stalk of corn.

After a heavy rain on the 20th (.64 inch) a few were found imbedded in mud in a roadside ditch, but otherwise little effect was discoverable. A number brought in from the field at this time were placed under the usual conditions resorted to for an experimental determination of the cause of death. Six specimens dying June 27 were placed on moist sand, and July 2 one was imbedded in a profuse growth of Sporotrichum. Forty specimens dead June 29 gave no evidence of muscardine by July 2. Of fifty dead June 30, ten exhibited Entomophthora July 2.

From another collection made in the same fields June 29, eleven dead were kept on moist sand in a Petri dish, and several exhibited Entomophthora by the 2d of July. Of fourteen others similarly transferred July 1, eight had grown Entomophthora by the following day.

On the 6th of July the chinch-bugs, whose development had been followed since the middle of April, were generally scattered through the corn, now averaging over twenty-five or thirty to a stalk. An occasional dead specimen was to be found in the field, sometimes covered with Sporotrichum and sometimes with Entomophthora. The number remaining was so small, and they were so widely dispersed, that our midsummer observations were transferred to a much more heavily infested field observed near Mahomet, Illinois, in the western part of Champaign county.

* Entomophthora had appeared in considerable quantity in these same fields in September of the preceding year.

In the field where most of these observations were made an attempt was made to intensify an attack of Sporotrichum among insects already visibly infected by it. To this end the contents of a culture jar, profusely fruiting, were scattered May 23 in the edge of a field of wheat heavily infested by chinch-bugs, and the grain was trampled down where the infection material was distributed, to form a mat of vegetation which might help to retain the moisture of the soil. The subsequent course of events in this field, as shown in the foregoing narrative, was not such as to satisfy us that any noticeable stimulus to the spread of Sporotrichum had been thus supplied.

August 31. Chinch-bugs in considerable numbers on University premises at base of broom-corn stalks, and also upon the flowering heads of this plant. All stages represented but that just from the egg.

September 12. Pupæ and adults observed at the tips of green ears of corn.

September 23. Numerous at base of stalks of Kaffir corn, mostly adults, but all other stages represented. No evidences of disease among them.

September 28. All stages of chinch-bugs collected on Kaffir corn, including a single one just hatched from the egg and two of the second stage. Adults most numerous. The weather of August had been fairly moist—3.77 inches of rain for the month, with only one heavy storm (1.26 in.). The temperature had been high, the maximum ranging from 73° to 97°, with an average maximum of 84.4. The September weather had been more moist, rain falling on thirteen days and amounting to 5.84 inches. The maximum thermometer readings for this month run from 60° to 91° and the minimum from 30° to 68°.

October 5. Warm, bright day, and chinch-bugs flying abundantly in every direction, resorting evidently to winter quarters.

Champaign County, Mahomet.—July 7. Wheat and rye were here largely harvested, and the bugs had consequently made their way into the borders of fields of corn and oats, penetrating the former forty rows or more and threatening considerable injury. In some cases single stalks were estimated to bear three or four thousand bugs. The situation was particularly interesting because of the extensive prevalence of disease, that produced by *Entomophthora aphidis* predominating greatly, but Sporotrichum also being very much more abundant here than at Urbana. The outbreak of Entomophthora was, in fact, more marked than any other which has come to our notice. It was probably due to this and its companion disease that the bugs were already much less numerous, according to farmers' reports, than they had been a short time before. Very nearly all were either pupæ or adults, the latter, of course, of the new generation. The dead found were consequently not spent imagos, and the deaths occurring were not due to age. Bugs killed with Entomophthora were so abundant in one badly infested field that as many as sixty dead were counted upon a single leaf of corn.

and in the grass adjacent thousands were found covered with Sporotrichum. In an oats field near by, wherever they had resorted to fallen corn stalks on the ground for shelter, an abundance of dead covered with Sporotrichum were mingled with the living.

July 8, two or three hundred living specimens collected from the corn were placed in a dry box without cover but chalked at the upper edge to prevent their escape. Green corn was furnished them daily for food.

July 9, about eighty dead were removed from this lot and placed in a Petri dish on damp sand. By afternoon of the same day all but two or three of these were more or less completely covered with a fresh growth of Entomophthora, most of it not yet fruited, but some already bearing spores. By the following day all but one were imbedded in Entomophthora.

July 10, eighteen more dead in this collection were placed on damp sand, and by the morning of July 11 fourteen of them were covered with Entomophthora. On the 20th of July it was noticed that the four remaining specimens of this lot were profusely covered with ripe Sporotrichum.

July 11, one dead bug removed. Covered with Entomophthora July 13.

July 13, one dead specimen removed. Coated with Entomophthora the following day.

July 14, three dead were removed. July 15 and 16 only one more each day. None of these presented later any fungus growth.

Ninety-four of the 104 dead bugs removed from this lot developed Entomophthora and only four of them Sporotrichum.

The parasitic Entomophthora, by which these bugs were so thoroughly infested when brought in that about a third of them died within twenty-four hours, had now practically disappeared under the conditions present in our breeding box. It is to be observed, however, that as the parasitized bugs were taken out from among their fellows as fast as they died and usually before the fungous growth had matured, little opportunity was given for a continuance of the disease among them.

July 11, a large number of chinch-bugs collected at Mattoon about July 7 and kept since in an open box were transferred to another box with moist earth, fresh food, and covering of large leaves, kept moist for the purpose of ascertaining how freely and promptly Entomophthora would spread among them under presumably favorable conditions. July 13, only about a dozen dead exhibiting Entomophthora. July 14, little if any change; bugs dying very slowly. July 16, twenty specimens of Entomophthora—all there were in the box—removed for experimental use. July 20, about a dozen bugs dead with Entomophthora. The greater part alive and apparently healthy. Experiment in good condition and properly managed. Spread of this infection evidently slow and slight.

July 15. No rain since July 4 except slight shower this forenoon. Thousands of dead bugs covered with weathered Sporotrichum in field of oats previously observed, especially where pupæ had collected for molting, but very few cases of fresh parasites found. Entomophthora outbreak also disappearing. Bugs more abundant than July 7, but very few young. Many freshly molted adults and many adults *in copula*. Eggs scarce. Quantity collected for laboratory experimentation.

July 16. Three hundred of the above placed in observation box.

July 17. Thirty-five dead removed and placed on damp sand as usual. July 20, four profusely covered with Sporotrichum. No Entomophthora exhibited, but many with bacterial decomposition, which was still more general July 23. July 25, discontinued, with no further change.

July 18. Number of dead removed not specified. July 19, two covered with Entomophthora and several undergoing bacterial decay. July 20, no Sporotrichum; a considerable amount of bacterial decomposition. Greenish, milky fluid, full of bacteria, escaping from the bloated bodies. In one case this fluid was black. Swollen abdomens greenish or pinkish before breaking down. July 23, no muscardine, but about a third of the specimens putrid. July 25, no change except increased putridity. July 29, no further change; experiment discontinued.

July 20. Forty dead removed. One covered with Entomophthora by five o'clock p. m. July 23, four completely covered with Sporotrichum; many softened bodies full of fluids of decomposition. July 29, no change; experiment discontinued.

July 21. Twenty specimens removed. July 23, five covered with Sporotrichum and one with Entomophthora. July 25 and 27, no change.

July 22. Twenty dead removed. July 23, one with Entomophthora, ten specimens putrid. July 29, no notable change; discontinued.

July 25. Twelve specimens removed. July 27, one covered with Sporotrichum.

July 27. Twelve specimens removed. July 29, three covered with Sporotrichum.

July 28. Unknown number removed. July 29, one with Entomophthora; others putrid.

The general condition of the chinch-bugs in these Mahomet fields, as exhibited by these observations and experiments, is thus summed up by observer Snow:

"The bugs must have been immensely thick in the wheat. They then attacked corn and wheat adjacent, doing the greater part of their damage by June 15. Millions of them died and are now (July 15) to be found sometimes hardly recognizable and broken up and covered with Sporotrichum. Entomophthora no doubt carried away many, as it was found in quantity in the corn July 7. Next, the oats

drying up and being harvested, the bugs have been leaving it for the last two weeks and are making a second invasion of the corn."

August 8. Fields had been flooded with heavy rains two or three weeks previously. Adults practically all gone, and very few young to be found. Possibly swept away by floods. Many bodies covered with Sporotrichum found beneath corn stalks and other rubbish.

ECONOMIC CONCLUSION.

As a general result of these investigations we certainly have no warrant for asserting that the natural agencies effective in reducing an extraordinary outbreak of the chinch-bug can now be definitely controlled by us for economic ends. So far as ascertained, the *final* causes of unusual natural destruction of this insect are meteorological; and until the weather of the season, or even of the year, can be foretold with approximate definiteness and certainty, we cannot forecast the course of events with respect to injuries by the chinch-bug. Economic entomology must wait at this point upon meteorology. Whether the fungi of contagious diseases can be artificially made use of to hasten or intensify the serviceable effects of favorable weather, with a frequency or to an extent to make this procedure economically worth while, I am not yet prepared to say. The methods of distributing these fungi in the field have hitherto been too crude to make their substantial failure conclusive as to the whole subject. It now seems quite clear that they can at best be used only as secondary to other measures, especially the midsummer measures described in the third article of this report. If applicable at all, however, they can be brought to bear at a point now entirely defenceless; and it seems the duty of the American economic entomologist to spare no pains to investigate to a final and indisputable conclusion anything which promises so much as a remote possibility that the chinch-bug may be attacked even to occasional advantage after it has settled itself in fields of small grain.

THE SPONTANEOUS OCCURRENCE OF WHITE MUSCARDINE AMONG CHINCH-BUGS IN 1895.

The fact that the fungi of disease become locally much more apparent among chinch-bugs after some years of excess in numbers of the insects themselves has already been repeatedly mentioned. The receipt in 1895 of large numbers of packages of living bugs, sent to the office with the expectation that they would be exposed by us to the contagion of disease and returned to the senders for use as an infection material, gave me a favorable opportunity to ascertain the condition of the insects sent with reference to the presence of disease among them when received. The first lot of the season arrived May 8 from Highland, Madison county. They were sent in a tin box with wheat for food. Several hundred were dead when received, but none showed traces of an external fungus growth. All were placed in a contagion box of the usual construction, and a very profuse growth of *Sporotrichum globuliferum* appeared on their bodies three days later—an interval so short for the full development of this fungous as to make it practically certain that they were infected when received.

Thereafter all such lots were placed, immediately on their receipt, in Mason fruit-jars, each with a little moist sand in the bottom, and were kept there with the screw cap of the jar tightly closed upon the rubber ring, a management which effectually prevented all infection from without unless during the brief interval of the transfer from the package in which the bugs arrived to the fruit-jar in which they were kept. The normal rate of growth and development of the white muscardine fungus on dead bugs is such that I think it practically certain that these were infected when received if the fungus appeared among them conspicuously within less than three days after their enclosure in the jar. If such appearance occurred later than three days, it seems possible, although in most cases scarcely probable, that they had become infected after arrival.

The second lot of the season, received from Sangamon county, was placed on damp sand May 14, and two days later one bug was dead and covered with *Sporotrichum globuliferum*. In three days more two others were in like condition.

Another lot, from Hamilton county in Southern Illinois, arriving May 17, was without traces of Sporotrichum five days thereafter. In ten days, however, a great many were dead and several dozens were well covered with the fungus of white muscardine.

May 29, a lot of bugs received from Pleasant Hill, Pike county, was placed on damp earth with wheat for food, a great part of them, however, being dead on arrival. The next day, May 30, many of them were covered with a dense growth of *Sporotrichum globuliferum*. They were returned to the sender the same day.

May 31, a lot received from Christian county and placed on damp earth. Seems not to have been examined until June 3, when many were found completely enveloped in a growth of Sporotrichum.

From June 7 to June 15, six lots were thus tested, received from Montgomery, Shelby, Greene, Macoupin, Randolph, and Clinton counties, all south of the center of the State and well distributed across it from east to west. In four lots, from Greene, Macoupin, Clinton, and Shelby counties respectively, the fungus appeared on the second day after their receipt; and in one from Randolph county on the first day. In all these cases the bugs were dead when they arrived. The remaining lot was not examined for six days after being enclosed, at which time the interior of the box containing them was thickly covered with dead, about half of which were imbedded in the white, fruiting fungus.

On the 17th of June seven lots, received from six different counties, were tested by the fruit-jar method. Two of these lots—from Moultrie and Franklin counties respectively—showed the presence of white muscardine within two days; a third, from Moultrie county, within three; and two, from Wayne and Jackson counties, within four days after receipt. A lot from Macon county and another from DuPage in Northern Illinois gave no sign of muscardine after ten days or more. Nine lots were tested on the following day from as many different counties, of which Saline, in Southern Illinois, was the farthest south; Edgar, on the Indiana boundary, the farthest east; Calhoun, at the mouth of the Illinois River, the farthest west; and Warren the farthest north. In the Edgar-county lot one bug showed the muscardine fungus on the following day; in that from Cumberland county, two specimens exhibited it within two days; and in that from Macon county it appeared within three. Fungus-covered bugs were abundant in the Warren county lot six days after receipt, and a single one was seen in the Saline county lot at the same time. Four of these nine collections showed no Sporotrichum within from six to ten days after receipt.

Results continued about as above to June 27, as shown by observations made on twenty-eight lots received between June 19 and that date. Of these but nine failed to develop Sporotrichum at any time. In two cases this fungus appeared within a day; in five, within two days; and in seven, within three, the intervals in the remaining cases ranging from four to nine days. During the three remaining days of June, however, ten lots out of sixteen received yielded no muscardine, and in the remaining six only two exhibited it within two days. Ten lots tested from July 1 to 13 showed the muscardine in all but two. Four of these came from extreme Northern Illinois—Will, DuPage and McHenry counties. In the DuPage county lot

the fungi appeared within two days, in the Will county lot within three, and in the McHenry county specimens within four days.

Eighty-two lots of chinch-bugs in all were thus tested for the presence of Sporotrichum. These came in from fifty-two counties of the one hundred and two in the State, only four of them from Northern, and eighteen from Southern, Illinois. Twenty-seven of these lots, or very nearly thirty-three per cent., yielded no evidence of the presence of muscardine; but in twenty-five cases, or about thirty per cent., the fungus of this disease appeared within one or two days after the arrival of the specimens. If we assume—as I think from my experience with this fungus that we safely may—that the bugs which gave evidence of its presence within three days had brought the infection with them, then the total number of these lots was thirty-eight, or approximately forty-six per cent. of the whole.

No especial localization of muscardine was apparent in any part of the State, but it seemed to be generally distributed. The bugs collected were of course ordinarily taken from badly infested fields, and the lots received were an insignificant fraction of the number in the field. No special search was made by the collectors of these insects for diseased specimens, but, on the contrary, they were sent to the office for inoculation on the supposition that they were themselves free from disease. We must suppose, consequently, that muscardine was very much more generally present than the results of these test observations would immediately prove, and it seems to me quite probable that it might have been found in all but a very small percentage of the fields of the State seriously infested by the chinch-bug during the spring and early summer of 1895. Indeed, I frequently advised correspondents who wished to get a supply of bugs infected with muscardine, simply to shut up in a contagion box with a supply of food any considerable number of bugs from their own fields, in the expectation that the fungus would presently appear among them and that they would thus become spontaneously infected.

To what extent this general occurrence of muscardine in Illinois may have been due to the several thousand lots of fungus-covered bugs sent out from my office to all parts of the State during the two years preceding, it is of course impossible to say; but the extremely dry weather of those years during the time when these distributions were made, very probably prevented in most cases the successful propagation of the fungus in the fields. This certainly was the case in our own experimental work. I am inclined to think, consequently, that the presence of Sporotrichum here reported was a normal and usual fact, not greatly influenced by the distributions of the preceding year.

It is worthy of additional remark that in most lots of specimens in which the muscardine fungus appeared under our observations only a very small percentage of the bugs in the lot were affected by it—often only one or two out of many hundreds. This would indicate either a comparatively scanty distribution of the fungus in the fields or an unequal susceptibility of the chinch-bugs to its attack.

In nearly every case by far the greater number of bugs received were dead when they came in, having died, of course, in transit, and being consequently quite fresh upon their arrival. The failure of the fungus to spread among these dead bugs after its appearance in our fruit-jars shows that dead insects do not furnish a suitable substratum for its growth except when recently dead. Indeed, we have not at present any evidence that this fungus will grow on a chinch-bug which has died from natural causes other than drowning, or similar sudden accidents which leave the tissues of the insect in substantially normal condition. Certainly if sufficient time elapses between death and infection for bacterial disorganization, the muscardine fungus cannot make a start; and when we remember that every chinch-bug has in the cœca of its alimentary canal an immense store of living bacteria, we see that the interval of freedom from *post-mortem* decomposition must be very brief. In short, notwithstanding our experimental determination of the susceptibility of the freshly killed chinch-bug to invasion by Sporotrichum, I do not think it probable that insects found dead in the field and imbedded in this fungus have very frequently been infected after death.

MISCELLANEOUS CHINCH-BUG EXPERIMENTS.

I have next to report a considerable number of miscellaneous experiments on chinch-bugs carried on from my office in the year 1895, the object of which was either to verify earlier experiments or to settle new points in the economy of these insects.

Some of these experiments related to the vitality of the hibernating generation of the chinch-bug as compared with the midsummer generation, with especial reference to the possibility of introducing contagious disease among this hibernating generation while concentrated in their winter quarters, just before the spring dispersal. I thought it possible that the much longer life of this generation and its exposure to the vicissitudes of hibernation might so reduce its vigor as to make it more liable than the generation next to follow to injury by rains and drouth and by the attack of its muscardine parasites. The results of the experiments give, however, no support to this hypothesis. On the contrary, hibernating chinch-bugs immersed continuously in water, confined in a saturated atmosphere, or exposed to death by drouth or by starvation, showed powers of resistance practically equal to those of the midsummer generation, as these had been determined by my experiments of previous years.

Attempts to introduce the contagious disease known as white muscardine among hibernating chinch-bugs completely failed so far as could be seen, owing primarily to the fact, learned in the course of these experiments, that the fungus of this disease would neither germinate nor grow in the hibernating quarters of the chinch-bug until the weather had warmed sufficiently to lead the bugs to abandon them for the fields of growing grain. The beginning of growth of the muscardine fungus at outdoor temperatures in jars placed on the ground was, in fact, quite simultaneous with the spring dispersal of the bug. It is possible, of course, that the muscardine infection was conveyed to the field by these scattering bugs, to take effect there later; but I have no definite evidence to that effect.

Another series of experiments was intended to test the possibility of the destruction of chinch-bugs under natural conditions in the fields by extreme midsummer heat. Here, also, the results were mainly negative. It was found by laboratory experimentation that a moist heat of 117° applied continuously for twenty hours, of 119° for six hours, and of 120° to 122° for two hours was fatal to chinch-bugs;

and that the effect of the same temperatures in dry air was not very materially different. Careful observations of temperatures in all outdoor situations where chinch-bugs are likely to harbor in the hottest midsummer days, gave no such fatal temperatures. It seemed possible, however, that chinch-bugs' eggs might be destroyed by midsummer heat, even when concealed by clods of earth of considerable size.

Experiments with the eggs of these insects show that they will hatch without loss if kept continuously submerged in water from the time that they were laid, but that the young hatching under water will almost invariably drown; that eggs may also hatch if kept continuously in a saturated atmosphere, but that a large percentage may fail under these conditions and that the freshly hatched young may drown; and that kept continuously in very dry air the eggs may fail to hatch almost entirely, large numbers of the young not succeeding in freeing themselves fully from the shell. Drouth of this degree, however, is probably never experienced in the field.

Contrary to an earlier conclusion it was proven that eggs of chinch-bugs are but little susceptible to infection by the muscardine fungi, Sporotrichum being, however, more effective than Entomophthora. This latter fungus was shown to spread among bugs in confinement slowly and imperfectly, less actively indeed than Sporotrichum. A field experiment confirmed again the already frequently repeated conclusion that hot and dry weather prevents the spread of white muscardine in the field, but showed also that the fungus of this disease manages to persist, in a small way, here and there, under general conditions extremely unfavorably to it.

An instructive series of laboratory experiments showed that the fungus of white muscardine can be grown very readily upon the dead bodies of chinch-bugs freshly killed if these are well infected immediately after death and kept under conditions of temperature and moisture favorable to the growth of the fungus. This is a point of some practical interest, since it suggests a possibility that chinch-bugs found dead in the field and covered with the fungus of muscardine may not always have been killed by it, but may have grown it as a consequence of *post-mortem* infection.

It is also clearly shown by these experiments that chinch-bugs cannot be killed in early spring in their winter quarters by burning over a grassy turf in which they have sought shelter for hibernation.

The burial of chinch-bugs' eggs by plowing and rolling was imitated by a laboratory experiment with the effect to prevent the hatching of from one fifth to one fourth of them when buried to a depth of two to four inches.

It is also shown that salt applied to soil and mixed with it to the amount of twenty per cent. produced no effect upon the hatching of chinch-bugs' eggs distributed through the earth.

Experiments on Comparative Vitality of Hibernating Chinch-bugs.—On page 187 of my Eighth Report it is shown that adult chinch-bugs of the midsummer generation may live floating upon

the surface of water from seven to fifteen days, with an average of about thirteen. To determine whether the hibernating generation might be more readily affected by moisture after prolonged exposure to the winter, a similar experiment was tried, beginning March 31, 1896, with small lots of chinch-bugs carefully placed upon the surface of water in glasses and covered with fine Swiss muslin. These hibernating adults, brought in from the field at the time, lived from three to twenty-one days, being an average of a little over twelve days—a result so similar to that of the preceding year that it seems likely that there is little difference between the capacity of the two generations of this insect to withstand the effect of continued moisture. On the other hand, an equal number of specimens, similarly placed except that the dishes containing them were covered with glass plates so as to keep the atmosphere thoroughly saturated throughout, lived on an average only eight and two-third days.

10. *Confinement of Hibernating Chinch-bugs.* The vitality of this generation was still further tested by putting eighteen specimens in three lots of six each in covered glass dishes over moist earth, this being occasionally moistened to maintain normal conditions. In this experiment, begun March 31, the chinch-bugs, kept without food, began to die April 25 and were all dead on the 18th of May, the average length of life under these circumstances being thirty-eight days. In a similar experiment, begun at the same time, with an equal number of insects, kept under like conditions except that the glass vessels were covered with Swiss muslin and that no water was supplied, the bugs began to die in four days and were all dead in eight, the average being between five and six days. Where the glass was empty, the conditions being otherwise the same, deaths began in two days and all the bugs were dead in four, the average period of survival being between two and three days. In these last two experiments death was evidently caused by drouth, and in the first one by starvation.

These results are fairly similar to those of like experiments with the midsummer generation reported on pages 187 and 188 of my previous report, and afford additional evidence that the hibernating generation is not noticeably weakened by its exposure to winter conditions.

A comparison of these results with those reported under experiment No. 6, on page 185 of my Eighth Report, would seem to indicate about an equal power of resistance to continuous submersion on the part of chinch-bugs of this hibernating generation collected in fall and those collected in spring. Experiment No. 5, on the other hand, described on page 184, shows that the freshly molted adults are more delicate than hardened adults.

Immersion of Hibernating Chinch-bugs.—From a series of twenty-one experiments made to determine the capacity of the hibernating generation to sustain continuous immersion in water, we learn that complete submersion in rain water at a temperature of 70 Fah. was sustained without loss of life for periods varying from

twenty-one to twenty-eight hours; that bugs began to die after thirty-one hours of submersion; and that all or nearly all were killed by fifty-eight to sixty hours' continuance of this treatment. One out of thirty-six survived seventy hours' immersion, however; two out of thirty were living after seventy-two hours; and one out of thirty-six could still move its legs after ninety-nine hours.

Attempts to infect Chinch-bugs with Muscardine in their Winter Quarters. First experiment. Pieces of corn-meal culture medium upon which *Sporotrichum globuliferum* had been grown were placed April 3, 1895, in bunches of orchard grass upon the Experiment Station farm among hibernating chinch-bugs. The ground at the time was very damp, snow and heavy rain having occurred during the two preceding days. The temperature at the surface of the ground was 52° Fahr. at 1:30 p. m. April 5, temperature at 2 p. m. was 72° Fahr. Culture material dry and abundant in stools of grass where it was placed. Many live chinch-bugs, but none dead and no signs of infection. April 10, temperature of surface at 1:30 p. m. 68° Fahr., ground very wet from heavy rains just preceding, and infection material all washed away. An abundance of live chinch-bugs but no dead ones. April 12, the afternoon temperature of the surface was 72° Fahr.; April 15, 54°; April 17, at 3:30 p. m., 59°; April 18, at 1:30 p. m., 68°; April 20, at 10:45 a. m., 72°. At this time the bugs were abundant and in good condition, and there was no trace of disease among them. A few were beginning to fly. April 23, at 2 p. m., surface temperature of ground 68.5°. Bugs less abundant than before, abandoning their winter quarters. No dead. April 24, surface temperature at 2 p. m., 74° Fahr. Remains of original infection material evident, but no fresh growth from it and no dead insects. Living chinch-bugs have all disappeared, having abandoned their winter quarters for the season.

April 17. Second experiment. It was the primary purpose of this experiment to ascertain whether the conditions obtaining in the winter quarters of the chinch-bugs are such as to permit the growth and fructification of the fungus of white muscardine. For this purpose a test-tube of agar-agar and a fruit-jar of corn meal and beef broth were profusely inoculated with spores from a lepidopterous larva which was completely enveloped in a fruiting growth of *Sporotrichum globuliferum*. Other larvæ in the same condition were broken up in fine dirt which was then distributed among chinch-bugs on a selected spot of orchard grass on the Experiment Station farm, where chinch-bugs were present in great numbers. The agar-agar and the corn-meal cultures were placed on the ground in the midst of the grass so treated, each being covered with broken tile.

The surface temperature of the ground at 3:30 p. m. was 59° Fahr. April 18, surface temperature at 1:30 p. m. was 68°; April 19, 2 p. m., surface temperature under grass 70°; April 20, 10:45 a. m., surface temperature 72°. Questionable fungous growth beginning on corn-meal culture; none on agar. April 22, 2 p. m., surface temperature 67°; bugs abundant in grass, but no traces of fungus among

them. Ground rather damp from rains within last twenty-four hours. April 23, 2 p. m., surface temperature of ground 68.5 Fahr. Slight development of impure fungus growth on corn-meal - some of it apparently Sporotrichum; none on agar. No dead chinch-bugs; living beginning to desert their winter quarters. April 24, surface temperature 74 at 2:30 p. m.; ground rather dry. Neither living or dead chinch-bugs in the grass. Traces of original material distributed have all disappeared. Agar culture without growth. April 25, surface temperature at 3 p. m. 72 . Growth on corn-meal medium more abundant on under side of mass, where it has shrunken away from glass; this part unquestionably Sporotrichum. Beginning growth of Sporotrichum in agar tube. A few remaining chinch-bugs found in grass, but no dead and no trace of fungous disease. April 29, surface temperature 71 at 2:30 p. m. Very good growth of Sporotrichum on surface of agar and well-marked in fruit-jars. By May 6 the corn-meal culture of this muscardine fungus was profuse and covered the entire surface; but that on agar was less abundant.

Temperature Experiments on Chinch-bugs.—For the purpose of determining the capacity of the chinch-bug to endure heat, a large number of experiments were tried in my laboratory with chinch-bugs of various ages exposed to temperatures ranging from 100 to 139 Fahr., for periods varying from half an hour to thirty-six hours, under conditions to compare the effects of dry and moist heat respectively at the various temperatures tested. The apparatus used for this purpose was an ordinary bacteriological sterilizer (Arnold Steam Sterilizer) with an automatic temperature regulator. The insects exposed were commonly placed in glass Petri dishes, with paper in the bottom,—either moist or dry, or, in some cases, in moist earth. In experiments to determine the effect of moist heat a portion of a green corn leaf was commonly enclosed with the insects as food.

The particulars and results of these experiments are best exhibited in tabular form.

No. of experiment	Date.	No. of insects.	Stage.	Air.	Temperature—degrees.	Hours exposed	Results
1	Aug. 15	40	1st molt	Moist	122	1	All dead
2	" 15	40	2d molt	"	122	½	"
3	" 21	24	1st and 2d molts	"	100-110	14½	Uninjured.
4	" 21	24	" "	"	139	½	All dead.
5	" 22	28	All stages	"	114	24	Uninjured.
6	" 22	35	"	"	110	6	"
7	" 22	35	"	"	112-114	13	"
8	" 22	35	"	"	114-126	4	3 adults dead; others living.
9	" 24	24	1st and 2d molts	"	130-133	½	16 dead.
10	" 24	24	" "	"	134-139	1½	All dead.
11	" 26	48	" "	"	122	7	Alive when removed; dead 1 hour later.
12	" 26	24	" "	Dry	122	7	All dead.
13	" 26	12	1st molt	Moist	125	3¾	7 alive; 5 dead.
14	" 26	12	2d molt	"	125	3¾	6 alive; 6 dead.
15	" 26	24	1st and 2d molts	Dry	125	3¾	All dead.
16	" 27	24	" "	Moist	129-137	2	"
17	" 27	24	" "	Dry	129-137	2	"
18	" 27	30	" "	Moist	135	½	All alive.
19	" 27	30	" "	Dry	135	½	All dead.
20	" 27	30	" "	Moist	135	2	"
21	" 27	15	1st molt	Dry	125-128	½	11 dead; 4 barely alive.
22	" 27	15	2d molt	"	125-128	½	12 dead; 3 barely alive.
23	" 27	15	1st molt	Moist	134	½	All alive.
24	" 27	15	2d molt	"	134	½	13 alive; 2 dead.
25	" 27	30	1st and 2d molts	Dry	134	½	All dead.
26	" 28	40	" "	Moist	120-132	½	All alive.
27	" 28	40	" "	Dry	120-132	½	All dead.
28	" 28	40	" "	Moist	125	1	All alive.
29	" 28	40	" "	Dry	125	1	"
30	" 29	40	" "	Moist	124-130	1	"
31	" 29	40	" "	Dry	124-130	1	All dead.
32	" 29	40	" "	Moist	115	4	All alive.
33	" 29	40	" "	Dry	115	4	"
34	" 30	50	" "	"	120	3	All dead.
35	" 30	50	All stages	"	120-122	3½	45 dead; 5 nearly dead.
36	" 30	50	"	Moist	120-123	2	45 dead; 5 alive.
37	" 30	50	"	"	120-123	2½	41 dead; 9 living.
38	" 30	50	"	Dry	128	2	All dead.
39	" 30	50	"	"	128	2	"
40	" 30	115	"	"	122	3	89 dead; only 4 active.
41	Sept. 2	100	"	Moist	113	49	All alive.
42	" 2	100	"	"	116.6	20	All dead.
43	" 2	100	"	Dry	116.6	20	"
44	" 3	100	"	Moist	118.4	6	"
45	" 3	100	"	Dry	118.4	6	"
46	" 4	100	"	Moist	120.2	1	All alive.
47	" 4	100	"	Dry	120.2	1	"

NOTES ON THE TABLE.

No. 1. These specimens were divided into four lots and put into small covered tin pill-boxes lined with moist blotting paper, with a piece of green corn leaf in each. The blotting paper was moist at the end of the experiment, showing that the air had been completely saturated.

No. 5. Most of the specimens were feeding on the enclosed corn leaf at the termination of the experiment.

No. 8. The temperature was gradually raised during this experiment from 114° to 126°. The fact that the adults began to succumb to the heat before the young, suggests that they were spent insects, since in the field the young are much more sensitive to heat than the old.

No. 9. The eight remaining alive just able to crawl. Three of them died afterwards.

No. 36. One of those living was an adult, three were pupæ, and one was of the second molt.

37. The living were adults, pupæ, and bugs of the second molt.

The data of the foregoing tables are not everywhere self-consistent, the results of some experiments being out of agreement with those of other experiments professedly identical, but these minor inconsistencies are not uncommon in biological experimentation, and are sometimes unavoidable. In our case they are probably usually due to the different history and previous treatment of lots of specimens used in the experiments. With the exception of Nos. 1 and 2 the specimens were placed in small covered tin pill-boxes of one-eighth ounce capacity, instead of being enclosed, as in all the other experiments, in glass Petri dishes three inches in diameter and an inch in depth. The difference in result due to this difference in management is shown by a comparison of Experiments Nos. 2 and 9, in the first of which half an hour's exposure to a moist heat of 122° killed all the specimens, while in the second an equal exposure to a temperature of 130° to 133° was fatal to only two thirds of those subjected to it. Nos. 1 and 2, for this reason, should be rejected.

The lowest temperature recorded by which chinch-bugs may be killed in *moist* air is 116.6°, and in this case all died on twenty hours' exposure (No. 42). A temperature of 118.4° of moist heat was completely fatal after six hours' exposure, and the greater part of those subjected to a temperature varying from 120° to 123° died after two hours' exposure (No. 36). On the other hand, none were killed by one hour's endurance of 120.2°; about twenty-five per cent. were able to endure from 130° to 133° for at least half an hour (No. 9); and about twenty per cent. survived after two and a half hours' exposure to a temperature of 120° to 123°. The lowest temperature and the shortest periods found completely fatal in *dry* air are 116.6° for twenty hours, 118.4° for six hours, 120° for three hours, 125° for one hour, and 120° to 132° for half an hour.

A comparison of these conclusions with data already published, based on field observations (see my Eighth Report, p. 10), leaves an unexplained discrepancy. In Experiment No. 3, there reported, chinch-bugs began to die in the open field when exposed to the sun when the surface dirt had reached a temperature of 108°, and in twenty minutes at 122° of surface temperature most of those exposed to it were dead (see page 9, Report cited). A similar observation is recorded on page 38 of the present Report, according to which 110° of heat in the surface of layer dust was found rapidly fatal to young bugs.

The greater efficiency of dry heat may be seen by contrasting Experiments 11 and 12, 13 and 14 on the one hand with 15 on the other, No. 18 with 19, 26 with 27, 28 with 29, and 30 with 31.

Temperature Experiments with Chinch-bugs' Eggs.—To ascertain the temperature exposures destructive of the egg of the chinch-

bug in the field, laboratory experiments with uniform temperatures were conducted on lots of chinch-bugs' eggs obtained in confinement under conditions such as to insure normal fertilization of the eggs. Twenty-five eggs set aside August 12, 1895, without treatment, and kept as a check, all hatched except two which had evidently been injured, hatching beginning August 17 and continuing until August 22.

Lots of ten eggs each were placed in small covered tin pill-boxes (of one-eighth ounce capacity) and placed in a sterilizer at uniform temperatures varying from 91.4° Fahr. (33° Cent.) to 136.4° Fahr. (58° Cent.) and exposed for periods varying from two hours to sixteen and a half hours. After these experimental exposures to uniform dry heat the eggs were placed under conditions most favorable to their hatching and watched from day to day until they either hatched or were evidently spoiled. Of ten lots so treated only three hatched, and of these all hatched with the exception of one specimen in each of two lots, crushed by accident. The temperature exposures thus found to be harmless were fourteen hours' exposure to 91.4° Fahr., six hours' exposure to 95°, and seventeen hours' exposure to 109.4°.

The minimum exposure found destructive to the chinch-bug egg was two hours at 116.8° Fahr., all the temperatures above this minimum being of course fatal to the egg. The various lots which finally hatched were neither notably retarded nor hastened in development by their treatment. No experiments were made to ascertain the effects of high temperatures in moist air upon the chinch-bug egg.

Field Temperatures in Hot Midsummer Weather.—Having frequently observed during field experimental operations the destruction of chinch-bugs by direct exposure to the heat of the sun in furrows of dry and dusty earth, I directed during the summer of 1895 some observations and experiments intended to determine (1) field temperatures during the heat of the summer in situations frequented by chinch-bugs, and (2) the power of resistance of chinch-bugs of various ages to high temperatures, dry and moist.*

August 13, 1895, a bright summer day in the midst of a long sea- of heat and drouth, with a maximum temperature for the day of 93°, a minimum of 55°, and a mean of 76°, it was found at 3:30 p. m. that a thermometer four feet above the ground, in the shade, registered 92° Fahr.; in the sun, six feet above the surface, 98°. At this time the temperature of the surface layers of the soil, as tested by a thermometer laid horizontally upon the surface and barely covered with dirt, was 128°. Similarly placed in the shade, the temperature reading was 80°. Under a clod three inches in diameter, exposed to the sun in a corn field, the temperature was 113°; on the surface of the ground in the midst of green vegetation, in the sun, 103°; on the surface under dead grass, in the sun, 94°; in corn, behind the sheath of a leaf, three and one half feet above the ground, 89°, and two feet

*Earlier data on both these points may be found in my last entomological Report, pp. 8-12.

above ground, 87°; on the surface, among the brace roots of the corn plant, in the shade, 91°; in corn field, barely buried beneath the surface, in the shade, 89°.

On the 27th of August, a fair day but somewhat cloudy, with sunshine about two thirds of the time, the earth and air somewhat moist from two thirds of an inch of rain which fell the previous day, a similar series of observations gave a maximum temperature reading of 95°, a minimum of 68°, and a mean of 80.5°. It was found at 3:30 p. m. that a thermometer four feet above the ground in the shade registered 92° Fahr.; in the sun, under the same conditions, 95°; and in the sun, six feet above the surface, 98°. At this time the temperature of the surface layers of the soil, as tested by a thermometer laid horizontally upon the surface and barely covered with dirt, was 101°. Similarly placed in the shade, the temperature reading was 86.5°. Under a clod three inches in diameter, exposed to the sun in a corn field, the temperature was 94°; on the surface of the ground in the midst of green vegetation, in the sun, 97°; on the surface, under dead grass, 88°; in corn, behind the sheath of a leaf, three and a half feet above ground, in shade, 90°, two feet above ground, 89.5°; on the surface, among the brace roots of the corn plant, in the shade, 91°; in corn field, barely buried beneath the surface, in the shade, 89°.

The second of these days, it will be noticed, was the warmer, the mean temperature exceeding that of the first by 4.5°, the maximum by 2°, and the minimum by 13°. The air temperature at 3:30 p m. was, however, the same for both days in both sun and shade, but the soil temperatures in the sun were much lower on the second and warmer day; a fact doubtless to be accounted for by the rapid evaporation in progress after the somewhat recent rain.

A comparison of these temperature records with those of the temperature experiments with chinch-bugs just reported shows that on August 27, a day of moist heat, the chinch-bug was nowhere exposed to a temperature sufficient to endanger its life, the highest reading in the field lacking several degrees of the heat found to be fatal to that insect; and that on a dry, hot day, August 13, the only place where the heat was sufficient to kill the chinch-bug was the bare surface of the earth in the unobstructed sunlight. The heat under a large clod in the open sunlight lacked but little, however, of a temperature high enough to kill the bug itself on six hours' exposure, and was probably quite sufficient to cook some, at least, of the eggs in two hours. It is quite likely, however, that the escaping moisture of the earth in such a situation would raise the fatal temperature point so far that no loss of either eggs or bugs would occur. The chinch-bug is prompt to shelter itself from the sun in hot weather, and we cannot infer from these observations any probability that it suffers at any time or in any stage a considerable loss from midsummer heat in the field if left free to protect itself according to its instincts.

Effect of Immersion in Water on Hatching of Chinch-bugs' Eggs.

August 6, 7, and 10, 1895, twenty-seven lots of recently hatched chinch-bugs' eggs, a dozen in each lot, were immersed in glass dishes

of water, the temperature of which varied from 64.4° to 78.8° Fahr., and kept immersed for periods varying from three hours to sixteen and a fourth days. An additional lot of a dozen was placed on blotting paper on damp earth in a similar vessel as a check. The periods of exposure and the number hatching out of each lot are as follows:

Time of exposure.	No. hatching.	Time of exposure.	No. hatching.	Time of exposure.	No. hatching.
3 hours	11	6 hours	8	9 hours	10
12 "	11	15 "	9	18 "	10
21 "	11	24 "	9	27 "	10
30 "	11	33 "	10	36 "	10
42 "	12	48 "	12	54 "	12
60 "	9	66 "	11	3 days	9
1 days	10	5 days	10	6 "	12
7 "	11	8 "	9	9 "	9
10 "	10	11 "	10	16¼ days	12

In the check lot, ten eggs hatched out of the twelve set aside.

From the above experiment it follows that submersion in water at usual temperatures does not affect the hatching of chinch-bugs' eggs, the last lot mentioned having been kept under water during the entire period of development, and hatching without the loss of an egg.

These results were confirmed by another experiment, begun August 20, in which two lots each of six recently deposited eggs were placed in small glass dishes, one lot being kept continually immersed in rain water and the other being placed on damp blotting paper on damp earth and kept barely moist. In both cases all the eggs hatched and at about the same rate, the first young appearing in the experimental lot September 4 and in the check lot September 3, the last egg hatching in the experimental lot September 5 and in the check September 4. The temperature of the water varied from 71° to 83° Fahr. All the young emerging from the eggs under water would apparently have drowned if they had not been carefully removed, and two of those rescued did not revive. The young in the check all survived and began to feed.

Effect of Moist Atmosphere on Hatching of Chinch-bugs' Eggs. May 9 a large number of eggs were placed upon blotting paper thoroughly soaked in water on a layer of damp sand in a covered glass dish, and kept under daily observation until June 6. Water was added as required to keep the contained atmosphere saturated, with the exception of a single day (May 26), when the contents of the dish became rather dry. Beginning development of eggs was evident by May 17, a change of color being especially conspicuous at the ends of the eggs. Molds of various sorts began to form upon the paper and to run over the eggs as early as the 18th, but with no apparent effect upon their development. Hatching began May 30, when fragments of wheat leaves were placed in the Petri dish as food for the young and as a means of escape from the supersaturated sand and paper. The bugs began to die at once in small numbers, apparently from drowning, as microscopic examinations of crushed specimens gave no evidence of bacterial or other fungous infection,

neither was any such growth detected in eggs which showed no evidence of development. The notes of these experiments do not give details as to numbers and proportions, but these were ascertained by removing one hundred and forty eggs from this lot May 22 and keeping them under identical conditions with the remainder. These began to hatch May 29, the air having been continuously saturated from the beginning, and by the 30th forty-seven young had emerged; by the 31st eighty-eight; and by June 1, one hundred and four. One more hatched June 3, and the remaining thirty-five did not hatch at all.

A comparison with other lots would indicate that this treatment of the eggs may have had the effect to prevent the hatching of an unusually large proportion, and to drown many of the young as they emerged.

Effect of Drouth on Hatching of Chinch-bugs' Eggs.—One hundred and forty eggs recently laid were placed May 9 on dry blotting paper in a small covered glass dish and kept continuously under daily observation until June 6. Forty-three of these eggs hatched, the remainder shrinking and shriveling without hatching. None of the young, however, succeeded in escaping entirely from the egg, but all died with about a third of the body sticking in the shell.

Effect of Exposing Chinch-bugs' Eggs to the Fungus of White Muscardine.—May 9, 1895, a large number of chinch-bugs' eggs recently hatched were placed on blotting paper in a shallow glass dish with a layer of damp sand in the bottom, and were then well covered with spores of the fungus of white muscardine (Sporotrichum) from adult chinch-bugs collected May 7 in the field. The sand and blotting paper were kept constantly moist and the air in the dish thoroughly saturated, water standing in drops upon the under surface of the cover the greater part of the time. Many of the eggs began to show traces of development by the 20th of May, but a few remained unchanged. The first young bug appeared May 22. It was especially treated with fungus spores placed on its body with a needle. By May 30 the young were hatching somewhat freely and were having difficulty in crawling up the very moist surface of the blotting paper. Several of them, however, had established themselves on a wheat leaf placed in the dish for their benefit. Additional spores of muscardine fungus were introduced at this time from another source. May 31 several dead bugs were seen, recently hatched and sticking to the blotting paper, while adults were crawling about and some were feeding on the wheat. June 1 several of these dead bugs were crushed on a slide in distilled water and examined microscopically. After having been thoroughly and repeatedly washed their bodies were found completely filled with mycelial threads, evidently those of *Sporotrichum globuliferum*, and a surface growth of this fungus had appeared at the broken end of a mutilated leg. There were no other external traces of this fungous infection on the young at this time. A microscopical examination of eggs apparently not likely to hatch was made June 3. They were carefully washed in distilled water and crushed on a glass slide and examined

microscopically. No bacterial affection was detected, but mycelial threads, apparently of *Sporotrichum globuliferum*, were present in them. Bodies of young bugs were likewise examined June 6 with a similar result. One especially significant examination was made of an egg apparently nearly ready to hatch, containing, in fact, a young bug quite fully developed. The egg was thoroughly washed three times in distilled water, and then crushed under a cover-glass. There were mycelial threads in the body cavity of the bug, in practically the same condition as those found in dead bugs after hatching.

August 6, 1895, a hundred freshly laid eggs were placed on blotting paper over damp earth in a covered dish, as above, and thoroughly treated with spores of white muscardine. These were from a pure agar culture one remove from growth on a dead insect obtained in the field. The eggs began to show the pinkish tint denoting development August 10. August 13, a single egg crushed under the microscope gave no evidence of fungous infection, but August 14 one egg was observed having a profuse growth of *Sporotrichum globuliferum* coming from one end. The egg was completely filled with this mycelium, as shown by a microscopic examination of a permanent mount. Two bugs dead at 8:30 a. m., August 16, and hatched since 10 o'clock a. m. of the previous day, were found filled with mycelial threads of *Sporotrichum globuliferum*. August 18 two young were observed which had not been able fully to release themselves from the egg shell, and one of these was covered with a very fine mycelial growth, coming principally from the dorsal surface. A dead young bug, which had hatched within twenty-four hours, was observed August 20 bearing a profuse mycelial growth of Sporotrichum, and two others were observed in the same condition the following day. Seventy-eight of the one hundred in this lot finally hatched, and six of the remainder exhibited a growth of muscardine. Two eggs showed a similar fungous infection, and twenty remained unhatched without change.

As a check on the foregoing experiment a hundred eggs from the same lot were treated precisely like the above, except that they were not exposed to fungous infection. These began to hatch August 15, on which date twenty-seven emerged. Twenty-one additional were removed on the following day, and by August 18 all had hatched except eight. By the 21st only five eggs remained unhatched of the hundred used, and no fungus of any sort was seen in or upon either eggs or young.

August 22, 1895, thirty freshly laid eggs were placed on blotting paper over damp earth in a covered glass dish three inches in diameter, and treated with spores of a pure culture of *Sporotrichum globuliferum*, one remove from the insect. These spores were distributed by rubbing them over and about the eggs with a platinum needle. The earth and air in the dish were kept continuously moist. Developmental changes began to manifest themselves August 26, and on the 27th one egg was observed emitting a conspicuous felt growth of *Sporotrichum globuliferum*. This growth fruited the following day, and a number of others seemed similarly infected. The young

began to emerge September 5, ten appearing on that day and six the day following. Four eggs taken at random from time to time and crushed under the microscope were apparently not infected. Nineteen young emerged in all. Four eggs were used for microscopic examination: one was infected with white muscardine; and six remained unhatched at the termination of the experiment, September 7.

In a check lot of thirty eggs, kept under identical condition except as to infection, hatching began September 4 and continued until September 7, at which time twenty-four had hatched and six remained without evidence of development.

Effect of Exposing Chinch-bugs' Eggs to the Fungus of Green Muscardine.—July 13, an experiment was made to test the possibility of infecting eggs of chinch-bugs with the parasitic fungus, *Entomophthora aphidis*. For this purpose eggs were removed from breeding-boxes containing collections made at Tamaroa July 10, and were placed on damp sand in a Petri dish, together with several dead chinch-bugs covered with a fruiting growth of Entomophthora. They were examined from day to day, the sand being kept moist, and more bugs covered with a fresh growth of Entomophthora being introduced. No evidence was seen at any time of an infection of the eggs. On the contrary, these began July 16 to change color in a way to show the development of the embryo within. On the 20th several eggs which seemed possibly infected were microscopically examined, but the contents of every egg were entirely healthy. On the 23d these eggs began to hatch, and further observations were not recorded.

Experiments with Entomophthora on Chinch-bugs.—Opportunities for laboratory experimentation with the Entomophthora of the chinch-bug, *E. aphidis*, have arisen in my experience so rarely that especial pains was taken to apply for experimental purposes, in comparison with the more common fungus Sporotrichum, some material brought in by Mr. Johnson from a field near Vandalia, Ill., September 14, 1895, in which field there was a considerable outbreak of Entomophthora among chinch-bugs. The fungus, although collapsed when brought in, was quite fresh. A number of bugs adherent to leaves of horse-nettle and covered with a growth of Entomophthora were placed on moist sand in a large jar covered with muslin, and to this were then introduced several hundred chinch-bugs fresh from a field adjacent to my office. Four days later, September 18, a few dead bugs were seen, but none exhibiting any fungous growth; and two crushed and examined microscopically gave no evidence of Entomophthora. On the 20th, however, six days after the experiment began, a single chinch-bug was found dead and attached to a piece of the corn put in as food, and showing a slight external growth of Entomophthora. No further evidence of infection was obtained until October 1, when the experiment was discontinued somewhat hastily, as it would appear from observations presently to be recorded.

At the same time with the preceding experiment, two open contagion boxes containing a layer of earth and a large number of chinch-bugs were used for a more extensive experiment that the pre-

ceding. Among the great number of chinch-bugs contained in these boxes a considerable number dead with Entomophthora were scattered September 14 on the damp earth among the living bugs. Fresh food was at the same time introduced, and the earth in the bottom of the boxes moistened. No trace of an extension of the Entomophthora to living insects was seen until September 20, when a single specimen was found dead and covered with a fresh growth of this fungus. Sporotrichum was, however, increasing in both the boxes, appearing not only on chinch-bugs, but on other insects accidentally introduced. No more Entomophthora was seen until September 26, when two bugs were found dead with it, one in each box. More than fifty insects in the meantime, among them a blow-fly maggot, had produced a fresh growth of Sporotrichum. The Entomophthora attack had, however, increased somewhat by the 28th, when about a dozen insects exhibited a profuse growth of it, some of them on the ground and others attached to leaves; this in one of the boxes only. By September 30 this appearance had died away, only a single chinch-bug being found dead with Entomophthora on that day.

Sporotrichum was, however, quite abundant, some twenty-five or more showing fresh growth. October 9 the Entomophthora seemed to have disappeared entirely, but on the 12th it had appeared again, showing a good growth on several bugs, specimens covered with Sporotrichum being at least equally common. The experiment was at this time neglected, the contents of the boxes being permitted to dry out and to remain dry until November 30, at which time most of the bugs were dead, such of them as were microscopically examined being filled with a fungus mycelium. Water was now added, with the effect to develop a few days later a good growth of Sporotrichum on many of the bugs, but none at all of Entomophthora.

There is a suggestion of periodicity in these results which leads me to suppose that the coming and going of the fungus in these boxes is to be connected with the period of incubation between the ripening of the spores and the growth and fruiting of the plant anew. The first and second of such intervals seem to have been six days After the second interval, for a period of eight days, from October 1 to 9, the contents of the box were not watered, and it is to this fact, perhaps, that the long interval of fourteen to sixteen days, running to October 12, is to be attributed. During the next month the contents of the box dried out completely, this treatment apparently killing the Entomophthora, as it did not revive upon the addition of water November 30. Sporotrichum was, however, much more persistent in this experiment, and evidently attacked from beginning to end a larger number of bugs than did the Entomophthora. Although this Sporotrichum had not been experimentally introduced in the beginning, its presence among the chinch-bugs used in the experiment had already been noted.

Field Experiments with White Muscardine Fungus (Sporotrichum globuliferum) on Chinch-bugs. The occurrence in 1895 of the chinch-bug in moderate numbers in a field of wheat on the Experiment Station premises, at a distance of a quarter of a mile from

my office, gave an opportunity not previously possible for careful experimental field work with the fungi of contagious diseases and regular observations of the results. Four such experiments were consequently made, the first beginning May 14, the second. May 23. the third, September 4, and the fourth, September 20.

The material for infection was obtained from cultures and infection experiments in progress at my office, and from various outside sources indicated in the detailed descriptions. As these are the only experiments of the kind which it has been possible for us to follow with practical continuity, they seem worth reporting in some detail.

May 14, in a plot of winter wheat containing about eight acres moderately infested with adult chinch-bugs and young just beginning to hatch, about one hundred and twenty-five dead chinch-bugs, covered with a good growth of *Sporotrichum globuliferum*, and a corn-meal culture of the same fungus having a surface of about a square inch. were placed in stools of wheat in a selected part of the field, the locality being marked for observation. The ground was somewhat damp at the time, a sprinkle of rain (.1 inch) having fallen the night before. and 1.5 inches on the night of the 11th. The wheat was trampled down in several places where the infested material was distributed in order to shelter the ground and keep it moist. A quarter of an inch of rain fell on the evening of the 15th. and .13 of an inch on the evening of the 18th. followed by a sprinkle merely on the night of the 19th. The weather of this interval was cloudy more than half the time. The mean daily temperature ranged from 41° to 61° Fahr. between the 14th. when the experiment began, and the 22d. when the first examination of the situation was made. The minimum reading reached the freezing point but once (on May 21) and the highest temperature of the interval was 75°.

On the 22d the ground was slightly damp and chinch-bugs were rather numerous. many of the eggs showing considerable development. No traces of fresh fungous growth were found. A large quantity of miscellaneous material from two contagion boxes in the laboratory and from artificial cultures on corn meal were distributed this day in the same field, together with a small number of chinch-bugs covered with a fresh fungous growth. Upon the ground where these distributions were made straw and grass were scattered to preserve the surface moisture.

An examination of the field was made May 27, the interval having been clear and dry except for a slight sprinkle of rain on the night of the 26th. and the ground was consequently very dry. No fresh fungous growth was discoverable. and the contents of two more culture pans, each a foot in diameter. together with a fruit-jar culture of Sporotrichum and a miscellaneous lot of chinch-bugs covered with the same muscardine fungus as that received from correspondents, were also scattered in the field. Chinch-bugs were pairing and young were hatching in some numbers. On the last of this month. no noticeable rain having occurred since the 18th. another thorough examination of the field was made. No traces of fresh fungous growth were seen on the dry material. which could still be found on the surface.

The bugs were most abundant in the lower parts of the field, where, in fact, they had dwarfed the wheat. Many young were now clustered on the stems, but none were found dead. Adults were still pairing, and a few eggs remained unhatched.

The month closed with a hot wave, the maximum temperature reaching 95° on the 31st, and the mean temperature of the last three days ranging from 75° to 83°. Similar weather continued until June 3, at which time the field was again examined with similar results. The only surface moisture observed in the field was under the patches of trampled wheat. The entire contents of two contagion boxes in the laboratory were at this time sown broadcast in the wheat. This material contained several hundred chinch-bugs dead and covered with Sporotrichum, and also many live bugs which had been thoroughly exposed to infection in the contagion boxes. Many fungivorous mites were, however, distributed with this material, these creatures having become so abundant in our laboratory cultures as to compel the cleaning out and renewal of the culture boxes. Five or six hundred other fungus-covered bugs obtained from Southern Illinois fields and the contents of three culture pans and six fruit-jar cultures were likewise distributed. Two days later several hundred dead bugs covered with Sporotrichum and many living ones exposed to infection were scattered broadcast in this field. A trace of rain fell on the 9th and two thirds of an inch on the 12th, the weather otherwise having been almost continually clear and usually very warm, the maximum temperature ranging from 78° on the 5th to 98.5° on the 10th, the minimum from 42° to 74°, and the mean from 66° to 82°. No traces of fungus infection were detected in this field on the 13th, even the artificial culture materials soon being denuded of fungous growth. Chinch-bugs were quite abundant, mostly in the first three molts, but none were found dead. The ground was only slightly damp from the rain of the preceding day.

The next examination was made June 20, only .4 of an inch of rain having falling in the interval. The ground was very dry to a depth of two inches or more, and the wheat had begun to ripen. Bugs of the hibernating generation were now probably all dead, and a few adults of the new generation just emerged were seen among the great numbers of young in the first three stages of development. Very thorough examination was made of all parts of the field in which infected material had been distributed, but no traces of disease were found among the bugs, nor any visible traces of fungus on the old material sown. That this distributed fungus was absolutely killed, if not destroyed, was shown by placing portions of the dried-up corn meal found in the field in a moist chamber under conditions favorable to the revival of the Sporotrichum culture. After four days there was no occurrence of any such growth, only Penicillium and two species of Sterigmatocystis appearing. It was evident at this point not only that the distributions made had failed to convey disease to the insects in the field, but also that the Sporotrichum itself had completely perished, whether as a consequence of exposure to heat and sun or devoured, in part at least, by fungus-eating mites, it is not now possible to say. Later in the season, however, after

considerable rains, portions of the original culture material were found under the straw where this had been scattered upon the wheat, with a good fresh growth of Sporotrichum, some of it profusely fruiting. It would seem likely, consequently, that the exposure to the sun of the material sown broadcast in the field had killed the fungous growth and prevented the germination of the spores—an explanation consistent with the results of laboratory experiments to be reported in another place. Although decidedly abundant in the field, no chinch-bugs were found under straw and grass strewn upon the wheat with a view to forming a suitable culture bed for the Sporotrichum infection. Neither was there in these places any fresh growth of the Sporotrichum itself.

A quantity of additional material from the contagion boxes was now distributed, consisting, as before, of dead and living bugs and debris from the bottom of the box in which they had been kept. On the 24th, the weather having in the meantime remained clear, warm and dry, another large quantity of this contagion-box material was distributed, being a third of the contents of each of two such boxes two feet wide by three feet long. Bugs were now beginning to leave the wheat, which was very dry and quite yellow, and to enter the corn adjacent. Adults of the new generation were beginning to pair, and they were also sparingly distributed throughout the corn field generally, having evidently flown in from the wheat. The field was harvested June 25. The bugs gradually left this plot, going in different directions to corn, oats, and sorghum, but lingering also for a considerable time in the stubble, feeding upon the grass-like weeds (Setaria). Towards the end of June the weather became comparatively moist, a fourth of an inch of rain falling on the 25th, a tenth on the 26th, five hundredths on the 29th, and 1.07 inches on the 30th—nearly an inch and a half on the last five days of the month. The temperature during this interval fell off materially, reaching 96° on the 25th, 84° on the 26th, the maximum then dropping away gradually to 68° on the 30th, when the mean daily temperature fell from 73° on the 25th to 63° on the 30th. The entire rainfall of the month, preceding the 25th had been but .7 of an inch, and the maximum temperature had been above 90° on fourteen out of the twenty-four days. A clear sky was recorded forty-five times out of seventy-two observations made. The weather of this period may consequently be described as very hot, dry, and bright. June 28 a good many chinch-bugs were seen under the straw and grass in the wheat stubble, evidently driven to shelter from the direct rays of the sun. A large quantity of infection material from our contagion boxes was scattered on this day among the chinch-bugs in the oats adjoining the wheat, and the contents of three pans of a corn-meal culture were distributed among the insects on the sorghum adjoining, the bugs in both cases being those that had entered these plots from the wheat. On the 2d of July, after the rainfall of the last of June, several dozen dead chinch-bugs were found in the oats covered with a profuse fresh growth of muscardine fungus. They were lying on the ground under a dense cluster of grain broken down by the reaper, and also under other rubbish

shelter in the field. This little appearance of muscardine was temporary, however, and after a few more days of dry weather, on July 5 only a single specimen could be found after a half hour's careful search. Even after a half inch of rain (July 7 and 8) less than a dozen chinch-bugs covered with the muscardine fungus were found by a search of about an hour on the ground under fallen grain or rubbish which had kept the surface somewhat moist.

The bugs in the oats were again exposed July 9 to muscardine infection, half the contents of a large contagion box being scattered among them. July 12 the other half, containing several hundred victims of muscardine, was similarly distributed where the bugs were most abundant in the oats field nearest the wheat stubble. No dead bugs or traces of fungus were found in the field until July 17, two days after the fall of two thirds of an inch of rain. At this time two bugs dead and covered with Sporotrichum were observed under rubbish on the surface of the ground where it was very wet. From this until the 20th, when the next search was made, rain fell each day, an inch and three quarters in all, but only half a dozen dead bugs covered with muscardine fungus were found even then. The remainder of the month was rather dry, except for a single shower on the 27th, when about three quarters of an inch of rain fell. Occasionally fungus-covered bugs were seen, but in numbers much too small to have the slightest appreciable effect upon the horde on these premises.

August was extremely dry and very warm, no rain falling until the 26th of the month, and the maximum temperature ranging in the meantime as high as 96° and 97°. Fifteen days of these first twenty-five give a record of 90° or more. During this period of drouth no trace of the fungus was detected after careful and protracted search of the experimental fields on August 2 and 15. Its presence in a latent condition among these chinch-bugs was, however, shown by an office experiment. August 3, 15, and 21, lots of adult bugs brought in from this field and kept enclosed with damp earth and food yielded each within a few days from two to several dead bugs, which became covered with a profuse growth of *Sporotrichum globuliferum*. Nearly three inches of rain fell during the latter days of August, after which a small number of young bugs were found dead in the field enveloped with a profuse growth of *Sporotrichum globuliferum*. More than three inches of rain fell September 3 and 4, and an inch and a half on the 16th of that month. The weather in the meantime was only moderately hot, reaching a temperature of 90° on only three days of the sixteen.

September 4 a special effort was made to take advantage of the recent heavy rains by introducing muscardine fungus at a selected point in the corn where chinch-bugs were very numerous and where the ground was moist. Corn was prostrate at the time, blown down by the recent storm, and the stalks of several of these fallen hills were brought together to form a thick covering over the wet surface of the earth. Thoroughly ripened spores from an agar culture of *Sporotrichum globuliferum*, but one remove from the insect, were

carefully dusted behind the sheaths of the leaves, on the ground among the chinch-bugs themselves, about the roots of the corn, etc., and the whole culture mass was then broken up and sprinkled among the bugs. The examinations made September 8, 13, and 18, yielded only a few bugs in this situation dead with muscardine. On this last date, however, many dead were found among the grass along the sides of the corn and in the sorghum adjacent, a large proportion of them covered with the fungus of white muscardine, especially on the damp earth in the sorghum field, where it was estimated that one such fungus-covered insect might be found on an average for every six inches throughout the plot. Additional visits made September 23 and 30 gave practically identical results.

The general inference from this somewhat prolix account confirms that often previously drawn, to the effect that hot, dry, bright weather, such as here described, even with occasional showers and storms, will not permit the development and spread of the so-called white muscardine disease among chinch-bugs in the open field, whatever may be the crop which they infest. The fact is to be especially noted that adults of the hibernating generation perished during the period covered by this narration, while the field infested by them was being frequently and profusely treated with Sporotrichum cultures and fungus-covered bugs, but that even these spent adults did not become infected to any appreciable extent. On the other hand, there was not during this whole season any weather so hot, bright, and dry as to put a complete stop to the continuance of the fungus in the field; but it was always present in some obscure form at least, likely to increase with change of conditions.

Inoculation of Dead Chinch-bugs with Sporotrichum.—By a preliminary experiment tried on a small scale July 26, 1895, it was ascertained that *Sporotrichum globuliferum* might be grown with great success upon dead chinch-bugs if these were inoculated immediately after death and kept under conditions suitable to the development of the fungus. To carry this experiment still farther, a number of experiments were arranged in September, 1895. Upon moistened sand in the bottom of four tumblers dead bugs were distributed and covered with moist filter paper. In one of these dishes was placed a lot of about five hundred and twenty chinch-bugs which had been killed in vapor of cyanide of potassium and kept exposed continuously to this vapor for about twelve hours. In a second experiment an equal number of chinch-bugs were placed in a tumbler after about three hours' exposure to the vapor; in a third, after one hour; and in a fourth, after ten minutes. In each case the bugs were thoroughly dusted with spores from a ripe culture of Sporotrichum one remove from an infected insect. In all these trials Sporotrichum grew abundantly upon the dead insects, in one case every bug but one of the entire lot being profusely covered with a fresh growth. A few bugs revived after exposure to the cyanide in all the lots except the first, nearly two thirds, in fact, of those exposed for ten minutes recovering sufficiently to crawl about.

In an experiment made June 16, 1896, with chinch-bugs killed by immersion in water heated nearly but not quite to the boiling point, dead insects were placed in a box of earth in the open air, infected with spores of Sporotrichum and slightly sprinkled with dirt. To prevent the drying out of the box it was moistened daily, and the surface of the earth was covered with a layer of green leaves. Within four days the bodies of all the bugs used in this experiment were completely covered with a good growth of Sporotrichum.

Burning in Winter Quarters.—It has been for many years commonly recommended by entomologists and economic writers, that rubbish, dead grass, and the like, along the borders of fields, be burned over in late winter or early spring, as a means of destroying in their winter quarters chinch-bugs and other injurious insects. Doubt having been recently cast upon the efficacy of this method, I directed in March, 1895, an experiment for the precise determination of the effect of such burning upon hibernating chinch-bugs on the Experiment Station farm at Urbana. This experiment was reported March 27, by the Assistant in charge of it, Mr. W. G. Johnson, and his report is given herewith:

"A small plot of orchard grass on the University farm, about two rods wide by four rods long, was carefully and thoroughly searched for chinch-bugs to-day. The bugs were found very numerous in and about the base of every stool of grass examined. Fourteen bugs were counted in one stool and nineteen in another; but these numbers are only approximate and do not represent the whole number in any cluster of grass, as it was exceedingly difficult to part the dense bunches, especially in and about the roots, just at the surface of the ground, where the bugs were most abundant.

The plot chosen was particularly favorable for experimental purposes from the fact that the ground was thickly matted with a dense growth of dead grass, which was extremely dry except at the bases of the stools, where it was still green. The common blue-grass was also abundant on the same plot, and this, together with the orchard-grass, made a bed of dry brown blades and stems three and four inches deep in places. The chinch-bugs were nestled between the stems of the stools of grass, usually just at the surface of the ground; but an occasional one was found an inch or so below the surface, between the stems. Such places were not very damp and were packed with small particles of dried blades and other rubbish; while the main stems of the grass were green about two inches above the surface, the tops having dried up and fallen over, deeply imbedding the green portions.

At one end of the plot a fire was started which burned briskly and soon covered the entire area. In about fifteen minutes I carefully examined the stools of grass at the end where the fire was started, and other places later. All the dead brown grass was burned off, leaving the ground bare, except where the clusters of orchard-grass

were growing; in such places the chinch-bugs remained in their hibernating quarters uninjured. When the green stubble was parted the bugs scrambled out in all directions when left exposed to the sun for a few minutes. Not a single bug, so far as I could see, had been injured by the fire.

Effect of Salt on the Hatching of Chinch-bugs' Eggs.—August 15, 1895, twenty chinch-bugs' eggs were placed in earth mixed with twenty per cent. of salt and put in a covered glass for observation. The surface was moistened with water and further sprinkled with salt. A check experiment was arranged at the same time, similar in every way except that the salt was omitted. The eggs began hatching in three days in the experimental lot, and by the 23d were all hatched except one. The record for the check lot was precisely the same.

Effect of Burial in Earth on Hatching of Chinch-bugs' Eggs. Beginning August 5, 1895, ten lots of chinch-bugs' eggs, twenty-five in each, were carefully buried in earth at depths varying from one sixteenth of an inch to four inches. An eleventh lot was similarly treated but left upon the surface. The depths to which the various lots were buried was as follows: one sixteenth of an inch, one eighth, one fourth, three eighths, one half, five eighths, one inch, two inches, three inches, and four inches. These lots were observed from day to day and record made of the emergence of the young. By August 24 all the check or surface lot had hatched; twenty-four of those buried to a depth of one sixteenth of an inch; all placed one eighth of an inch under the surface; twenty-three of those buried a fourth of an inch; twenty-four of those at three eighths inch; all at one half inch; twenty-three at five eighths of an inch; twenty-three at one inch; and twenty in each of the three remaining lots, buried respectively at two, three, and four inches depth.

If one may judge from this experiment there was some loss of eggs—from twenty to twenty-five per cent.—from burial at two inches or more.

Precise Laboratory Experiments with Muscardine Fungi on Chinch-bugs.—Notwithstanding the great amount of experimental work done with the fungus of white muscardine, as applied to chinch-bugs for their destruction, exact laboratory experiments kept under close observation and carried on under perfectly uniform conditions remained a desideratum, especially as a means of refuting with authority the extravagant statements often made by careless or inexpert observers. On this account experiments were begun at the State Laboratory of Natural History in July, 1895, by Mr. B M Duggar, an Assistant engaged for the investigation of insect disease.

In the first of these experiments the chinch-bugs used were placed in small covered glass jars half filled with moist sand and kept in a moist condition. Those in the experimental lots were all wet with water in which a large quantity of spores of the muscardine fungus had been thoroughly mixed. To insure still further thorough infection small pieces of an ordinary agar culture, one remove from the dead insect, and bearing an abundance of muscardine spores, were

placed in the jars with the bugs. In each experiment an equal quantity of chinch-bugs derived from the same source as the experimental lot was kept as a check under identical conditions except as to the infection.

On July 26 about one hundred bugs were inoculated with muscardine fungus (Sporotrichum) as above described. By the 29th twenty-five of these bugs were dead. In one microscopically examined an internal fungus growth was detected, and in another, not yet quite dead, similar fungus threads were seen in comparatively small quantity. Both these observations indicated a successful inoculation. The remaining dead were transferred to another covered dish, where they were kept on moist sand with a view to obtaining a further development of any fungus by which they might have become infected. July 30, eleven more were dead. From a number of chinch-bugs evidently diseased several slides were made which showed that the germinating threads of the fungus were penetrating the joints of the legs. July 31, seven more were dead, and one of these, microscopically examined, contained fungus threads within the body. On the 5th of August all the dead bugs removed from this experimental lot exhibited a good growth of the white muscardine fungus, with the exception of about six specimens. The number of deaths in the *check* lot amounted at this time to twelve, on none of which was there at this time any apparent growth of the fungus of muscardine.

From this first experiment it appears that about three times as many bugs had died where they had been infected with the spores of the muscardine fungus as would have died if they had not been so treated; and that six of these bugs in this lot, which had certainly been thoroughly infected before death, did not grow the muscardine fungus after death, even under the most favorable conditions it was possible to supply. From this last observation it would seem that chinch-bugs dying from natural causes other than parasitism by this fungus are not at all certain to afford a suitable basis for the growth of the fungus even though they may be thoroughly infected with the spores at the time of their death.*

On April 9, 1896, two lots of chinch-bugs, from seventy-five to a hundred each, which had been collected from their winter quarters on the 25th of the preceding month, and kept in confinement with a sufficient supply of moisture and food, were separately placed in glass dishes, one lot being well dusted with spores from a corn-meal culture of the fungus, while the other was similarly treated, but without inoculation, and kept as a check. It should be said that six bugs had previously died in the lot from which these were taken, but that no trace of muscardine had appeared among them. Nevertheless, six days after the experiment began one dead bug was seen in the check covered with the muscardine fungus, and by April 22 about an equal number were dead in the check and in the experimental lot.

* In this connection see page 78.

most of the latter, however, showing a growth of Sporotrichum, and only two of the former. On the 29th, on the other hand, the number of fungus-covered bugs was approximately the same in the two lots.

From this indeterminate experiment we must conclude either that Sporotrichum was present in the original lot before division, or that the check lot became accidentally infected at or near the beginning of the experiment.

A third experiment with the white fungus (Sporotrichum) was begun September 2, 1895, as a basis of comparison with a series of experiments made at the same time in the application of several other kinds of fungus parasites of insects obtained from Prof. A. Giard, of Paris, France.

In this muscardine experiment a small pill-box of living chinch-bugs (not counted) were treated as in the foregoing experiments, except that infection was produced by shaking the bugs up thoroughly with a quantity of dry spores of the muscardine fungus from an artificial culture one remove from the dead insect. Four days after infection fifty bugs were dead from this lot; three days later, September 9, thirty-three additional dead were removed, and, finally, on September 12, twelve more, making ninety-five in all within ten days Transferred to moist sand, approximately half of them exhibited a strong growth of *Sporotrichum globuliferum*.

It has been for some time a favorite surmise of mine that native American insects might be found more susceptible to European fungus parasites of related species than to American parasitic fungi. With a view to testing this supposition, nine European species of parasitic fungi* known to infest insects in the Old World were obtained,—all but one (*Isaria densa*) from Prof. A. Giard, of Paris, France,—and September 2 were brought into use in a series of experiments arranged like those last described. Each parasitic species was used in two experiments, observations on which were continued for fifteen days. In each of these lots the number of bugs dying was recorded, and these dead bugs were transferred to dishes of moist sand with a view to obtaining if possible a *post-mortem* growth of the parasite used in the infection. A detailed report on these lots of specimens is rendered unnecessary by the fact that in no case was such a growth obtained, unless possibly in two lots where *Isaria densa* was used. In these a growth appeared upon some of the dead bugs, which did not make sufficient progress to permit its determination. In all the other cases *post-mortem* fungi, if developed at all, were either the fungus of white muscardine or non-parasitic kinds. As an attempt at the introduction of European fungus parasites of insects these experiments were, consequently, a failure.

Some incidental information of interest was obtained, however, with regard to the effect of *Sporotrichum globuliferum* as applied to

* The fungi used in this experiment belonged to the following species of Isaria: *pachytili*, *nolitoris*, *farinosa*, *cochyliera*, *arnaudi*, *ovalispora*, *destructor*, *densa*, and one unknown. Infections were induced by shaking up the bugs with a small quantity of spores direct from the original culture received from Professor Giard.

one lot in comparison with the *eighteen* lots not so treated, which may be regarded as checks upon it. In the lot dusted with spores of Sporotrichum ninety-five bugs died within the period of the experiment, about half of which afterwards exhibited a strong growth of the fungus, while the number of deaths in the eighteen companion lots ranged from ten to forty-eight, with an average of twenty-six. This difference is rendered more significant if we note the fact that Sporotrichum appeared to some extent in eight of the foregoing checks, showing that some at least of the twenty-six bugs of the above average had died under the influence of this fungus. If we further notice that a large majority of the dead bugs appearing in these lots remained free from this fungus growth, notwithstanding the fact that a part of them exhibited it, we shall have additional evidence of the comparative rarity of the occurrence of Sporotrichum on dead chinch-bugs under natural conditions as a consequence of *post-mortem* infection.

AN ENTOMOLOGICAL TRAIN WRECKER.

(*Odynerus foraminatus* SAUSSURE.)

If the most experienced economic entomologist were asked to show how a single small insect might embarrass and even wreck a transcontinental railroad train he would doubtless be obliged to admit that the problem was beyond his knowledge and ingenuity, and it speaks highly for the powers of observation and adaptation exhibited by the solitary wasps that these remarkable insects should have appropriated to their purposes the one minute point in the anatomy of a freight train through which its destruction can be brought about by so insignificant a cause. This point is the opening for the escape of air from the retaining valve of the automatic brake the use of which on all freight trains is now required by national law. If this small opening is plugged, it is impossible for the engineer to release the brakes on a car when once applied; and the effect of this failure to release one or more brakes on a long freight train is not always noticeable to the engineer until, perhaps, the braked wheels become overheated and burst, or are flattened by sliding along the track, with results destructive to the safety of the train.

It so happens that this little opening in the solid iron leading into the cavity of the valve is precisely to the liking of certain of the solitary wasps in search of places in which to build their mud nests and lay their eggs; and it is not an uncommon occurrence on the Great Plains for a brake valve to be plugged by these insects with an air-tight packing of mud, with consequences which greatly overtax the entomological knowledge of the puzzled brakeman in search of the cause of the difficulty with the brake.

My attention was first called to this curious entomological relationship in September, 1896, by a letter from Mr. G. W. Rhodes, Superintendent of Motive Power, of the Chicago, Burlington, and Quincy Railroad Company, of which the following is the essential part:

"A curious difficulty has arisen on some of our cars which are equipped with the air brake. You are doubtless aware that the law requires that after 1898 sufficient cars in each train in interstate business must be equipped with automatic brakes to control the speed of the train. The point that I refer to and wish to call attention to is that an insect has been making its nest and depositing its eggs in the air-opening in the retaining valve. The nest is composed of some sort of earth and completely stops up the air passage. That you may understand how serious this is, I enclose a cut of the re-

taining valve, and for the present purpose all that is necessary for you to understand is that if the opening is closed up, the brakes on the car so afflicted cannot be drawn off. The result is that if the train is in motion the brakes will remain applied, increasing very materially the coal consumption until released, and in case of the rail being slippery and oily probably sliding the wheels and therefore making the equipment liable to accidents and wrecks incident to having flat spots on wheels. I was told some eight or nine months ago that this trouble was one of frequent occurrence."

In a later letter Superintendent Rhodes reports that more retaining valves are found stopped up by wasps in cars coming from the Union Pacific Railroad than from any other point. In an illustrated article* on the subject, published after considerable correspondence with me, Mr. Rhodes gives full details of the construction of these valves and of the nature and consequences of the difficulty described.

On examination of the contents of six of the plugged valves kindly sent me by Mr. Rhodes, remains were found of caterpillars which had evidently been stored there by the wasps as food for their young, and in one such valve was an entire specimen of a common and widely distributed species of solitary wasp (*Odynerus foraminatus* Saussure).

The habits of these wasps are well known to entomologists, and indeed the selection of a somewhat similar nesting place by a species of this genus has been reported by Professor Comstock, of Cornell University, in his "Manual for the Study of Insects," p. 659. "One year these wasps plastered up many of the keyholes in our house, including those in the bureaus, thus constructing for us locks that required a good deal of time and industry on our part to open."

Having prepared the selected cavity for her purpose by plastering and shaping it with mud, the mother wasp brings into it a number of small caterpillars which she has partially paralyzed by stinging them, and stores them there as living food for her young. She then lays an egg in the cavity, closes it with a plug of mud for the protection of the larval wasp presently to appear and to enjoy in due time the resources thus carefully provided for it.

The details of this history have never been reported for this particular species of wasps, but they may be illustrated, no doubt, by an account given by J. H. Fabre, in his *Souvenirs Entomologiques*, of the methods of a related species, *Odynerus reniformis* Latr., which may be thus summarized:

From the roof of the cavity containing her paralyzed prey the mother spins a fine, thread-like spider web, at the end of which she suspends an egg. The young larva presently breaks through the envelope of the egg, which it is careful not to leave, its weight stretching the cable by which the egg is suspended, so that by reaching downward it may get at the first caterpillar of the series placed at its disposal. On being attacked, the caterpillar wriggles and

* "The Air Brake Encounters a New Enemy," Proc. Western Railway Club, January, 1897, pp. 218-229.

writhes in a way to endanger the delicate larva, which recoils until its prey regains its composure, when it renews the attack, persevering until the helpless victim succumbs to repeated wounds and is finally devoured. The second caterpillar of the series is then attacked in the same way, and so on with each in turn, until the larval wasp gains a size and strength that enables it to abandon its suspended cable and make its attack on foot. The quantity of food originally stored for it is nicely regulated to its needs, being neither too much nor too little for its growth and development. When ten or twelve days old it is prepared for its change to the pupa state, in which condition it remains encysted within its cell for several months. At the end of this pupal period it transforms, of course, to the adult, gnaws its way out of the cell, and escapes.

The prevention of this interference with the air brake by solitary wasps would seem to be a matter of no great difficulty. Commenting upon my suggestion that access to the interior of the valve be prevented by making the passageway with an angular or spiral turn, or by making the air opening in the form of a narrow slit instead of a circle, Superintendent Rhodes says: "The best suggestion has come from Mr. Forbes, and is contained in his letter of October 26th. An angular opening or one with slits like a grating would be quite practicable. We trust the suggestion will be immediately acted on by all manufacturers of retaining valves for air-brake purposes. One other change in application should be observed. Owing to the construction of the retaining valves, as made up to the present time, the opening must necessarily be placed facing the side of the car. This adds to the difficulty of cleaning out the obstruction, even should the stoppage be discovered. There is no reason why this should not be placed so that it can be opened up with a wire or some other sharp-pointed instrument. With these remedies generally known and applied, it is believed future encounters with our new enemy will result in signal victories for the air brake."

NOTE ON A NEW DISEASE OF THE ARMY WORM.

(*Leucania unipuncta* HAWORTH.)

A minor outbreak of the army worm in the vicinity of Champaign which occurred in May, 1896, was brought to an extraordinary termination by the appearance of a fatal disorder of a kind not hitherto observed in this species. While my observations were limited to the Experiment Station farm and its immediate vicinity, the widespread occurrence of this disease throughout Central Illinois was shown by letters and specimens sent me by several correspondents at about this time.

So far as known, destructive outbreaks of this insect have heretofore been brought to a conclusion mainly by insect parasites, which multiply so rapidly among the concentrated hordes of the army worm that they are almost certain to reduce the species to insignificance before another generation can take the field. In this Champaign county case, however, deaths by insect parasitism were insignificant in number compared with those due to the new disease – a fact which I ascertained by keeping under observation in breeding-cages, with an abundant supply of food, large numbers of army worms collected at random.

Attention was first called to this disease by the occurrence of many dead or disabled army worms fastened to the upper part of standing stalks of blue grass, to which they commonly clung by their false legs or sometimes by their entire length. These were in various stages of degeneration, some of them still living, and merely torpid when disturbed, and others dead and dried away to shriveled remnants of the empty skin. Looking across an infested field of grass hundreds of caterpillars exposed in this manner might be seen at once, and search on the ground among the grass blades would disclose a great many more. Of those brought in from the field and confined in boxes or cages for observation scarcely one survived to complete its transformations.

The bodies of the insects were always blackened when very seriously affected, and at death would rapidly soften, the whole interior becoming finally converted into a thick broth or gruel of a dirty cream color or a grayish white. The disease usually began at the hinder end of the body and moved gradually forward, the last segments being sometimes dead, blackened, and almost rotten while the anterior parts were so far alive that the caterpillar could crawl sluggishly about when disturbed. The bodies did not, however, soften

so rapidly under the influence of this disease as in mere decay, their firmness being rather between that of the cabbage worm when dead with its characteristic disease the so-called white plague—and that of caterpillars infested by fungus parasites which give origin to the diseases known as muscardines.

Microscopic examination of recently dead or dying caterpillars showed that these were little more than a mere gruel of minute, slightly angular, highly refracting particles, varying in size, but with an average diameter of 2.7 microns. In less degenerate parts of the body these particles were massed in more or less spherical bodies, cell-like in form, and either floating free in the fluids or collected in large clusters of such cells. Comparison with the fatty bodies of the insect showed that the spherical bodies were detached cells of that tissue, and that nearly the whole substance of this organ was practically converted into these minute peculiar granules. Each cell in such a diseased tissue was an opaque collection of the dark spherical granules, sometimes surrounded by a more or less continuous layer of ordinary oil globules. This degeneration of the fatty bodies was in fact the most marked peculiarity of the disease, a point in which it agrees with the so-called "yellows" or jaundice of the silkworm as described by me in 1886.* The cells of the Malpighian tubules were similarly degenerated.

Besides these various products of degeneration derived from the fatty bodies, the fluids of the diseased caterpillars contained three other classes of cellular elements in sufficient abundance to make them worthy of notice. Normal blood corpuscles were still recognizable in caterpillars not too far gone with disease. They were commonly rather few in number and spherical in form, with a great number of minute hair-like pseudopods.

Mingled with these, and in badly diseased specimens much more abundant, was a class of amœboid cells distinguishable at a glance from normal blood corpuscles, but, nevertheless, possibly derived from them, their peculiar condition being perhaps the result of changes induced by disease. These were pale protoplasmic cells without distinguishable wall, with very little distinction of ectoplasm and endoplasm, and commonly with two or three pseudopods, or very rarely with more, usually thick at their origin and tapering to an acute point. Sometimes as many as twenty of these bodies were seen in a single field of the microscope, with a power of five hundred diameters, in a slide made from the blood. Occasionally one was seen with a distinct nucleus, but rarely so without special preparation. The protoplasm was homogeneous though very finely granular, even the finest pseudopods being commonly granular as far as they could be distinctly traced. Vacuoles of any sort were rarely seen, although occasionally one or two small pale circular areas were discoverable within the cytoplasm. The cell was commonly more or less definitely spindle-shaped, with a thick median portion, and the spindle was often bent to one side, sometimes so much as to give the cell a semicircular form, the pseudopods starting from the angles of the semi-

* Bull. Ill. State Lab. Nat. Hist., Vol. II., Art. IV., p. 280.

circle. If a third pseudopod occurred it commonly started from some part of the more convex surface, and was then usually shorter and smaller than the other pseudopods. Occasionally, however, a specimen was seen in which this third pseudopod started from one side of an ordinary fusiform body or from the shorter side of a curved individual. Not infrequently when a third pseudopod was present it was of about the same size as the others, the cell having then a triangular form, with an acute slender pseudopod from each angle. The highly refracting granules already mentioned as mainly derived from the fatty bodies, and with which the blood of diseased army worms was loaded, were very rarely seen imbedded in the substance of these amœboid cells.

The third variety of free cells in the fluids of the army worm were protoplasmic bodies showing more or less conspicuously a coarse segmentation within, the segments varying in size in different individuals and likewise in definiteness and distinctness. These cells always contained apparent nuclei, and the segments were sometimes arranged in a circular manner around a common center, giving a rosette-like appearance to the cell. Some of these segmented protoplasmic bodies were spherical, others oval, others oblong, and others almost linear, with rounded ends. None were seen with acute extremities. I could not trace these to any organ or tissue in the body, and their persistence in the fluids of dead insects far on the way to disorganization, together with their general appearance, suggested a parasitic character.

With these merely descriptive notes I was obliged to content myself, not being able under the conditions existing even to determine the contagious character of the disease, much less clearly to recognize its cause. Its universal prevalence among army worms at the time, of course made it impossible to obtain material of that species for infection experiments. A similar condition of things was found, however, in a miscellaneous lot of cutworms collected June 10 for experimental use. From sluggish larvæ, motionless except when irritated, segmented cells like those last described above were obtained in great numbers from the blood by snipping off a proleg and touching a cover-glass to the exuding fluid. In these cutworms, however, such cells were commonly oval, sometimes approximating a spherical form. They were very abundant in the fatty bodies, as were also dark granules reminding one of the peculiar granules of the diseased army worms but much larger than these and oval in form, like the corpuscles of pébrine. These oval, segmented cells varied in transverse diameter from eight to twelve microns, the usual diameter being nine and five tenths. Their length varied from 10.8 to 14.85 microns, the average of those measured being about fifteen.

The importance of this disease as a check upon the multiplication of the army worm is shown by the fact that although the very moderate outbreak reported was that of the first generation of the year, there was no appearance whatever of any considerable number of army worms of the second generation, either at Champaign or in any other locality from which this disease was reported to us. It is be-

cause of this economic importance of the subject that I have thought it worth while to place on record the imperfect data here given, in the hope that they may call attention in future to phenomena of this class, and that they may serve as a means for the early identification of this disease in some case where experimental tests and economic applications may perhaps be practicable.

EXPLANATION OF PLATES.*

Plate I.

Map of Illinois, showing known distribution of San José Scale in Illinois (October, 1897). Red dots indicate infested localities (See p. 8).

Plate II.†

Fig. 1. Appearance of San José Scale on bark: *a*, infested twig, natural size; *b*, bark as it appears under hand lens, showing scales in various stages of development and young larvæ.

Fig. 2. San José Scale: *a*, pear, moderately infested—natural size; *b*, female scale—enlarged. (See pp. 2 and 15.)

Plate III.‡

Fig. 1. San José Scale, adult female, before development of eggs. *a*, ventral view, showing very long sucking setæ; *b*, posterior extremity, showing characteristic ornamentation of edge. Greatly enlarged.

Fig. 2. Young larva and developing scale: *a*, ventral view of larva, showing sucking beak with setæ separated, with enlarged tarsal claw at right; *b*, dorsal view of same, somewhat contracted, with the first waxy filaments appearing; *c*, dorsal and lateral views of same, still more contracted, illustrating further development of wax secretion; *d*, later stage of same, dorsal and lateral views, showing matting of wax secretions and first form of young scale. All greatly enlarged.

* Pl. V., Pl. VI., Fig. 2, Pl. VII., and Pls. VIII. to X. are from drawings made by Miss Lydia M. Hart, artist to the State Laboratory; Pl. VI., Fig. 1, is from a photograph.

† From Bull. No. 3, N. S., and from Circular No. 3, U. S. Dept. Agr., Div. of Ent.

‡ From Bull. No. 3, N. S., U. S. Dept. Agr.

Plate IV.*

Fig. 1. San José Scale, adult male. Greatly enlarged.

Fig. 2. Development of male insect: *a*, ventral view of larva after first molt; *b*, same, after second molt (pro-pupa stage); *c* and *d*, true pupa, ventral and dorsal views. All greatly enlarged.

Plate V.

Middle portion of alimentary canal of Chinch-bug, showing closed tubular appendages (cœca) which always contain bacteria (see p. 57): *a*, posterior end of second stomach; *b*, third stomach; *c*, *c*, *c*, etc., eight cœcal appendages, which contain bacteria; *d*, tubular intestine behind cœca; *e*, enlargement of intestine into which Malpighian tubules open; *f*, *f*, etc., cut ends of Malpighian tubules; *g*, cut end of rectum. *Prepared by S. A. Forbes.*

Plate VI.

Fig. 1. Growth of white muscardine fungus (Sporotrichum) on chinch-bug infected at death. (See p. 97.)

Fig. 2. Retaining valve of automatic air-brake showing air-vent plugged with mud by Solitary Wasp, *Odynerus foraminatus.*

Plate VII.

Fig. 1. Air-brake valve broken to show mud plugs made by Solitary Wasp. (See p. 104.)

Fig. 2. Solitary Wasp, *Odynerus foraminatus*, bred from plugged valve of air-brake. (See p. 104.)

Plate VIII.

Fig. 1. Part of fatty body of diseased Army Worm. (See p. 107.)

Fig. 2. Single cell from slightly affected part of fatty body of Fig. 1.

Fig. 3. Single cell of greatly affected part of fatty body of Fig. 1.

Fig. 4. Epithelial cells of Malpighian tubule of same Army Worm. (See p. 107.)

Fig. 5. Cluster of characteristic granules of disease. (See p. 107.)

Fig. 6. Blood corpuscle of diseased Army Worm, containing characteristic granules. (See p. 107.)

Fig. 7. Nucleated amœboid cell, containing dark granules; probably a blood corpuscle.

* From Bull. No. 3, N. S., U. S. Dept. Agr., Div. Ent.

Fig. 8, 9. Granules in naked cells of doubtful origin, possibly dead blood corpuscles.

Fig. 10. Fusiform amœboid cell with blunt ends. (See p. 107.)

Fig. 11. Fusiform amœboid cell with acute pseudopods and a few with dark granules.

PLATE IX.

Fig. 1. Various forms of amœboid cells, with acute pseudopods. From blood of diseased Army Worm. (See p. 107.)

Fig. 2. Amœboid cell with three pseudopods and large nucleus.

Fig. 3. Segmented cell from blood, three-cell stage; in outline. (See p. 108.)

Fig. 4. Segmented cell from blood, four-cell stage; in outline.

Fig. 5. Segmented cell showing continued proliferation. Segments swollen by water.

Fig. 6. Segmented cell in optical section.

Fig. 7. Segmented cell with segments separated by pressure.

PLATE X.

Fig. 1. Segmented cell from blood of diseased Army Worm; two-cell stage. (See p. 108.)

Fig. 2. Segmented cell, four-cell stage.

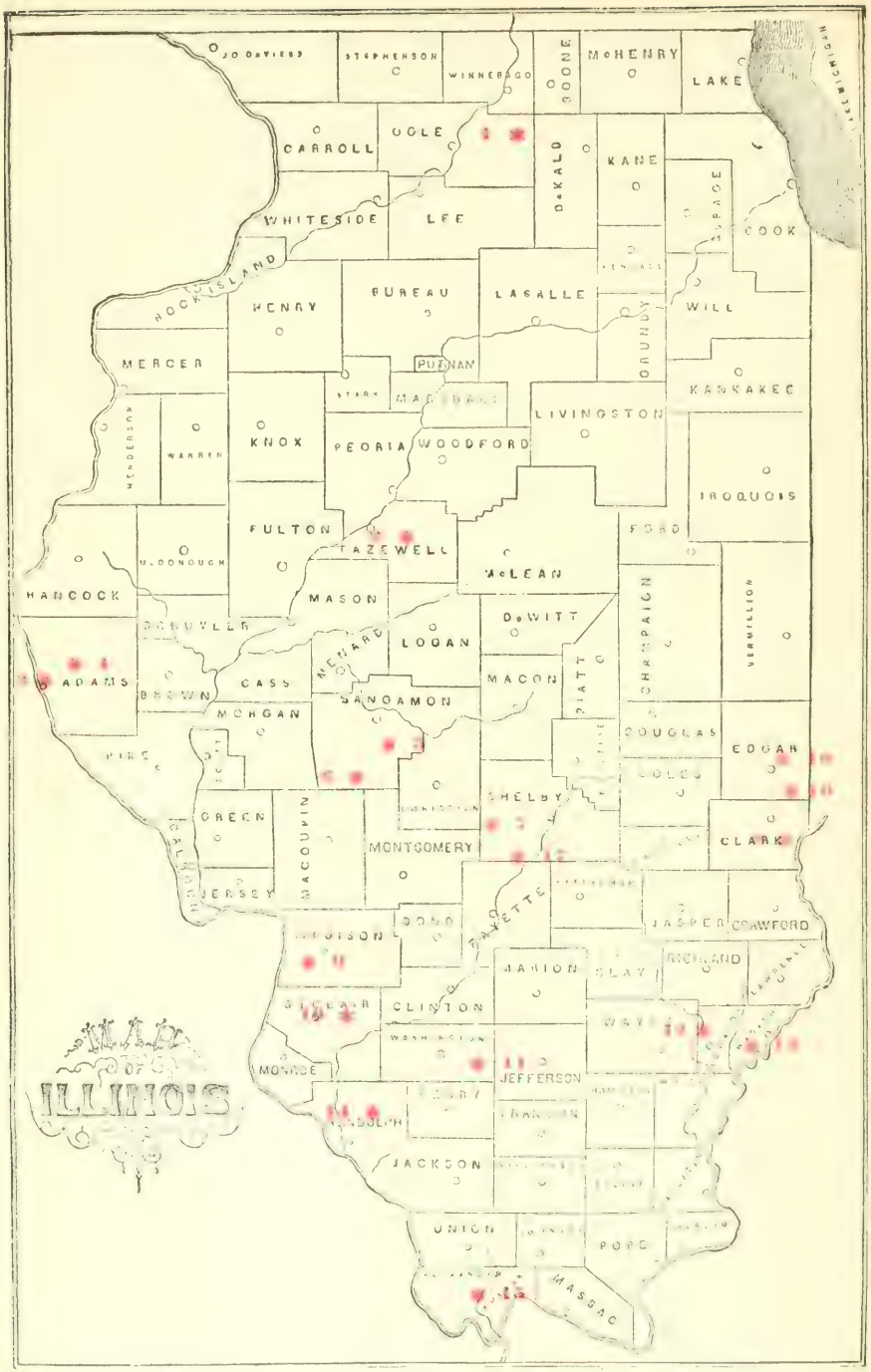
Fig. 3. Segmented cell showing nucleoid center.

Fig. 4, 5, 6. Different forms and stages of cells of same class as 3.

Fig. 7. Disintegrating segmented cell.

Fig. 8. Detached cell of doubtful origin from blood of diseased Army Worm.

PLATE I.



LOCALITIES INFESTED.—1, Monroe Center. 2, Tremont. 3, Quincy. 4, Paloma. 5, New City. 6, Auburn. 7, Tower Hill. 8, Ernst. 9, Collinsville. 10, Mascoutah. 11, Richview. 12, West Salem. 13, Mt. Carmel. 14, Sparta. 15, Villa Ridge. 16, Farm near Sandford, Ind. 17, Herrick. 18, Vermilion.

PLATE II.

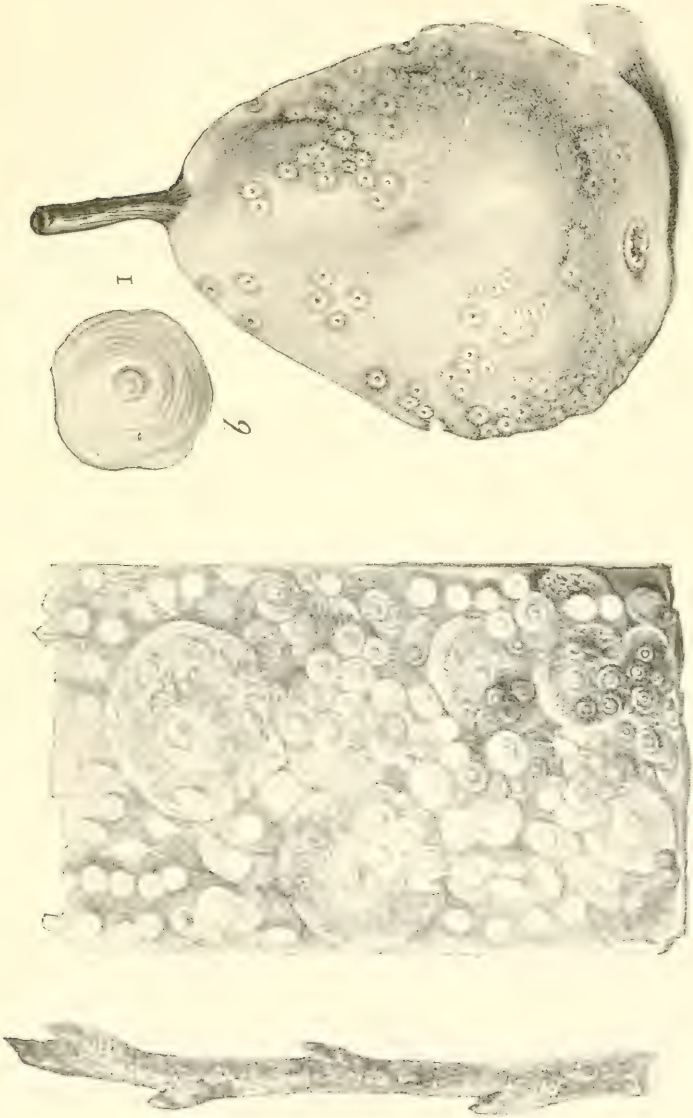


Fig. 2

Fig. 1

PLATE III.

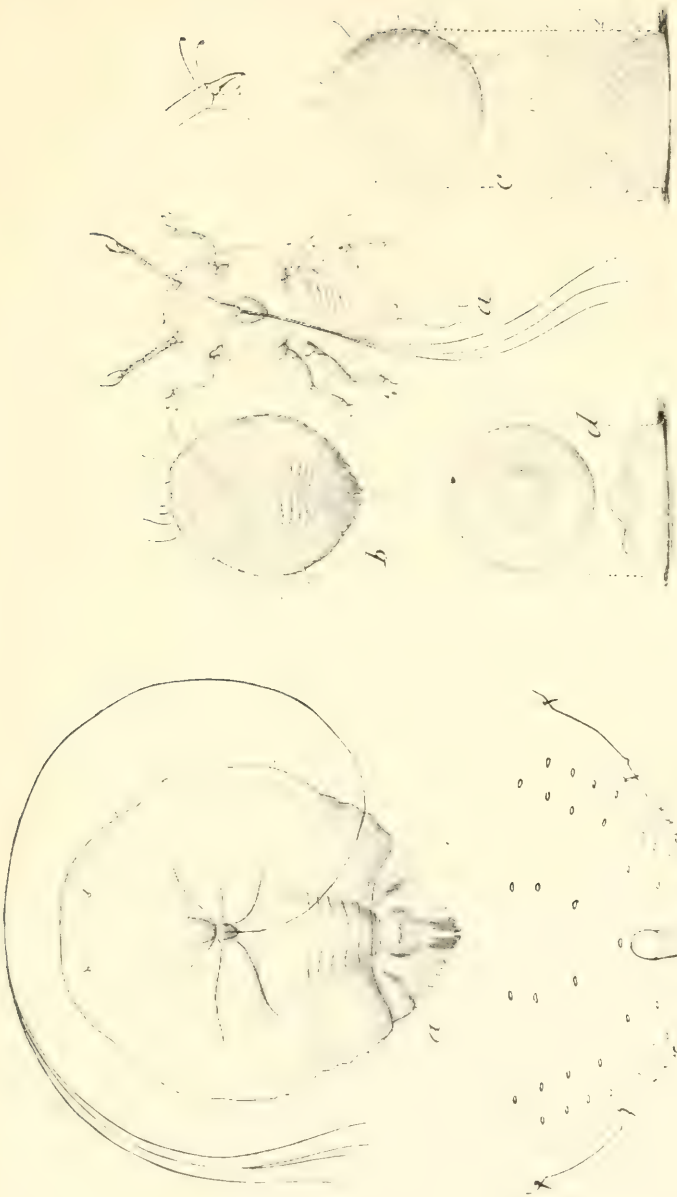


Fig. 2.

Fig. 1.

PLATE IV.

Fig. 1.

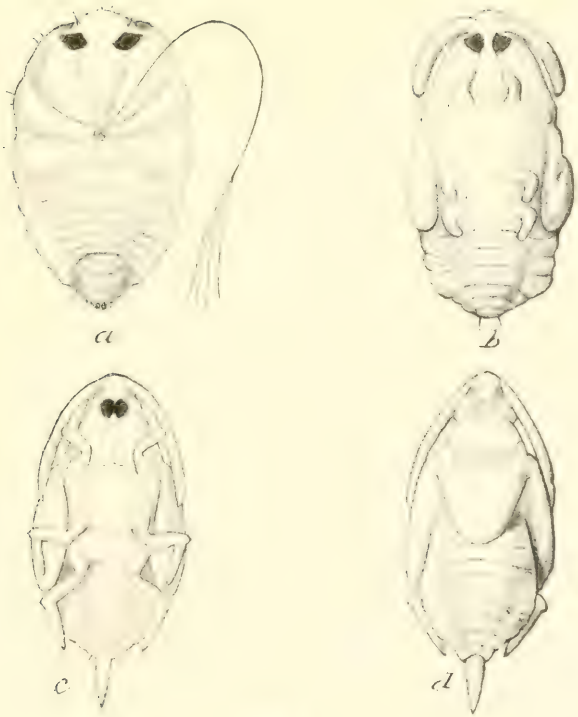
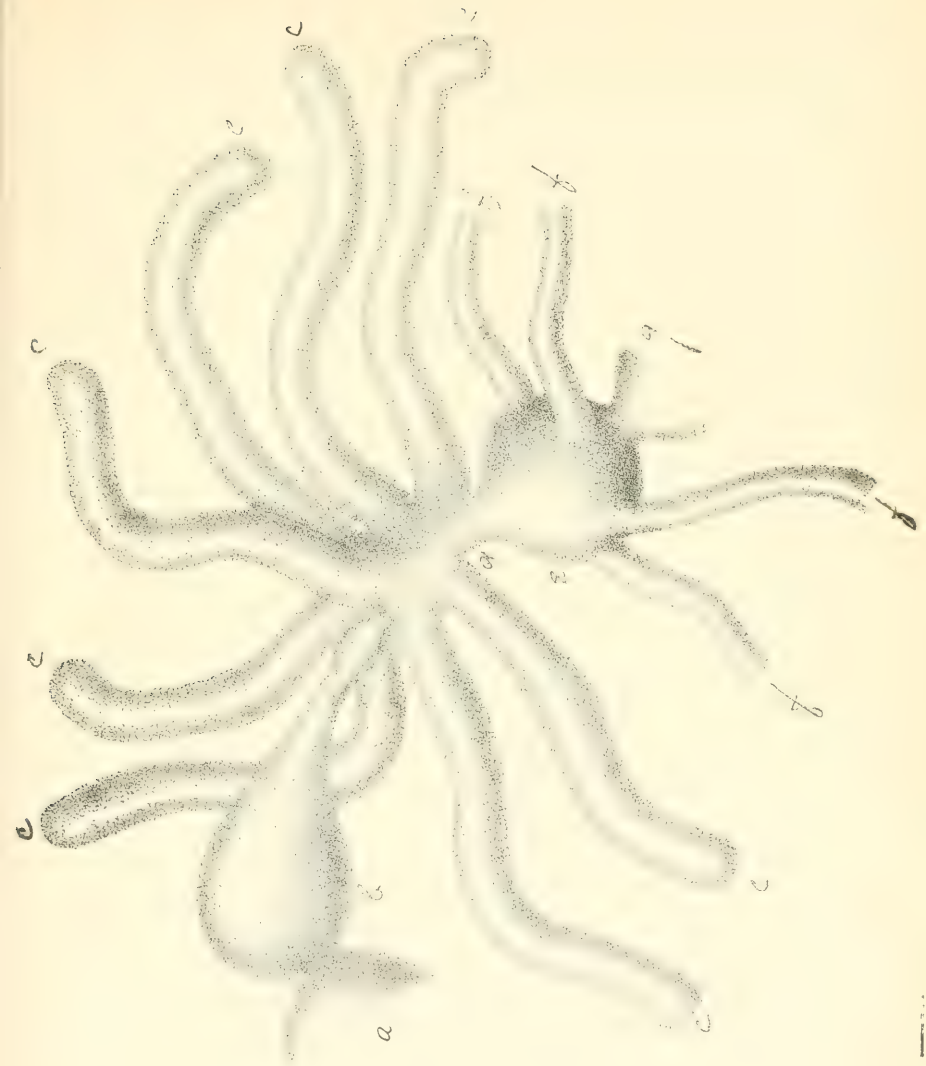


Fig. 2

Plate V.



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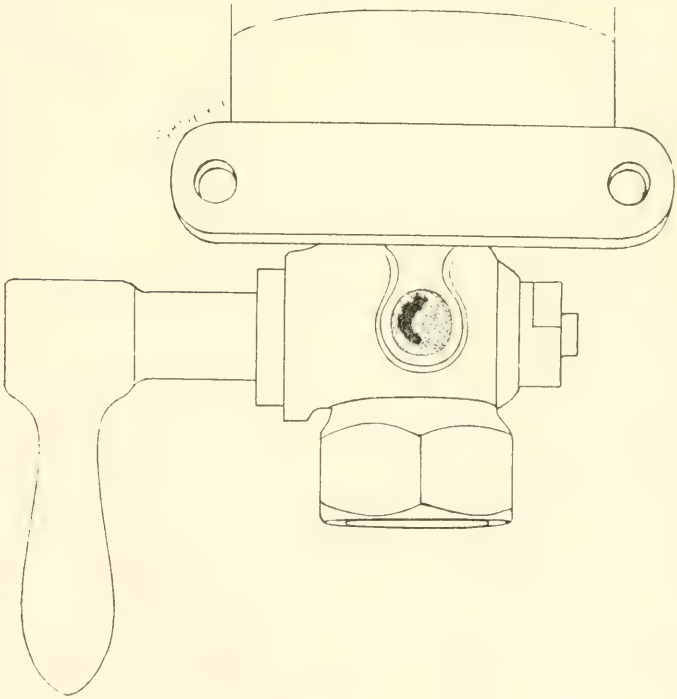


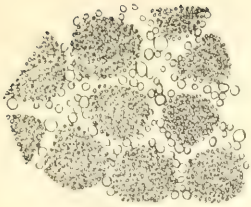
Fig. 2.

PLATE VII.

Fig. 1.

Fig. 2.

Plate VIII.



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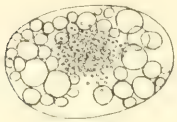
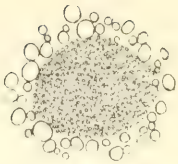


Fig. 2



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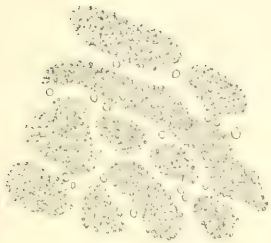

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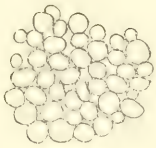

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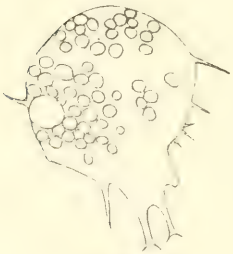


Fig. 6.

Fig. 7.

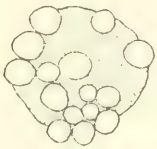


Fig. 8.

Fig. 9.

Fig. 10.

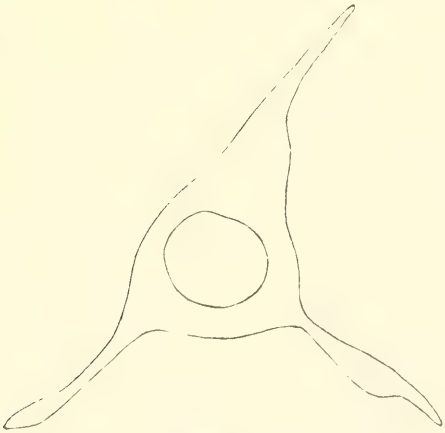
Fig. 11.

PLATE IX

Fig. 1.

Fig. 3.

Fig. 4.



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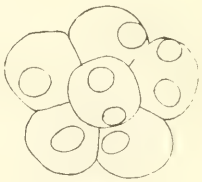


Fig. 5.

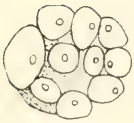


Fig. 6.

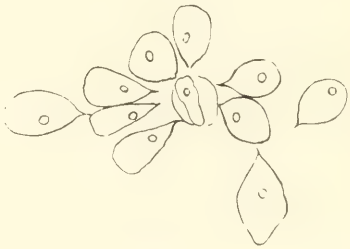


Fig. 7.

Plate X.

Fig. 1.

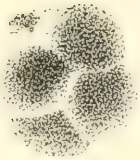
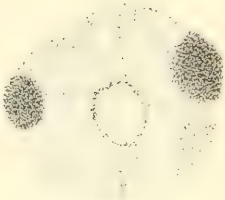


Fig. 2.



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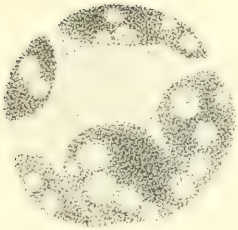

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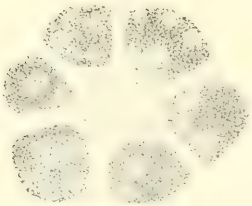
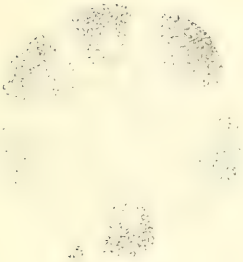


Fig. 5.



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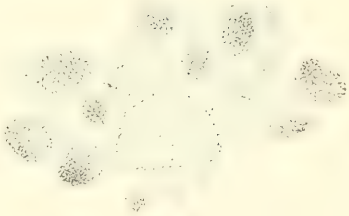


Fig. 7.

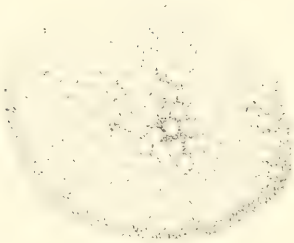


Fig. 8.

APPENDIX.

THE WHITE PINE CHERMES.*

(*Chermes pinicorticis* FITCH.)

BY E. L. STORMENT.

The University of Illinois possesses a small grove of white pines on the eastern side of its Experiment Station farm, the average size of the trees being about six inches in thickness and thirty feet in height. For several years the trunks and larger limbs of the trees in this grove have been badly infested by this white pine plant-louse, and the trunks in many instances appear as if freshly whitewashed, so thickly is the woolly excretion of the *Chermes* spread over the bark. The damage the insects have been able to inflict is difficult to estimate with accuracy, but there is no doubt that it is considerable. It is evident in the shortened leaves and the small annual growth of the tips of the branches—on the whole quite sufficient to demonstrate that the louse is of economic importance to such as appreciate the white pine as an ornamental tree.

TREES ATTACKED BY THE CHERMES.

In order that those interested may be sure of their "diagnosis," it may be well to give here some details of the appearance of trees infested by this plant-louse. So far as known at present, the insect restricts its attack to the white, Scotch, and Austrian pines, and my own observations indicate that the white pine is very much preferred. On the Experiment Station farm, growing side by side with the white pines above mentioned, is a grove of Scotch pines of about the same area. These trees show no evidence whatever of injury, though the *Chermes* is found plentifully on the white pines immediately adjoining. It is also noteworthy that the original description of the insect was made by Dr. Fitch from specimens taken from a white pine. Reports by other observers also indicate this preference—probably due to the fact that the white pine has a smooth, rather tender bark, lacking the rough outer bark found in the Scotch pine. There is, however, no doubt that under certain conditions this species does attack the Scotch pine, the observations establishing this fact being made by Professor Herbert Osborn, at Ames, Iowa. Its attack upon the Austrian pine is vouched for by the same authority.

* This paper, kindly placed at my disposal by the writer, is the product of special studies made by him while a student in entomology at the University of Illinois.—S. A. FORBES.

As I have observed the insect at work upon the white pine only, the descriptions that follow are correspondingly limited, except when they may be quoted from some other observer. In the case of the white pine, if the attack be bad the trunk of the tree is covered with a white woolly substance, excreted from numerous pores scattered over the body of the insect. When the attack is just beginning, the white patches of wool appear so similar to the hardened gum that has escaped from wounds on the tree as to deceive a careless observer. If the insects are not so numerous as to cover the bark, this resemblance to scattered drops of resin is perfect when viewed at a distance of three or four feet. Examined with a lens, the woolly mass is seen to be filamentous and "crinkly," much as true wool appears. When touched it is found to be sticky and to stain the skin dark. Water does not dissolve it; ether does, but not readily. The distribution of the "wool" on the tree, since it accords with the distribution of the insect, is worth noting. To some extent it is found on all parts of the trunk and branches, but is usually more abundant on the northern exposure of the trunk, around the bases of the limbs, beneath the limbs, and just at the bases of the leaves. No experiments were made by me to determine the causes of this distribution, but the tendency to seek the under side of the limbs and their bases indicates a desire to escape the sunlight. The upper side of a limb is usually entirely free from the insects, except just at its base, and even on the lower side the area of attack does not extend beyond the point where the limbs taper to about one half or three quarters of an inch. This leaves from two to four feet of the ends of the branches free from the insects except the small area of new growth about the bases of the leaves.

GENERAL DESCRIPTION OF THE INSECT, ITS FEEDING HABITS, AND ITS CLASSIFICATION.

During the winter months the wingless female may be seen under the "wool," sometimes alone, as noted by Professor Osborn, but more often in the company of several others, as stated by Dr. Fitch. These females may or may not be fixed by their long sucking beaks to the bark, according to the time the observation is made. If in the spring, the beak will be found inserted. About the middle of April the female is usually surrounded by a mass of yellowish or brownish eggs. The insect itself is quite small (0.51 mm.) and dark in color, the head and thorax varying from brown to black and the abdomen being yellowish, shading to brown on the segments next the thorax. The form is depressed or spherical, in either case approaching a circular outline when viewed dorsally. When in its natural position on the bark there may be some difficulty in distinguishing the insect. Dr. Fitch said it was invisible with the naked eye, but when free in the white wool, or when placed on a piece of white paper, it may be easily seen. During this period of its life history the power of locomotion is very slight. When placed upon its back, the insect is quite as unable to right itself as a tortoise in the same position would be, and for the same reason—

the shortness of the legs. The young larval forms, appearing during the latter part of April and the first days of May, move easily and with considerable rapidity.

In its zoölogical relations, the insect belongs to the order *Hemiptera*, family *Aphididæ* (plant-lice). It is peculiar to North America, so far as known. The insects of this order are easily recognized by their sucking beak, and it is by this beak that *C. pinicorticis* causes injury to the pine. After a short period of active movement immediately following the time of hatching, the young larvæ insert their beaks into the bark, and begin sucking the sap of the tree. As there are immense numbers of the larvæ the effect is soon noticeable in a marked retardation of the growth of the tree, and sometimes in its death. Their presence causes a lessened yearly growth, both in diameter and height; the leaves are thinner and shorter, often tinged with yellow, and the limbs are more slender than is natural. To these results, particularly bad in an ornamental tree, must be added the disagreeable appearance of the sticky white secretion, which stains whatever it touches. Finally, when the injury is at its worst the lower limbs die and fall away, leaving unsightly scars, and exhibiting in all its ugliness the spotted, striped, diseased trunk, capped with a small and sickly crown of branches at its top. When an ornamental tree has reached this condition its death is as certain as it is desirable.

ECONOMIC IMPORTANCE AND GEOGRAPHICAL DISTRIBUTION.

Under ordinary conditions it is not probable that this *Chermes* is able to kill the tree outright. There are a number of insects (some of which are mentioned further on in this paper) that find the *Chermes* quite as good food as the *Chermes* does the pine. Usually these enemies, taken in connection with climatic checks, prevent an attack from being absolutely fatal, but seldom or never can do more. In the grove referred to the injury has been continuous for several years and the appearance of the trees presages their final destruction. A few trees separate from the grove show a much less virulent attack, but the injury is still quite apparent. In general the *Chermes* seems to be able to maintain itself against its enemies, and to take full advantage of any favoring circumstances which may disturb for a time the "balance of power" in its life relations. The rapid multiplication of plant-lice—most of which, as is well known, produce several or many generations during the season—enables them to take immediate advantage of any cessation or weakening of opposition on the part of their natural enemies, however slight it may be. This peculiarity may at any time elevate *Chermes pinicorticis* from the rather subordinate position it now occupies economically to one of prime importance to those who possess or admire any of the species of pine which it attacks.

The latter consideration makes its geographical distribution a matter of interest. Presumably the original description by Dr. Fitch was made from specimens taken in New York, and his statements indicate that the attack was severe. Dr. Shimer reported it

from Mt. Carroll, Illinois; Dr. Lintner, from Albany and Tivoli, New York; Professor Osborn, from Ames and Ft. Dodge, Iowa; Dr. S. A. Forbes, from Champaign, Illinois, and Prof. W. G. Johnson, observed it at Hamilton and at Normal, Illinois—in the former locality not numerous, in the latter plentiful. Other localities reported from Iowa are Iowa City and Muscatine, the observers being, respectively, Mr. Lathrop and Mr. Foster. The attack at Ft. Dodge was a severe one. Doubtless this plant-louse is much more thoroughly distributed than these reports indicate, for it is not probable that it would appear in states so widely separated as New York and Illinois and be absent from the intervening territory.* It is noticeable that the places reported are all in the zone of deciduous trees. If further reports should similarly circumscribe its distribution, it would indicate another host plant. More information in regard to the distribution would be of much value.

NATURAL ENEMIES OF THE CHERMES.

The natural enemies of *Chermes* are numerous and active. Those coming under my own observation are as follows: An unknown species of *Syrphus*; *Chrysopa robertsoni* Fitch, and an unknown species of the same genus; *Hemerobius alternans* Fitch; *Leucopis simplex* Loew; *Chilocorus bivulnerus* Muls; and *Megilla maculata* DeG.

Of these, all but the last two were plentiful, the *Syrphus*, *Chrysopa*, and *Hemerobius* larvæ being especially destructive. Regarding the *Leucopis* there still remains a shade of doubt, owing to the fact that I did not succeed in observing it actually destroying the *Chermes*; but the circumstantial evidence points strongly to the conclusion that it does. The ladybirds were not at all plentiful although observed in quite large numbers at a distance of half a mile from the grove busily feeding on the pine scale *Chionaspis pinifoliæ*. Just at the time my observations ceased the ladybird larvæ began to increase in the grove, but were still far from plentiful.

I was unable to rear the *Syrphus* larva to maturity and am therefore ignorant of the species. It may be known in this connection, however, by its elongate, wedge-shaped form; by its size—about one half inch in length; by its habit of marking itself with the woolly excretion of the *Chermes*, and by the absence of feet. In addition to these means of identification, there are two movements which are quite characteristic. In locomotion the body is extended, the anterior end (armed with very small jaws) is pressed against the surface on which it is traveling and to which it adheres by means of a sticky secretion, while a muscular retraction of the mouth and a small area immediately surrounding it forms a sucking disc by which the larva remains attached while the posterior end is brought

*Since the above was written I have received a letter from Professor Johnson confirming this opinion as to its distribution. Professor Johnson says: "It may interest you to know that the same plant-louse is not an uncommon thing in Maryland and the District of Columbia. I saw it also on pines on the campus of Cornell University, Ithaca, N. Y."

At about the same time that Professor Johnson reported its presence at these places I observed several trees near Ticona, Ill. (La Salle Co.) which were badly infested, and noticed signs of its presence in Putnam Co., nine miles southwest of Ticona.

forward and fastened in its turn. The other characteristic motion is due to the fact that the larva is blind. When feeding, after the posterior end has been attached in the manner described, with this as a center and point of support, the anterior, or oral, extremity moves through an arc of about 120°, touching the surface on which the larva rests several times while so moving. If during this movement it should happen to touch any living thing the small jaws fasten upon it and the fluids of its body are extracted by the sucking process described above.

So far as observed *Syrphus* larvæ are not choice regarding their food, attacking with absolute impartiality all soft-bodied insects that are unfortunate enough to fall in their way, including even their own kind. Although *Syrphus* larvæ were so plentiful in the cages and on the trees, I did not succeed in getting them to pupate in the former and observed but two puparia on the latter. One of these was lost, and from the other emerged ten specimens of the parasite *Syrphoctonus pleuralis*. *Pachyneuron semiauratus* Ashm. emerged from a jar in which several specimens of *Syrphus* had been placed.

The two *Chrysopa* larvæ may be known by their long curved jaws, spindle-shaped body, about one-half inch long when grown, free from the woolly excretion of the *Chermes*, and without the peculiar movements of the *Syrphus* larvæ. Usually there are some yellowish markings on the side of the full grown larvæ. They will be found burrowing under the "wool."

The larva of *Hemerobius alternans* (Pl. II, Fig. 7) may be known by its close general resemblance to that of *Chrysopa*, differing, however, in having spines on the back. These spines, or hairs, becoming entangled in the woolly excretion of the *Chermes* form so effectual a mask that the larva is often not apparent to a trained eye until it moves, and is doubtless concealed when at rest, from eyes more directly interested in its discovery than are those of man. In the vigor of its attack on the *Chermes* it is second to neither *Chrysopa* nor *Syrphus*.

An indication of the presence of the *Syrphus*, *Chrysopa*, or *Hemerobius* larvæ is a change in the appearance of the "wool." Early in the spring it lies close to the bark, and is compact in texture; but since all these larvæ burrow in it in search of the *Chermes*, soon after their advent it becomes loose and hangs in tangled masses.

The eggs of none of these natural enemies were obtained except those of *Chrysopidæ*. These were found in abundance on the bark of the trees and on dead leaves adhering to the bark. They may be easily recognized, each egg being borne on a stalk, both egg and stalk being white.

When the trees were first examined (March 30), scattered thickly through the "wool" were found many empty puparia about one tenth inch in length and of a light grayish color. Later in the season these were ascertained to belong to a small fly, *Leucopis simplex*, Loew. These flies were by far the most numerous of all insects observed to sustain any close biological relationship to the *Chermes*.

As stated above, the evidence that the *Leucopis* preys upon the *Chermes* is circumstantial. The larvæ are found under the "wool," being very seldom seen without removing the latter. This may be done with a penknife, and at the times of the year hereafter given* a careful search will almost certainly reveal several of these minute maggots, of a bright red color, so small that it is necessary to magnify them to make observations at all satisfactory. They have little power of locomotion and usually die soon after being removed from the "wool." The puparium is found in most cases on the upper surface of the "wool," is light red at first, passing through dark red to dusky, and becoming grayish when the fly emerges.

The adult ladybirds are so well known to all as to need no description further than to give the distinguishing marks of the two species named above. These descriptions are adapted from the Sixth Report of the State Entomologist of Illinois, by Dr. Cyrus Thomas, in which *Megilla maculata* is characterized as follows:

Body somewhat elongated, thorax much narrower than wing cases, ground color pink or reddish yellow, two black spots on the thorax and ten on the wing cases, four on each case and two on the suture; length one fourth to three tenths of an inch.

Chilocorus bivulnerus is somewhat smaller, about one-fifth of an inch in length, almost perfectly hemispherical in form, of a deep polished black color, with a single blood-red spot on each wing cover.

The larvæ are not so likely to be recognized by those interested as are the adults. "They are rather short and somewhat thickened grubs, with numerous prickles or spines, not in a single row along the sides but in several rows. They are sometimes gaily colored, but usually rather dull."

There are other insects which have been ascertained or suspected by other observers to attack the *Chermes*, which have not been certainly noticed in the University grove. Professor Osborn observed a mite belonging to the genus *Oribates* which was probably feeding on the *Chermes*, describing it as "jet black, hard and shiny, and almost globular in form;" and he thinks there is a strong probability that the mite *Iscarus malus* (a natural enemy of the oyster-shell bark louse of the apple), which he placed upon a pine began to feed upon the *Chermes*. Dr. Shimer names in this connection *Scymnus terminatus* Say; an unknown species of *Scymnus*, the latter parasitized by a chalcid fly which he named *Eulelus? scymnæ;* and *Smilia misella* Zimm. Professor C. V. Riley refers (5th Annual Rep., p. 100) to "the larvæ of certain small ladybirds" as attacking the *Chermes*, and on page 101 more definitely mentions *Coccinella picta* Rand. Dr. Shimer also mentions *Camaronotus fraternus* Uhl.—a plant-bug which in the larval state "resembles a brown ant" and is equal to the ant in activity—as doing its share toward the destruction of the *Chermes*.

* See tables, pp. x, xi.

KEYS TO LARVAL AND PUPAL FORMS OF NATURAL ENEMIES.

As a key that will enable any one interested to distinguish the principal insect enemies of *Chermes* may be of value, one is here inserted. It is founded on larval peculiarities, since it is in this stage that they are apt to be observed.

a.—Larva very small, bright red, footless.—*Leucopis simplex.*
Larva larger, not red.—b.

b. Larva widening toward the posterior extremity, footless, usually covered with woolly excretion of *Chermes*, jaws very small.—*Syrphus.*

Larva short, thick, several rows of spines, body of nearly the same diameter throughout, possessing feet.—*Ladybirds.*

Larva slender, tapering at each end, jaws large, curved.—c.

c.—Larva spiny, with "wool" on the back.—*Hemerobius.*
Larva not spiny, usually clear of "wool."—*Chrysopa.*

To this key is added another by means of which the pupal stages of the same insects may be distinguished.

a.—Pupa inclosed in a silk cocoon, spherical, opening by a circular lid.—b.
Pupa not inclosed in a cocoon, not spherical.

b.—Cocoon of white silk.—*Chrysopa.*
Cocoon of brown silk.—*Hemerobius.*

c.—Attached by the side.
Attached by one end, often possessing the power of motion.—*Ladybirds.*

d.—Small, $^1/_8$ in. or less, reddish or grayish color, opening at end.—*Leucopis.*
Larger, $^1/_5$ to $^1/_4$ in., brownish.—*Syrphus.*

COMPARATIVE LIFE HISTORY OF THE CHERMES AND ITS ENEMIES.

The important events noted in the life of the *Chermes*, up to June 10, when my observations ceased, are given in the accompanying tables (pp. x, xi).

Attention is called to the following facts exhibited by this calendar:

1. There is a period of a few days in early spring when the *Chermes* is comparatively free from attack, though its enemies are no doubt present. The larvæ of *Leucopis* were on the pines in small numbers, and the adults of *Chrysopa*, *Hemerobius*, and the ladybirds were observed in numbers in other locations at this time.

2. The severity of the attack reaches its climax at the period when the larvæ of the *Chermes* are attaching themselves (Apr. 26). At that time the *Chrysopa* and *Syrphus* larvæ are destroying great numbers. Moreover, although not observed at the time, an inspec-

Life History of Chermes pinicorticis and its Enemies from March 25 to June 10.

Date.	Chermes pinicorticis.	Chrysopa.	Syrphus.
Winter	Apterous female hibernating		
March 25	Apterous female feeding		
March 29		Adults plentiful (not observed among pines)	
April 8	Egg-laying begins		
April 15	Hatching begins	Chrysopa larvæ begin attack	Larvæ begin attack
April 18			
April 22			
April 25		Attack at its height	Attack at its height
April 26	Young begins to attach themselves		
April 30			Attack decreasing
May 1	Apterous females disappear		
May 7	Hatching ceases		
May 8			
May 9	Winged adults begin to appear		
May 10		Pupation observed	
May 12		Eggs plentiful	Larvæ have disappeared
May 15			
May 17	Larvæ all attached		
May 18		Larvæ of brood of April 15 disappear	
May 19			
May 22		Adults begin to emerge. Brood of April 15	
May 23	Winged adults disappear		
May 27			
May 29		Adults cease to emerge. Brood of April 15	
May 30			
June 8		About this date larvæ from eggs of May 12 will be in full attack	
June 10			

Life History of Chermes pinicorticis and its Enemies Concluded.

Date.	Parasites of Syrphus.	Leucopis simplex.	Hemerobius alternans.	Chilocorus bivulnerus and Megilla maculata.
Winter				
March 25				
March 29		Larvæ observed on pines	Adults seen outside the grove	Adults seen outside the grove
April 8				
April 15				
April 18				Adults (few) in the grove
April 22		Adult emerging		
April 25				
April 26				
April 30				
May 1		Adults cease to emerge		
May 7				
May 8			Adults observed	
May 9				
May 10				
May 12		Larvæ at work (2nd brood)		
May 15			Larvæ (2nd brood) began work about this date	
May 17	*Syrphoctonus pleuralis Cr.* emerged			
May 18				
May 19	*Pachyneuron semiauratus* Ashm. emerged			
May 22		Adults of 2nd brood emerging		Larvæ at work, but comparatively few
May 23			Attack at its height	
May 27				
May 29			Pupating	
May 30		Adults of 2nd brood cease to emerge		
June 8				
June 10		Larvæ on the trees (3rd brood)		

tion of the dates of the life history of *Hemerobius*, as shown in the calendar, indicates that the larva of this insect may have been at work at about the same time.

3. A little later (middle to the last of May) the attack is taken up by *Leucopis simplex* and *Hemerobius alternans*, reaching in its turn a climax of severity, about May 23, scarcely less acute than that of the preceding onslaught. This period covers that during which the young of *Chermes* progress to the winged form and lasts until the latter disappears.

4. The complete series of transformations in the *Chermes* extended from April 8, when egg-laying began, to May 9, when winged adults began to appear—a period of one month. This history seems to be reflected to a certain extent in the lives of its destroyers. Thus, the *Chrysopa* attack lasts from Apr. 15 to May 18; *Syrphus*, from Apr. 18 to May 12; *Leucopis*, adult to adult, Apr. 22 to May 22; *Hemerobius* adults observed May 8, pupation May 29. In the last two the period of feeding is somewhat shorter than one month, but will not fall below three weeks if we consider the history of the species as a whole and not the life of an individual merely.

5. It will be further noted that this difference of about one week in the length of the attacks made by *Leucopis* and *Hemerobius*, consequent upon their shorter periods of transformation, results in distributing the total attack of the combined enemies of *Chermes* through the entire time from the opening of spring to the disappearance of the winged form, May 23.

Of the relations existing among the enemies of *Chermes* themselves, it may be said that the *Chrysopa*, *Syrphus*, and *Hemerobius* probably prey upon the *Leucopis*, as the first two certainly do upon each other and the *Syrphus* upon its own kind.

USE OF INSECTICIDES.

An examination of the calendar indicates that the best time to destroy the *Chermes* with insecticides is probably in the winter or early spring. If force enough be applied to the spray the presence of the "wool" need not be disadvantageous, and if the spraying be done in the winter the natural enemies of the *Chermes* will escape the application. But one experiment has been made at Urbana in this line. The kerosene emulsion was used, the spray being applied May 8, 1895. At this time the eggs had not hatched. Professor Johnson, who made the experiment, records that no lice had made their appearance, up to Aug. 7, on the tree treated, while all other trees that had been infested were covered by them. This experiment seems to be conclusive not only as to the lice but as regards the eggs also.

SOME VARIATIONS IN LIFE HISTORY.

Professor Osborn does not give us the periods of any of the natural enemies but records that of *Chermes pinicorticis* as follows:

1878.	1879.
Apr. 15. Found eggs and adult females.	
Apr. 20–24. Eggs hatching rapidly, larvæ traveling.	
May 6. Larvæ attaching themselves to the bark.	
May 13. Becoming densely covered with woolly substance.	May 13. Lice well developed, parasites at work, eggs unhatched.
	May 16. Young hatching and traveling.
May 21. Winged males* noticed for the first time.	May 21. Egg clusters, newly hatched larvæ, winged males.
	May 27. Egg clusters and living females on new growth of wood.
June 3. Winged males disappeared.	
June 10. Lice almost entirely disappeared; after this none observed during the summer, but adult females probably present in the fall.	
	Oct. 9. Adult females abundant, a few eggs, and an occasional larva.

The presence of the eggs late in the autumn led Professor Osborn to think at first that the *Chermes*, in part at least, passed the winter in this form, but he adds that no eggs could be found Jan. 15, when the apterous female was abundant. In a later paper he states that he has seen nothing to warrant Dr. Shimer's opinion that "the normal winter condition of the species is the egg, and that these are on the ground." My own observations revealed no eggs in the latter part of March, but a few larvæ were found. Mr. John Marten, in an unpublished note dated Jan. 9, says he made a careful examination of the insect in the University grove at Urbana, and gives in some detail the hiding places of the apterous females but does not mention the eggs. Taken together, these observations leave no doubt that the apterous female is the winter form of this *Chermes*.

The winter of 1896 broke up earlier than usual, and this fact will probably explain the difference of seven to ten days between the various dates in the life of the *Chermes*, as recorded by Professor Osborn in 1878 and by myself in 1896. The intervals between the successive dates in the records kept by each are not so divergent as to be irreconcilable. The time from the beginning of hatching to the attachment of the larvæ is given by him as sixteen days and in my record as eleven; from egg-hatching to appearance of winged form is in his record thirty-one days, in mine twenty-four; but to my date five more days should be added to reach the time when they were appearing most rapidly. Professor Osborn's record gives twelve days' existence for the winged form, mine fourteen.

Professor Osborn's record for 1879 shows a peculiar condition of the lice, one quite at variance with that of the previous year. The eggs were still unhatched seven days later than the time when the larvæ had begun attaching themselves to the bark in 1878, and twenty-three days later than the hatching had begun in that year. *Nevertheless*,

* In a publication issued on this subject in 1884 by Professor Osborn, he states that he has been unable to distinguish male and female in the winged form. It is probable that this form consists of females only.

the winged adults appeared on the same date in each year. At Urbana, according to Professor Johnson, the eggs had not yet hatched May 8, 1895. Such variations as these suggest quite a marked susceptibility to meteorological influences, but just what these influences are the notes do not indicate. One might conjecture, however, since the insects pass the winter in almost complete exposure to the weather without serious injury, that the effect of the climate upon them is possibly quite as much indirect (through the deferred elaboration of the sap of the tree) as direct—through the cold.

DESCRIPTIVE.

In preparing the following descriptions I have made free use of those given by previous students of this insect, adding notes and comments whenever my own observations are divergent.

The Eggs.

"The eggs, found in downy balls, vary from five to sixty or more in number; usually, however, they are few. They are yellowish, slightly ovate, with a longitudinal diameter of 0.34 mm. and transverse diameter of 0.17 mm. In development the mouth parts are first apparent, and afterward antennæ and legs appear, these being fully developed by the time the larva breaks the egg-crust."—OSBORN.

Eggs examined by Professor Johnson at Urbana April 18, 1895, were "0.38 mm. × 0.19 mm.; color brownish or amber; surface rather smooth, but covered more or less by threads of the woolly excretion." My own measurements of the width vary from 0.156 mm. to 0.173 mm. and of the length 0.312 mm. to 0.346 mm., an average of all measurements made being 0.163 mm. × 0.329 mm. The color of the eggs varies slightly from yellowish or amber to brownish amber, sometimes with a reddish tint.

On April 17 sixty-four eggs were taken from the trees and divided into three groups, consisting of twenty, twenty, and seventeen eggs respectively. Each group was placed on one of the ordinary glass slips used in microscopic work, and surrounded by a ring of albumen fixative, which interposed an effectual barrier to the escape of the larvæ when they should be hatched. The slides were examined every morning until hatching had certainly ceased. From the first were taken nineteen larvæ, from the second twenty, from the third thirteen, giving a total of fifty-two or 81¼ per cent. of the eggs originally placed on the slides.

By means of slides prepared in the same way, four experiments were made for the purpose of determining the period of incubation. The following are the results in tabulated form:

No. of Exp.	Date of Deposition.	Date of Hatching.	Period of Incubation.
1	Between April 17, 10 a. m., and 18, 9 a. m.	Between April 23, 10 a. m., and 24, 8 a. m.	121 hrs. min... 166 hrs. max..
2	Between April 18, 12 m., and 20, 8 a. m.	April 25, before 8 a. m.	120 hrs. min... 164 hrs. max..
3	Between April 28, 10 a. m., and 29, 8 a. m.	May 5, before 8 a. m.	144 hrs. min... 166 hrs. max .
4	April 29, 10 a. m.	May 5, between 10 a. m. and 5 p. m.	144 hrs. min... 151 hrs. max..

In experiment No. 4 the egg was found still adhering to the abdomen of the female and was observed not to be hatched at 10 a. m. May 5, but by 5 p. m. of the same date the larva had emerged. The time required for incubation, therefore, is probably about six days, though it will vary no doubt as external conditions change. I was unable to determine the number of eggs deposited by an apterous female in the course of the season, but believe it to be nearer sixty than five.

The Larvæ of the Winged Form.

"The larvæ when first hatched are oval in shape, flattened, yellowish, or light brown. Professor Riley in his manuscript notes says 'purple-red,' but I have not been able to detect this color. The antennæ are three-jointed; the first joint is short and thick; the second is slightly longer and not so thick; the third is three times as long as the first and half as thick, set with a few stiff hairs at the apex, one being two thirds the length of the joint; also a few lateral hairs. Near the end of this joint are a few transverse marks or ridges extending part way around.

"The mouth parts are well developed; there is a long sucking tube, twice the length of the body, inclosed in a sheath extending under the body nearly to the end of the abdomen. The sheath is apparently four-jointed, sparsely set with stiff hairs, mostly at the apex; the legs are of moderate length, coxa short and thick, femur and tibia equal; tarsus one-jointed, half the length of the tibia, ending in two short ungues surrounded by digitula (knobbed hairs). There is a short hair or seta on the outer angle of each abdominal segment. Length, 0.38 mm.; width, 0.19 mm.; antennæ, 0.12 mm.; legs, 0.15–0.18 mm.

"As these larvæ grow they become darker in color, assuming a deep red-brown, and finally almost black, appearance, while the woolly substance develops thickly on the abdominal segments and also on the meso- and metathorax, entirely hiding the insect, which thus appears like a ball of white down. The substance develops from gland-like surfaces arranged sub-dorsally on each segment, the abdominal segments having also a lateral row of smaller surfaces performing the same office."—OSBORN.

All newly hatched larvæ observed at Urbana were yellow; antennæ three-jointed, thick and fleshy; first and second joints about the same size, the three diameters of each apparently equal, the width, however, in rare cases, exceeding the length, also the second joint sometimes exceeding the first in all dimensions. The third joint appears as described by Professor Osborn, except that the edge is usually irregularly serrate, and the joint shows throughout its extent the rings he mentions as being near its distal extremity. The distal extremity bears four hairs, one long and the others about half its length. Two or three other very short hairs were observed along the edges of this segment. At the posterior distal angle of the second segment another short hair is located, while four others are visible along the cephalic margin of the head, and still another at the latero-cephalic angle. The eye consists of three ocelli. The hairs on the margin of each abdominal segment are the same in my specimens as in Professor Osborn's. I notice, however, that the two hairs at the caudal extremity surpass the others in length and thickness. (Plate II, Figs. 1 and 3.)

The sucking tube is usually bent on itself, the extreme end only being inserted into the sheath. The tube is composed of three filaments. The tarsus appears to be free from rings with the exception

of a slight shaded line near the base, suggestive of another segment. Above the claws is a hair nearly equaling the tarsus in length; one other hair is visible on the same side toward the proximal end; while the under side of the tarsus carries a hair, located a short distance toward the tibia, and still nearer to the tibia four comparatively long hairs are visible. A few hairs are also visible on the femur and tibia. (Plate II, Fig. 2.)

The Pupa of the Winged Form.

"The pupæ are similar to the larvæ with the exception of the wing pads. The thorax is yellowish or reddish, the wing-pads yellow from the wings showing through, and appear washed with brown from the darker color of the outer membrane. The abdomen is reddish, darker than the thorax. Occasionally patches of woolly substance are seen on various parts of the body. The antennæ are folded back against the head, though not joined; the legs are free." —OSBORN.

No study of the pupæ was made at Urbana.

The Winged Form.

"The winged form is, when it first issues from the pupa, light reddish in color, the wings are very white, expanding rapidly and becoming transparent, while the body gradually becomes darker till nearly black. The antennæ are five-jointed, short; the tarsi one-jointed with rudimentary first joint and two ungues. The wings are four, folding roof-like over the body, the anterior ones being furnished with a strong sub-costal vein which is branched at one third the distance from the base, the lower branch running parallel for some distance, then turning obliquely toward the posterior margin; also from this branch two oblique discoidal veins running to the posterior margin. The stigma is indistinct. The posterior wings have a sub-costal vein with no branch veins. This venation applies to the inner structure of the wing when magnified forty or more diameters. Under a simple lens of low power and without transmitted light, the venation appears quite different and is as follows: A strong vein running to the costa slightly before the apex and sending a short oblique branch to the costa at about its middle, inclosing the stigma. From the main vein three oblique veins passing to near the posterior border of the wing. There is a slight fold of the posterior border at the termination of the first oblique vein for the reception of the costal hook of the hind wing. The hook on the front border of the hind wing which slips into the fold of the front wing, holding the two wings together so that they may act as one, is composed in this species of two curved rods of chitine."—OSBORN.

Some variations from the above description are shown by the specimens taken at Urbana. In a number of them the subcostal vein does not branch, the vein spoken of by Professor Osborn as a branch lying close beside the subcostal and extending to the base of the wing (Plate 1, Fig. 4). In others it appears as a branch. The curved rods of chitin on the hind wing are *usually three*, sometimes two, in one case three on one wing, two on the other. Average measurements were as follows: Entire insect 0.46 mm. × 0.92 mm.; front wing 1.4 mm. × 0.6 mm.; hind wing 0.95 mm. × 0.33 mm.; antennæ 0.23 mm.; tarsus 0.07 mm.; tibia 0.26 mm.; femur 0.19 mm.

The leg of the adult winged form has its femur and tibia covered with scattered tubercles, each tubercle bearing a hair; these tubercles are thick on the tibia, fewer on the femur, none on the tarsus. The

tibia ends in a cup-like expansion receiving the tarsus, which is articulated to the former by what appears to be a rudimentary first joint. The tarsus is serrate and ringed, bearing a few hairs in positions shown in the drawing. A small trochanter is present in its usual position. (Plate 1, Fig. 2.)

The Apterous Female.

"The apterous female is not fixed, but enclosed in a woolly mass which adheres to the bark. The legs and antennæ are persistent, comparatively small. The antennæ are three-jointed, and the tarsi one-jointed, terminated by two ungues. The body is elongated, pyriform during egg-laying; contracted to a globular or flattened form afterward or in winter."—OSBORN.

My observations lead me to think that the apterous female is often, though not always, free from the bark during the winter months. When spring opens the tube is inserted and the insect remains fixed for the remainder of its life. The long sucking tube found in this form is similar to that of the larva before described, but the sheath differs slightly. The sheath of the apterous female lies in a fossa formed by the coxa and their supporting sclerites. No differences of importance were discovered in the three pairs of legs; all are very short, so short that the insect can not right itself when placed upon its back. The thickness of the femur is about two thirds its length, the tibia is as long as the femur but more slender, the tarsus about one half the length of the tibia. Both tarsus and tibia showed a few hairs, such as were observed being shown in the drawing (Plate III, Fig. 4) in proper position. As in the case of the larval tarsus, but one ring is visible on the tarsus of the apterous female, and that one so situated as to once more suggest a first joint. A curious notch is visible just at the base of the two claws.

Average measurements of insect before egg-laying period were 0.51 mm. ×0.345 mm.; sucking beak, 1.385 mm. Measurements during the period of egg-laying were: width, 0.485 mm. to 0.605 mm., length, 0.52 mm. to 0.71 mm., averaging 0.55 mm. ×0.60 mm.

The ventral surface of the abdomen shows six segments, the last being widest. Color, before the period of egg-laying, brown to black on head and thorax, abdomen yellowish, shading to brown on the cephalic segments. The "spinnerets" or excretory pores are disposed with regularity on the abdomen, a double row down the back and a single row on each side of the body, none on the ventral aspect. On the thorax the arrangement is different, the groups of pores being on both ventral and dorsal surfaces. The ventral surface of the caudal third of the thorax is free from pores. These pores, from which the woolly excretion so often mentioned comes, are arranged in groups, each group occupying a small circular elevation or papilla, the papillæ being in turn gathered into groups of from four to twenty. From this form of the pores, the inference is that the fibers of woolly material excreted really consist, like the spider's web, of numerous fine threads which cohere into one.

B. E.

SOME GENERAL OBSERVATIONS.

There have been some remarkable differences of opinion in regard to this insect, which deserve brief attention here. Some of these differences may be easily explained, others not so easily.

Dr. Fitch, in his original description, says, "The insects are wholly imperceptible to the naked eye," and gives their measurements at a little more than .01 of an inch. Dr. Shimer also says, "The insect is quite a minute creature, and is not readily seen without the aid of a lens." Professor Osborn calls attention to the statement of Dr. Fitch, adding that it is quite an easy matter to see the eggs even, much more, then, the insect itself, with the unaided eye. This is very evidently true; the difficulty in seeing the insect arises mostly from the protective coloration.

Dr. Fitch observed them upon the white pine, most numerous upon the trunk, absent from spots where the direct sunlight fell. Professor Osborn notes (1879) that they infest the Scotch pine, being most numerous upon the small twigs, and avoid the white pines. My own observations sustain Dr. Fitch, both as to the tree infested and the distribution thereon. Though the Scotch pines grow immediately beside the white in the grove at Urbana, yet, so far as I was able to learn, the *Chermes* were not found at all upon the former.

In the matter of classification, Dr. Fitch placed the apterous female among the *Coccidæ*, naming it *Coccus pinicorticis*. Later, when he discovered the winged form, but without recognizing its connection with the apterous female, he named it *Chermes pinifoliæ*. Dr. Shimer in 1869 pointed out its connection with the apterous female, but meanwhile Mr. Walsh confused it with *Aspidiotus pinifoliæ*. Professor Osborn confirms Dr. Shimer's statement, and here again he is, without doubt, correct.

Dr. Fitch says of the winged form, that the females remain seated upon the pine needles, with the head toward the base, until they die, covering the eggs. No such habit was observed at Urbana. Shortly after the appearance of the winged form, all the lice disappeared completely. If any eggs were laid upon the white pine before their disappearance, I failed to discover them. If none were laid upon the pines, then another host plant must be sought. Professor Osborn records a similarly sudden disappearance of the lice, June 10, 1878. Dr. Shimer says that on June 3, 1868, he first observed a few specimens of the winged form, and on June 4 he found them plentifully on the leaves; then he adds: "On June 8, I had great difficulty in finding one perfect specimen of the winged imago; the cold rain which had fallen since the 4th seems to have almost entirely destroyed them; many dead ones, with their wings shriveled, were found adhering to the leaves. From the 8th to the 25th of June, no winged specimens could be found." It is evident that their disappearance is not to be accounted for by the cold rain. The most satisfactory explanation is the presence in the vicinity of another host-plant.

Regarding the venation of the wings, that given by Dr. Fitch was supported by Dr. Shimer. Their description is such as one would give when using low magnifying powers. As detailed elsewhere, Professor Osborn corrects the errors of their description. Such variations from Professor Osborn's description as my specimens show, I think to be due to the variability of the species. That it is unusually variable, both in form and habits, seems to me apparent.

CHOLODKOVSKY'S MONOGRAPH ON THE CHERMES ATTACKING THE CONIFERÆ.*

On a preceding page it is suggested that a complete explanation of certain peculiarities of *Chermes pinicorticis* seems to require the intervention of another host plant. After I had finished the preceding pages substantially in their present form, I received from Prof. S. A. Forbes a copy of the *Zoologischer Centralblatt*, June 15, 1896, which contains an abstract of a work by N. Cholodkovsky on several European forms of the genus *Chermes*. The contents of this abstract strengthen the view that the white-pine louse attacks some other plant, and indeed may be known to American entomologists under some other name. Briefly, the contents pertinent to the subject of another hostplant are as follows:

In the monograph by N. Cholodkovsky, it is stated that *Chermes coccineus* Cholodk., *C. sibericus* Cholodk., *C. viridis* Ratz., *C. pini* Koch, and *C. strobilobius* Kalt., pass through a cycle of two years in their life history, and during that time are found on two different plants. Two kinds, *C. abietis* Kalt. and *C. lapponicus* Cholodk., complete their life cycle in one year, and are found upon one host plant only.

Of those which consume two years' time in development, and attack two different plants, the following is given as a generalized life history. The first form is found upon the fir, and is known as the "*fundatrix*." In the spring she deposits her eggs in galls. These egg hatch into larvæ, which, after having moulted four times, become "*migrantes alatæ*," and pass to the pine, where they deposit their eggs upon the needles. The eggs in turn give rise to the "*emigrantes*," which remain for the winter under the bark of twigs (*C. strobilobius*) or on the needles (*C. coccineus*). From the eggs deposited by the "*emigrantes*" are produced forms which suck either leaves or bark, and after three moults fall into two different series, the "*exules*" and "*sexuparæ*." The "*exules*" remain on the pine, spending the summer in laying eggs from which similar individuals are developed. The winter is passed by this form upon the pine, partly in the egg, partly in the larval form. Some of the larvæ hatched from the eggs of the *emigrantes* after the third moult pass into a pupal stage, from which they emerge as winged *sexuparæ*, which return to the fir, (May to June). Here they lay their eggs on the needles of the young shoots, and from the eggs emerge the form known as the "*sexuales*," consisting of males and females. After the impregnation of the female, she hides in a cleft of the bark and lays a single egg. From this egg is hatched the *fundatrix* late in the

* Beiträge zu einer Monographie der Coniferen-Läuse.

summer. It will be observed that six different forms are recognized as constituting the cycle, the *fundatrix* and *sexuales* being found upon the fir alone, the *emigrantes* and *exules* upon the pine alone, the *migrantes alatæ* and *sexuparæ*, winged forms, upon both. It is a remarkable history.

Finally, reference is made to the forms of *Chermes* found on the white pine, in a short statement to the effect that they are not wholly unknown. If *Chermes pinicorticis* should be found to have another host plant, as all indications lead us to suspect, there will, I think, be discovered some variations from the above generalized history as given by Cholodkovsky. The above forms given by him as infesting the pines do not agree with those of *C. pinicorticis*. All the American observers who have specifically mentioned the matter, state that the lice are absent during the summer, or were not observed during the summer. Professor Osborn states that he believes the eggs to be deposited throughout the entire season, but says that he observed them no later than May 27, in 1879, and again in the fall, October 9, thus leaving the interval between May 27 and October 9 unaccounted for. In 1878, June 10, he notes that the lice had almost entirely disappeared. These observations seem to exclude the "*exules*" from the forms of *C. pinicorticis* found upon the pine. If this form exists in this species it must therefore be looked for upon the other host plant. In addition to this fact, *C. pinicorticis* presents a further difference from Cholodkovsky's statement of the typical life history in that there is no winged form ("*migrantes alatæ*") which lays its eggs upon the pine in early spring. From the information at present in view it seems that the pine is the present host plant of our species, and some other species of conifer the intermediate one, if we accept the idea of a two-year cycle. On the other hand, I am aware of no evidence other than analogy which supports the idea of a two-year cycle for *C. pinicorticis*. It is quite possible that the cycle is completed in one year. The absence of other evidence than analogy opens an inviting field for further observation.

SYNONYMY AND BIBLIOGRAPHY.

1855. *Coccus pinicorticis* FITCH.

Trans. N. Y. St. Agr. Soc. for 1854, Vol. 14, 1855, pp. 871–873.—Original description of apterous female.

1856. *Coccus pinicorticis* FITCH.

1st Rep. Insects of N. Y. pp. 167–169. Repetition of original description. States that "wool" is thickest around the axils where limbs leave the main trunk, on the north side of the trunk, and on its lower part; no spots or but few where much exposed to the sun; insects "wholly imperceptible to the naked eye;" measurement a little over 0.01 of an inch in length; broad, oval, hemispherical, soft, black, or blackish-brown; back coated with whitish mealy powder; legs short, robust, feet of one piece (seemingly), ending at tip in two minute, bristle-like setæ; shanks little longer than broad, slightly enlarged toward their tips; thighs slightly longer than shanks, thickest in the middle; no thread-like or other projections at the hind end; head separated from body by faint transverse line; antennæ represented apparently by two small conical points. Insects found only on transplanted trees; suggests soap-suds as a remedy.

1858. *Chermes pinifoliæ* FITCH.

Trans. N. Y. St. Agr. Soc. for 1857, Vol. 17, 1858, p. 741.—Republished in *4th Rep. Ins. of N. Y. 1859, p. 55.* Description of winged form.

1859. *Coccus pinicorticis* FITCH.

Fourth Rep. Ins. of N. Y. p. 46. Dr. Fitch mentions it as an insect infesting the pines, largely young trees, and states again that it is invisible to the naked eye.

1859a. *Chermes pinifoliæ* FITCH.

Fourth Rep. Ins. of N. Y. p. 55.—Dr. Fitch here republishes his description of the winged form, first published in 1857. The description contains some observations not yet repeated by others. For example, he says: "Stationary on leaves, usually toward their ends, puncturing them and sucking their juices; a very small black fly, .08 long to tip of abdomen and .12 to the end of its wings, which are dusky grey, abdomen dusky red, and slightly covered with fine cottony down. The females do not extrude their

eggs. Clinging closely to the leaf with their heads towards its base, they die, their distended abdomens appearing like a little bag filled with eggs. The outer skin of the abdomen soon perishes and disappears, leaving the mass of eggs adhering to the side of the leaf, but completely covered over and protected by the closed wings of the dead fly. I have met with the dead females thus adhering to the leaves the first of July and have noticed the live insects on the leaves in full life and vigor the middle of May." No one has since observed the eggs in the position noted by Dr. Fitch.

In this description the venation of the wings, as given by Dr. Fitch does not agree with later descriptions, but is exactly such a description as would be given when the wing was viewed with a low power of the microscope.

1862. *Chermes pinifoliæ* FITCH. B. D. WALSH.

On the Genera of Aphidæ Found in the U. S.—Species listed only.

1866. *Coccus pinicorticis*, FITCH. B. D. WALSH.

Practical Entomology, Vol. 1, p. 90.—In this publication Mr. Walsh regards the apterous female as the larva of *Aspidiotus pinifoliæ*.

1869. *Coccus (?) pinicorticis.* SIGNORET.

Essai sur les Cochenilles, p. 866.—Simply catalogues it, and refers to Fitch's papers on the subject.

1869. *Chermes ? pinicorticis.* HENRY SHIMER.

Trans. Am. Ent. Soc., Vol. 2, p. 383.—This paper by Dr. Shimer gives a brief account of the habits of the insect, a description of the winged form, and asserts its identity with *Chermes pinifoliæ* Fitch; enumerates as natural enemies *Camaronotus fraternus* Uhl., "the larva of an unknown species of *Chrysopa* which covers its back with the wool of the *Chermes*, *Chilocorus bivulnerus* Muls., *Scymnus terminatus* Say, *Pentilia* (=Smilia) *misella* Zimm., many larvæ of unknown species of *Syrphus* and a *Scymnus* larva longer than *terminatus*, infested by a chalcis fly.

The "*Chrysopa*" mentioned by Dr. Shimer is doubtless *Hemerobius alternans*.

1873. *Coccus pinicorticis*, FITCH. J. A. LINTNER.

A paper in the *Country Gentleman, Aug. 21, 1873, Vol. 38, p. 535*, by Prof. Lintner.

1878. HERBERT OSBORN.

In the *Trans. Iowa State Hort. Soc., Vol. 13, p. 400.* Prof. Osborn discusses it, (without name) somewhat fully; notices its occurrence on white, Scotch, and Austrian pines; makes a study of its stages; description of eggs, larva, adult male and female; discusses its zoölogical relations.

1879. *Chermes pinicorticis* FITCH. HERBERT OSBORN.

Trans. Iowa Hort. Soc. Vol. 14, pp. 96–107. Prof. Osborn here gives an account of observations on different stages, description, and life history so far as made out.

1879a. HERBERT OSBORN.

College Quarterly, Vol. 11, p. 10. Short notice of injury without scientific name of insect.

1879. *Chermes pinifoliæ* FITCH. CYRUS THOMAS.

Eighth Rep. St. Ent. of Ill., p. 156. Quotes Fitch's description.

1881. *Chermes pinifoliæ* FITCH. A. S. PACKARD.

Ins. Inj. to Forest and Shade Trees, 1881, p. 118.

1884. *Chermes pinicorticis* FITCH. HERBERT OSBORN.

Bulletin No. 2, Iowa St. Agr. Coll., Dept. of Ent.—In this paper Prof. Osborn republishes, in substance, the papers previously referred to, with additions and corrections, bibliography and plates, showing apterous female, upper and lower side, winged form, young larva, antennæ and leg of young larvæ.

1885. *Chermes pinicorticis* FITCH. J. A. LINTNER.

2nd Rep. St. Ent. of N. Y., p. 180–187.—Prof. Lintner gives the natural history of the *Chermes* according to Osborn, and a resumé of the studies made by Shimer, Walsh, and himself; reproduces Osborn's figures, refers to other species of the genus, and deals to some extent with their bibliography; recapitulates the natural enemies and suggests remedies.

1887. *Chermes pinicorticis* FITCH. OESTLUND.

Syn. of Aphididæ of Minn., p. 93.—Listed as attacking pine, and mentioned as an American species on p. 18.

1888. *Chermes pinicorticis* FITCH. J. A. LINTNER.

4th Rep. St. Ent. of N. Y., p. 147.—A few notes on its distribution and habits.

1890. *Chermes pinicorticis* FITCH. PACKARD.

Fifth Rep. U. S. Ent. Comm., p. 810.—Lists it and refers to Osborn; also to *Chermes pinifoliæ* Fitch, p. 805, Fitch's description being quoted; also to *Coccus pinicorticis*, Fitch, again quoting from Fitch, p. 871. Refers also to Shimer's paper of 1869.

1890. *Chermes pinicorticis* FITCH. S. A. FORBES.

17th Rep. St. Ent. of Ill., p. xii.—Notes its first reported appearance in Illinois, in the University forest, saying that it not only attacks the twigs, but also the bases of the needles.

1891. *Chermes pinicorticis* FITCH. T. A. WILLIAMS.

Host Plant List N. A. Aphididæ, Bull. No. 1, Univ. of Neb. Lists it as attacking the pine.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. *Chermes pinicorticis*, winged form; head, dorsal aspect, showing outlines, antennæ, and position of eyes.

Fig. 2. Tarsus and part of tibia of same, lateral aspect, showing hairs of each, tubercles of the tibia and rings of tarsus. At the junction of the tarsus with the tibia is shown the rudimentary first joint. The small accompanying figure is a sketch of the upper side of the extremity of the tarsus, showing the peculiar claw.

Fig. 3. Antenna of same, showing the position of hairs, and the markings of the segments.

Fig. 4. Front wing of same.

Fig. 5. Hind wing of same, showing the three chitinous hooks, and the markings which were mistaken for a branch vein by Dr. Fitch and Dr. Shimer.

Plate II.

Fig. 1. *Chermes pinicorticis*, larval form; outline of head, exhibiting three-jointed, ringed antennæ, and three simple eyes.

Fig. 2. Tibia and tarsus of same, showing position of hairs, and rudimentary first joint of tarsus.

Fig. 3. Ventral view of larva of same.

Fig. 4. Tibia and tarsus of apterous female of same, showing peculiar notch at extremity and rudimentary first joint.

Fig. 5 One group of excretory papillæ of same.

Fig. 6. Larva of ladybird, probably *Chilocorus*.

Fig. 7. Larva of *Hemerobius alternans*, with enlarged drawing of the head beneath.

Plate I.

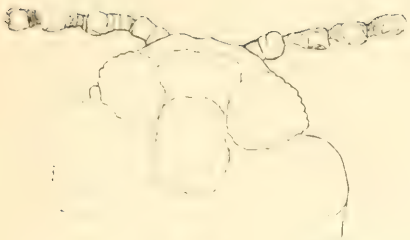


Fig. 1.

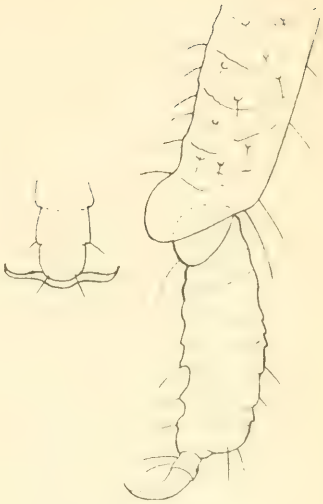


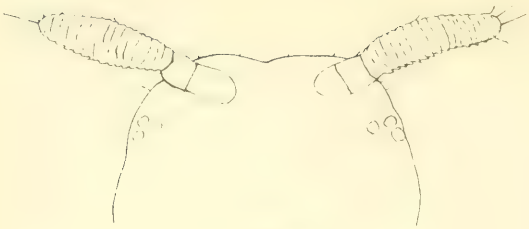
Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Plate II.



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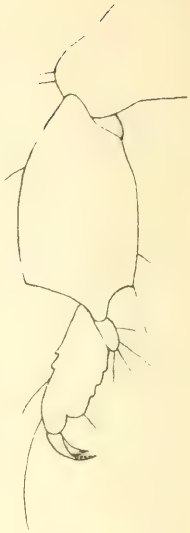

Fig. 2

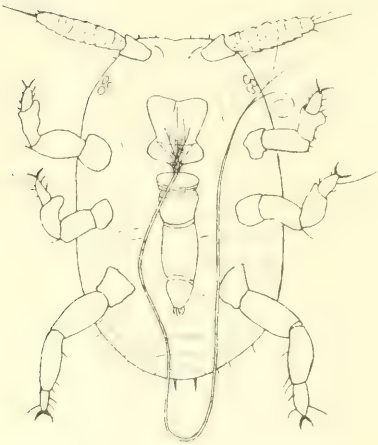

Fig. 3.

Fig. 4.

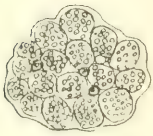

Fig. 5.

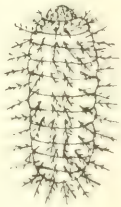

Fig. 6.

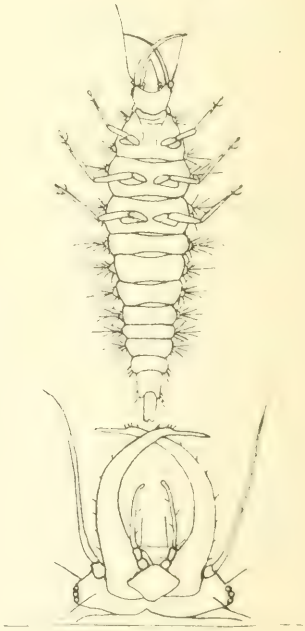

Fig. 7.

ERRATA.

Page 10, line 8, for *Sanford* read *Sandford*.
Page 81, line 16, *dele* 10.
Page 85, line 12, for *with the exception of* read *in*.

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TWENTY-FIRST REPORT

OF THE

STATE ENTOMOLOGIST

ON THE

NOXIOUS AND BENEFICIAL INSECTS

OF THE

STATE OF ILLINOIS

TENTH REPORT OF S. A. FORBES

CHICAGO
HACK & ANDERSON
Printers
1900

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CONTENTS.

INTRODUCTORY NOTE.

Since 1876 the reports of the State Entomologist of Illinois have been published mainly as appendices to the reports of the State Department of Agriculture, an edition of two hundred or three hundred copies, bound separately, being furnished to the Entomologist for his personal use. This mode of publication has now been changed in consequence of an item in the general appropriation bill for the expenses of the State Government passed by the Forty-first General Assembly, making special provision for the publication, by the State Agricultural Experiment Station, of Bulletins prepared by the State Entomologist, with a proviso "that one thousand copies of each of said bulletins shall be furnished to the State Entomologist in condition for binding and distribution as his biennial report." This appropriation for publication became available July 1, 1899, and the present report is the first to be printed in this new form. The two articles of which it consists were separately issued as Bulletins 56 and 60 of the Agricultural Experiment Station, and the reserved copies have now been provided with a special index and are here issued as an entomological report.

RECENT WORK ON THE SAN JOSE SCALE IN ILLINOIS.*

(*Aspidiotus perniciosus Comstock.*)

The work of this office on the San Jose scale was begun in September, 1896, with the discovery of the scale in Illinois, and an article on the subject was published in my entomological Report for 1895 and 1896 under the title of "The San Jose Scale in Illinois." This article was revised in printing to include a general account of our operations up to October, 1897, and of this report the present one may be regarded as a continuation. The work here described, like that previously reported, has been in part purely practical and in part scientific. It has included a continuation of the search for infested Illinois localities and a thoroughgoing examination of those detected, as begun in 1896; the inspection of Illinois nurseries and nursery stock as a basis for official certificates issued to nurserymen; the insecticide treatment of infested premises in Illinois, undertaken to arrest the spread of the scale in this State; the collection, study, cultivation, and introduction, into orchards of two fungus parasites of this scale; field experimentation with special insecticides and insecticide apparatus; and a study of certain minor points in the life history and œcology of this insect.

The search for infested Illinois localities has resulted in the discovery of six † points not on the list given in my last biennial Report, thus making twenty-five‡ such localities now known in Illinois. A considerable increase of the area known to be infested at four localities already reported has also been thus made out. The nursery inspections, forty-three in number, made by my Assistants have covered thirty-four Illinois nurseries, besides one in an adjacent state examined by special request and arrangement. The cost of these inspections, as paid by nurserymen, ranged from $1.50 to $31.73, and averaged $10.43 each, of

* Printed also as Bulletin No. 56 of the Illinois Agricultural Experiment Station, in August, 1899.

† Now eleven. ‡ Now thirty.

which $5.55 was for traveling expenses and $4.88 for the pay of inspector.

The insecticide measures undertaken have covered thoroughly and carefully all the known points infested with the exception of six, at two of which the distribution of the scale was so widespread that it was impossible with the funds at the service of the office to go over the entire ground. At one of these (Richview) the premises worst infested were carefully treated and all those less seriously involved were sprayed sufficiently to prevent the spread of the scale from them for the season. At a second (Sparta) numerous orchard experiments with insecticides were made and most of the premises seriously infested by the San Jose scale were thoroughly and successfully infected with two parasitic fungi causing contagious diseases of this insect. These fungi, both obtained from Florida on a personal visit of the writer, were distributed to Illinois orchards partly by direct transfer of twigs and branches bearing infected scales and partly by means of extensive artificial cultures of the fungi made for this purpose at my office. Both methods of infection were entirely successful, and one of these fungous diseases of the San Jose scale is now well established at both Sparta and Richview.

At Mt. Carmel, the third of these localities, all trees found infested on our earlier inspections were thoroughly treated except those on one town lot to which the owner persistently refused us access. Later examinations have shown, however, that the scale was more widely distributed at this point, both within and without the town, than was known to us when this work was done, and much additional spraying is needed at and near that place.

The occurrence of the scale at Browns, in Edwards county, and also on a farm near Worden, in Madison county, was not ascertained until my field parties had been called in, owing to an exhaustion of appropriations available; and at Villa Ridge, in Pulaski county, reliance on the efforts of the owner of an infested orchard to clear it of the scale by cutting out infested trees, proved to be ill founded. His work was not thoroughly enough done, and the scale still continues on his premises.*

Our experimental insecticide work was done mainly with kerosene, either pure or in mechanical mixture with water. We have failed, so far, to find conditions under which this insecticide may be safely and successfully used by orchardists generally for the destruction of scale insects.

The points in the habits and oecology of the scale to which especial attention was paid were the length of life of the young scale and its

* These premises have since been cleared of the scale by a destruction of everything on the place which could have become infested.

power of locomotion if born where it could not readily attach itself to a suitable plant.

Discovery of New Illinois Localities.*

The new Illinois localities found infested by the San Jose scale since the publication of my last Report are Dundee, in Kane county, Manito, in Mason county, Assumption, in Christian county, a farm near Walnut Prairie, in Clark county, one near Worden and another near Alhambra, in Madison county, a farm near Mt. Carmel, in Wabash county, and town lots in Browns, Edwards county.† More extensive occurrence of the scale than hitherto reported was also found at Tower Hill, in Shelby county, at Mt. Carmel, in Wabash county, at Richview, in Washington county, and especially in the Sparta neighborhood, in Randolph county. Near the place last mentioned it has now been found by my inspectors in more than sixty orchards, scattered over an area of approximately twenty-five square miles.

At Dundee, in Kane county, the presence of this scale was first observed in the course of a general inspection of premises made at the request of the owner November 8, 1897, by Mr. R. W. Braucher, an Assistant of this office. In one corner of an eight-acre lot was a small block containing about two thousand trees and shrubs of various kinds, including apple, peach, plum, cherry, gooseberry, and currant, and a considerable variety of deciduous trees. This block was slightly infested with the San Jose scale, occurring mainly on the apple, although a few were detected on peach and mountain-ash. The infested apple-trees came originally from a nursery in Missouri some two or three years before. It was difficult to believe, however, that they were infested when received, because of the comparative scarcity of the scale upon them when discovered in the fall of 1897. None of them were badly attacked, although in some cases the scale was well distributed through the top of the tree. A row of apple-trees eight or ten years old adjoined this block at one end, and short rows of young cherry and pear were separated from it, at a considerable distance, by beds of young evergreens. Rose-bushes, syringas, spiræas, grape-vines, gooseberries, currants, plums, apricots, hard maples, and ornamental shrubs, were growing on various parts of this eight-acre lot, but no trace of the San Jose scale was detected on any of them.‡

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* See map, Plate I.

† To the above should be added the following localities, discovered since this manuscript was prepared: Monticello, in Piatt county, a farm near Quincy, in Adams county, Summerfield, in St. Clair county, and Albion, in Edwards county.

‡ These premises have since been completely cleared of the scale by a destruction of everything on the infested place which could harbor it.

At Manito, in Mason county, on the farm of Mr. P. B. Stem, about half of a twelve-acre peach and apple orchard, and twenty rods of osage-orange hedge adjoining were quite generally infested by the San Jose scale. Numerous other osage-orange hedges, extending in all directions in this infested tract and containing many nests of birds, were not visibly infested by the scale. The pest was evidently introduced to this place by means of six apple-trees obtained from the Pomona Nurseries, in New Jersey, in 1891. These trees were first to die, but later the trees surrounding them gradually perished.

At Assumption, in Christian county, in a small orchard on a city lot belonging to Mr. H. Tobias, a pear-tree was found badly incrusted with the San Jose scale, in the midst of a few other trees, apple, peach, and cherry, through which the insect was scattered less abundantly. The pear-tree on which it had apparently been introduced was obtained by mail from a Philadelphia nursery two years before. It had made but little growth, and was only about three feet high. Four other pear-trees received at the same time and from the same firm were not infested.

At Walnut Prairie, in Clark county, two orchards infested by the San Jose scale were found as the result of a letter of inquiry addressed to me February 16th by Mr. E. H. Baird, of Marshall, Ill. One of these places, belonging to Mr. Kreager, had become infested from the other, belonging to Mr. J. Cline. On the latter, situated a mile and a half east of the station of Walnut Prairie, both apple- and pear-trees were infested, while on the former, plum- and apple-trees and currant bushes were involved. The precise origin of the scale at this place could not be clearly ascertained. It was, however, probably brought by means of pear-trees bought from a tree peddler at Marshall.

Knowledge of the occurrence of the scale near Alhambra, in Madison county, came to me as a result of a personal inquiry from Mr. L. A. Pearce, a farmer of that neighborhood. The infested apple orchard, owned by Mr. C. S. Frame, is three and a half miles northwest of Alhambra. About thirty trees, all large, were very badly infested, together with several large elm-trees near the orchard. The former owner of this place, from whom Mr. Frame had bought it a few months before, had obtained his trees from a great variety of sources, and it was consequently impossible to trace this outbreak to its origin.

The occurrence of the scale in an orchard near Mt. Carmel was reported by Dr. J. Schneck of that place and verified by a visit of inspection made by my Assistant, Mr. Braucher, in October, 1898. It is there well distributed among about four hundred trees belonging to Mr. C. C. Lingenfelter, on a farm about two and a half miles from town.

These trees were bought in 1893 of a traveling agent for the nursery of John Siebenthaler, at Dayton, Ohio.

At Browns, the scale occurs on peach, plum, and pear, a fact ascertained by Professor T. J. Burrill while attending a Farmers' Institute at Albion, and verified by him and Dr. Schneck by the examination of several infested twigs.

At Worden, the scale was found September 23, 1898, by Mr. Green in a farm orchard belonging to Mr. C. C. Hoxey, living in the outskirts of the town. It was evidently conveyed to this orchard by means of a plum-tree and several June-berry trees (*Amelanchier*) from the farm of Mr. C. S. Frame, near Alhambra, reported above. In Mr. Hoxey's orchard the scale was very generally distributed through some two hundred fruit trees of various kinds, some but slightly infested and others badly incrusted.

Increased Area Infested in Old Situations.

At Monroe Center, in Ogle county, where only a single infested tree had been found the year before, as stated on page eight of the Twentieth Entomological Report, Mr. Braucher found November 18, 1897, a pear-tree, some scattered pear sprouts, and two Rocky Mountain cherry-trees slightly infested with the scale.

On Mr. Jacob Winzeler's place, near Tremont, in Tazewell county, where only half a dozen trees (Japanese pears) had been previously found infested, it appeared by an inspection made December 2, 1897, that the San Jose scale was obscurely present in different parts of the orchard on plum and peach, some of the latter from fifty to seventy-five feet distant from the pear-trees worst infested.

At Tower Hill about eighteen infested cherry-trees were found on the premises of Mrs. J. Connor, living near the village. The origin of this colony could not be ascertained. The infested premises of Mr. Grisso, mentioned in my last Report, were at a distance of three miles from the town. Careful inspection of the latter place, made by both Mr. Green and Professor Summers, covering all trees in the vicinity of those originally infested, resulted in the detection of no dispersal of the scale except to one tree, at some distance, which had been grafted with a scion from one of the infested trees. This was said to be the only scion that had been cut from these trees originally infested by the San Jose scale.

Conditions at Ernst, as reported by Mr. Braucher January 17, 1898, were particularly instructive. As stated in my article for 1896 (see Twentieth Report, page 9), only one infested tree had been originally reported from this place, and this had been at once thoroughly destroyed.

A careful inspection made by an office Assistant some months later discovered no others in this entire neighborhood; nevertheless on the date of Mr. Braucher's visit, several pear-trees and one peach-tree in the immediate vicinity of the tree originally attacked, and a plum-tree two or three hundred feet from it, were all found slightly infested, the plum-tree evidently by means of nesting birds. On this the scales were clearly most abundant on the forking branch of the tree supporting a last year's nest.

At Richview, where but three colonies had been previously reported, —one of which proved upon more critical examination to be an allied scale,—fourteen colonies of the San Jose scale on as many different premises were finally found. All these were in the vicinity of the town, and so far as known all had been derived from a common source.

Careful study of this district suggested some interesting queries with respect to the mode of distribution of the scale and to variations in its attack. It was found, for example, to be very much more abundant in infested orchards upon young trees than upon old and large ones immediately adjacent. Indeed it was often impossible to find it upon any part of large trees standing beside small infested ones at so short a distance that the young must have been frequently conveyed to the larger trees. It seems possible that in such case the young scales perished because they were unable to reach a part of the tree from which they could draw sap. In several instances small numbers of the San Jose scale were found in the midst of orchards of considerable size at distances as great as half a mile from the nearest infested premises, and in others the scale was very sparsely distributed over a considerable part of an orchard not otherwise infested. Observations to this effect were made only in districts where the scale had become decidedly abundant and destructive at several points. It seems, in fact, to spread slowly and steadily from the points of first introduction until it reaches a certain abundance, when its distribution becomes so rapid and general that the attack may almost be said to become epidemic. Three methods of distribution may be suggested in explanation of these facts: the well-known transfer by means of nesting birds; the probable transfer of the freshly hatched young by strong and long-continued winds; and the passage of human beings, particularly during the season of fruit harvest, from infested orchards to others in all directions and to considerable distances. It will be seen at once that whenever this stage of general, sparse, and obscure dispersal has been reached, the complete extermination of the scale in that locality is hardly to be expected without most thoroughgoing, oft-repeated, and long-continued insecticide measures.

Serious as was the case at Richview, that in the Sparta neighbor-

hood was very much worse, for there a general survey of the region made by an experienced observer, Mr. R. W. Braucher, resulted in the discovery of the San Jose scale in larger or smaller numbers on no less than sixty-five farms distributed over an irregular area of about twenty-five square miles. Moreover, his inspection was incomplete, and the area infested is possibly still considerably larger. In one case the scale was even found abundant in a roadside hedge at a distance of a quarter of a mile from the nearest orchard; and as this whole region still retains a considerable amount of the forest which originally wholly covered it, there is undoubtedly in this district a general scattering of the scale which no inspection would detect. Its complete extermination here I judge to be impracticable without an expenditure of several thousand dollars and the adoption of drastic measures similar to those applied in the East for the destruction of the gypsy moth.

Inspection of Nurseries.

The widespread and active public discussion of the San Jose scale during recent years has had the effect to alarm many prospective purchasers and in many cases to prevent or postpone purchase, and to arrest the planting and extension of orchards. Several illustrations of this fact have come to my office in the form of inquiries concerning the damage to be anticipated in planting or developing orchards at specified localities in this state and concerning the presence of the scale in specified nurseries, which inquiries were sometimes accompanied by a statement that contemplated purchases would be deferred until my reply was received.

Further, several states to which our nurserymen are accustomed to ship stock, in some cases amounting to considerable annual sums, have passed laws prohibiting the importation into those states of any nursery stock not covered by an inspector's certificate of freedom from injurious insects. In all such cases regular inspection of nursery stock grown within their own limits is of course provided for by law, but no such provision being made in Illinois, both local and outside trade was becoming seriously embarrassed for lack of a system of inspection which would give assurance of protection to purchasers and enable nurserymen to meet the requirements of the export trade. Having at my call or already engaged under my direction trained, trustworthy, and experienced entomologists, capable of making expert inspections upon the results of which I felt entirely willing to base official certificates signed by myself as State Entomologist, it seemed possible to meet the somewhat difficult situation, outside any requirement of law, by volunteering the services of the office to nurserymen on condition that the expenses

of inspection and travel were borne by those whose business was facilitated and whose interests were served by the official certificates to be issued. Consequently, after advising with leading horticulturists and nurserymen and with the Governor of the State, I issued in July, 1897, a circular notice concerning the San Jose scale and other fruit insects, containing the following paragraph:

"As a guarantee of the freedom of Illinois nursery stock from this and other notably injurious insects likely to be conveyed in trade, the Entomologist offers to inspect the premises of nurserymen and other dealers at least once each year, and to give to the owner after such inspection a certificate setting forth the precise facts apparent with respect to the presence or absence of the San Jose scale and other insects dangerous to the property of customers. Such inspections will be made and such certificates issued only on application to this office, and on condition that the actual traveling expenses of the inspector and a *per diem* of three dollars* are paid by the owner of the inspected property. Special inspections of nursery stock imported for sale will also be made, so far as this may be practicable, on the same conditions and terms; but to insure such inspections requests should be made as long as possible in advance of the receipt of importations, with at least an approximate indication of the time when they are expected to arrive. Trips may thus be arranged which will provide for the largest possible number of inspections, and reduce the cost of each. Statements of receipts and expenditures under this head will be reported to the Governor and published in the regular reports of the State Entomologist of Illinois."

Numerous applications were received in response to this proposition, and twenty Illinois nurseries were inspected between August 10, 1897, and April 25, 1898. The form of certificate issued to those whose premises were found free from dangerous insect pests was substantially as follows:

"This is to certify that on.....an Assistant of this office, acting under my direction, examined the growing stock in the nursery of....., and found no indication of the San Jose scale or of any other dangerous insects likely to be transported to the injury of customers.

"This statement is invalid after July 1, 1898 [or 1899].

S. A. FORBES,

State Entomologist."

This form was slightly modified in individual cases to meet variations in condition and requirement. In some cases, for example, the stock was inspected after removal from the ground, exposing the roots to examination, in which case the certificate was so framed as to show that fact. In other instances, the occurrence of some of the ordinary

* Four dollars in 1898.

injurious insects of the region capable of being conveyed on nursery stock to premises free from them necessitated a limitation of the terms of the circular to the insects or classes of insects absent from these premises, or, if present, incapable of transportation in the nursery trade. No certificate was issued, however, which did not testify to the apparent absence of the San Jose scale. This insect was found, indeed, in only one Illinois nursery, and this was one which made a specialty of evergreens—not subject to attack by that scale.

It was supposed that these inspections would commonly be made at or near the close of the growing season, when all important insect injuries of the year would be conspicuous and when, furthermore, the results of an inspection would remain good until the growing season of the following year was fairly well advanced. A certificate issued upon such inspection would apply to both the fall shipments of the current year and the spring shipments following, but would be valid no longer.

The Illinois nurseries inspected during the period just mentioned were, as already said, thirty-four in number, ten in the northern, seventeen in the central, and seven in the southern, part of the state. Eleven of these nurseries were inspected in 1897, and nine of these eleven with twenty-three others, or thirty-two in all, in 1898. The total number of nursery inspections for the two years was therefore forty-three. Fourteen of these inspections were made by Prof. H. E. Summers, fourteen by Mr. R. W. Braucher, eleven by Mr. E. B. Forbes, and four by Mr. E. C. Green. During 1897 Messrs. Braucher and Forbes were regular Assistants of the office and were detailed for service as inspectors as calls came in. They received personally the *per diem* earned, their regular monthly salaries being suspended for the time devoted to this inspection work. Professor Summers, on the other hand, was not at the time on continuous salary, and was engaged only as needed for this service. In 1898, Mr. Braucher was engaged as needed for necessary inspection, and paid only from the fees; Mr. Forbes was so engaged and paid for a part of his inspections, and for the remainder, while in service as a State Laboratory Assistant, he received the fee, the time so paid being deducted in computing his monthly salary.

The total expenditures on account of inspections were $448.30, of which $209.45 were paid for services of inspectors, the remainder ($238.85) being for expenses of travel. The average cost per inspection was thus $10.43. The receipts from nurserymen were $429.55, leaving a balance of $18.75 paid personally by the Entomologist to inspectors and not repaid by nurserymen.

EXPENSES OF NURSERY INSPECTION, 1897 AND 1898.

Nurserymen.	Place.	Date of inspection.	Inspector	Rec'd from nurserymen.	Paid inspector.
W. A. Watson & Son..	Normal.....	Aug. 10, '97	H. E. S.	$ 9.03	$ 9.03
Phœnix Nursery Co ..	Bloomington	" 13, '97	H. E. S.	20.73	20.73
Bryant & Son.....	Princeton...	" 20, '97	H. E. S.	15.95	15.95
F. S. Phœnix	Bloomington	Sept. 10, '97	H. E. S.	12.56	12.56
W. H. & A. L. Tincher	Decatur.....	" 24, 25, '97	R. W. B.	.....	12.25
Geo. Gould & Son....	Villa Ridge..	Oct. 5, '97	R. W. B.	4.00	4.00
C. H. Webster	Centralia ...	" 6, '97	R. W. B.	6.13	6.13
Augustine & Co.....	Normal.....	" 6, '97	H. E. S.	15.61	15.61
Theo. Bechtel.....	Staunton....	" 12, '97	H. E. S.	13.84	13.84
J. Husband.....	Leanderville	" 16, '97	R. W. B.	3.00	3.00
A. L. Klank.....	Champaign .	" 29, '97	H. E. S.	1.50	1.50
P. S. Peterson & Son..	Chicago	Mar. 7, 8, '98	H. E. S.	8.75	8.75
J. W. Miller Co.....	Freeport....	" 10, '98	H. E. S.	6.50	6.50
H. R. Cotta.....	Freeport....	" 10, '98	H. E. S.	6.50	6.50
Lebkicher & Spitler...	Freeport....	" 11, '98	H. E. S.	.....	6.50
J. V. Cotta.	Nursery	" 12, '98	H. E. S.	8.95	8.95
J. C. Vaughan.....	Chicago	" 14, '98	H. E. S.	7.75	7.75
H. Schroeder.....	Bloomington	April 4, '98	H. E. S.	6.66	6.66
R. Douglas' Sons.....	Waukegan ..	" 19, '98	E. B. F.	18.76	18.76
Rob't C. Uecke.....	Harvard....	" 25, '98	E. B. F.	21.07	21.07
J. C. Vaughan.....	Chicago.....	Aug. 25, '98	E. B. F.	11.93	11.93
R. Douglas' Sons.....	Chicago.....	" 27, '98	E. B. F.	13.73	13.73
Spaulding Nurs. & Orch. Co....	Spaulding ..	" 30, '98	R. W. B.	10.92	10.92
Phœnix Nursery Co ..	Bloomington	Sept. 1–4, '98	R. W. B.	31.73	31.73
W. W. Thomas.....	Makanda....	" 5, '98	E. B. F.	3.04	3.04
J. H. Bradly	Makanda....	" 5, '98	E. B. F.	3.04	3.04
D. W. Leib & Son.....	Makanda....	" 6, '98	E. B. F.	4.51	4.51
W. A. Watson & Co...	Normal.....	" 6, 7, '98	R. W. B.	8.54	8.54
Rob't C. Uecke.....	Harvard....	" 7, '98	E. C. G.	2.00	2.00
Galeener & Thacker ..	Vienna	" 7, '98	E. B. F.	10.09	10.09
F. S. Phœnix	Bloomington	" 8, '98	R. W. B.	6.00	6.00
Augustine & Co.....	Normal. ...	" 9, '98	R. W. B.	6.10	6.10
Arthur Bryant & Son..	Princeton...	" 15, 16, '98	R. W. B.	16.50	16.50
Alpha Nursery Co. ..	Alpha	" 17, '98	R. W. B.	7.59	7.59
L. S. Frese (Forest Oak Nursery).	Coatsburg...	" 19, '98	R. W. B.	12.69	12.69
Gustav Klarner (Quincy Star Nurseries).....	Quincy	" 21, '98	R. W. B.	13.44	13.44
Hollard, E.....	Melville	" 26, '98	E. C. G.	3.29	3.29
Burton & Son	Upper Alton	" 26, '98	E. C. G.	3.29	3.29
Theo. Bechtel.....	Staunton....	" 29, '98	E. C. G.	2.00	2.00
P. S. Peterson & Son..	Chicago.....	Oct. 4, 5, '98	E. B. F.	19.66	19.66
Custer Brothers	Normal.....	" 7, 8, '98	R. W. B.	12.11	12.11
Missing Link Apple Co.	Clayton.....	" 22, '98	E. B. F.	19.25	19.25
D. Hill.....	Dundee.....	" 28, 29, '98	E. B. F.	20.81	20.81

In nearly all cases the nursery stock examined was still standing in the rows; a fact which made it usually impossible to ascertain anything directly with regard to the condition of the roots. Indeed, any practicable inspection of large nurseries can give at best only a rather loose approximation to a knowledge of injurious insects infesting them—at least on a small scale and to an obscure extent. Our inspectors could only walk through the nursery plats back and forth at intervals of several rows of trees, judging of the general condition of the planta-

tion, stopping now and then to examine an individual tree, and giving careful attention only to trees whose general appearance indicated the possibility of insect injury. Of course no premises were found entirely free from insects commonly classed as injurious. In the great majority of cases, however, those present were kinds which would necessarily be left behind in the shipment of clean young nursery trees, and without exception all were common widespread insects of the region or of the state at large.

It is clear, however, that no certificate, however carefully it may be drawn, or however thoroughgoing may be the inspection upon which it is based, should be taken as more than presumptive evidence of the entire absence of seriously injurious insect pests. Indeed, in the hands of any except a thoroughly reliable and honest nurseryman it is entitled to no credit whatever, but may be even worse than no certificate at all, since it would be perfectly easy for an unscrupulous dealer to deceive first the inspector and then his customer, and this with little or no danger of detection. The inspector, of course, must take the word of the nurseryman as to the extent of his property, and can only presume that he has seen all the stock from which the owner is likely to draw for sale, for if deceived in this regard he has usually no means of detecting the deceit. On the other hand, there is no certain means of limiting the use of the certificate to stock actually grown by the nurseryman or on the grounds where the inspection was made. Duplicates of it may be used, with perfect security from detection, upon any stock from any source, received perhaps long after the last inspection was made. So far as the official certificate tends to give a sense of security to the customer in dealing with a nurseryman he does not know or in whom, if known, he does not have full confidence, it is undoubtedly an evil instead of a benefit; but notwithstanding these drawbacks to its use, it will be difficult, I think, to devise any satisfactory substitute for it, as it is now commonly worded and as it should be generally understood.

Insecticide Treatment.

Heretofore and in other states under circumstances such as existed in Illinois in 1897, either nothing has been done in the general behalf, the San Jose scale being left to the care of individuals acting in their own interest, or laws have been passed establishing some state authority competent to deal with the economic situation. In Illinois an attempt was made to secure such thoroughgoing legislation at the biennial session of the state legislature for 1897. A bill establishing a state board of horticulture with ample powers of inspection and police was introduced in both houses and passed the senate by a unanimous vote,

but was vigorously opposed while in the house and finally failed in committee, the only immediate result of the effort being an item in the general appropriation for the expenses of the state government appropriating $3,000 to the State Entomologist "for experiment, publication, and instruction concerning the San Jose scale, and for the inspection and disinfection of orchards and nurseries."

It thus became a part of the duty of the Entomologist to do everything possible to exterminate the San Jose scale in Illinois wherever it had been or might be detected or, if destruction should prove impracticable, at least to check its multiplication and spread as vigorously as possible, and to give to owners of infested premises full instruction with respect to precautionary and remedial measures. It was also clearly intended that the office should act to protect the state as far as practicable against the dispersal of the scale through the nursery trade. With a view to the discharge of these duties the following circular was issued in July, 1897:

An appropriation of $3,000 was made to the State Entomologist of Illinois by the General Assembly at its last session, "for experiment, publication, and instruction concerning the San José scale, and for the inspection and disinfection of orchards and nurseries." It is the earnest desire of the Entomologist that this sum may be used to the best advantage to disclose the present condition of the fruit interest of the state with reference to this pernicious insect; to exterminate the scale promptly wherever in Illinois it has been or may be found; to protect the nurseryman and fruit grower as far as practicable against the chance of future invasion; and to assure the customers of Illinois nurserymen and of other dealers in fruit plants that Illinois stock offered for sale is free from this pest.

It was the evident intention of the legislature to trust the control of this important matter to the public spirit and enlightened business enterprise of the private citizen, aided in every practicable way by the official Entomologist. It is the purpose of this circular to make to all interested a cordial offer of information, advice, aid, and supervision of insecticide operations, as far as the resources at our disposal will permit; and also to ask early and full information from all concerned with reference to the occurrence or introduction, known or suspected, of the San José scale in Illinois.

Location of Colonies.

It must be our first endeavor to discover promptly and to locate exactly all the colonies of this insect now established in the state. Eighteen such colonies have already been found, nearly all by an inspection of premises to which we have had reason to believe that nursery stock was imported at a time when the nurseries from which it came were infested by this scale. It is of great importance that we have at once full information concerning all importations into the state from places and at times such as to make it possible that the San José scale was conveyed by their means. I consequently earnestly request all to whom this notice may come that they will send to this office prompt and precise information with regard to the importation into Illinois of nursery stock or other trees or plants subject to its attack, which were grown in any of the following localities within the time mentioned after each: California, since 1873; eastern New Jersey, between 1886 and 1894; Maryland since 1887;

Florida, since 1889; Washington State and Ohio, since 1890; Georgia and Louisiana, since 1891; Long Island, N. Y., since 1892; Delaware and eastern Massachusetts, since 1893.

The plants thus far found subject to injury by the San José scale are the apple, pear, peach, apricot, plum, cherry, quince, grape, raspberry, blackberry, gooseberry, currant, and persimmon, among our fruits; the chestnut, hickory, pecan, English walnut, black walnut and almond among the nut-bearing trees; the oak, basswood, elm, catalpa, birch, poplar, and willow among our shade and forest trees; and a large miscellaneous list of trees and shrubs, including the rose, thorn-apple or red haw, crab-apple, wahoo, spiræa, loquat, cotoneaster, flowering quince, flowering currant, acacia, alder, and sumach. This insect also seriously infests the osage orange, spreading with the greatest facility through the thick growth of the wayside hedge.

It is very important that all supposed or possible cases of the appearance of the San José scale in Illinois be reported at once to this office, accompanied by twigs or pieces of bark illustrating the supposed attack. To all communications accompanied by such specimens prompt reply will be made, and energetic measures for its destruction will be taken wherever the scale is thus detected.

Exterminaton of the Scale.

To owners of premises on which this scale is found the Entomologist will give all information and assistance necessary to the prompt extermination of the pest, sending an agent to inspect the situation and surroundings, to give personal instruction as to methods of procedure, and to supervise and direct insecticide operations, An efficient spraying apparatus will also be furnished for use where this cannot otherwise be readily obtained. This proposition is made on the sole condition that the owner will destroy stock hopelessly diseased and will provide the necessary insecticide and the labor for its preparation and for its distribution to infested stock, and that the whole operation will be carried on and continued to the satisfaction of a representative of this office. Experience elsewhere has shown that expert assistance of this sort is, as a rule, necessary to insure success; and expenditure of public money in such an interest can be justified only on condition that everything is done needful to the accomplishment of the end desired.

The San José scale is commonly regarded by those best informed concerning it as the most dangerous and injurious insect enemy of American fruits. It now occurs in Illinois in comparatively small colonies, where in most cases it can probably be exterminated at small expense. Considering the enormous loss which is likely to fall upon the horticulture of the state if this highly destructive insect is allowed to spread generally throughout our orchards and to infest our nurseries, it is to be hoped that every person upon whose property it appears will regard the situation in the light of the public welfare as well as in that of his private interest, and that he will take without hesitation such measures as may be necessary to protect both.

* * * * * * *

Bulletin of Information.

An illustrated bulletin of information concerning the San José scale and its distribution in Illinois has been published by the State Agricultural Experiment Station (Bulletin No. 48), and will be furnished on application to Prof. Eugene Davenport, Director of the Station. A later and more comprehensive article upon the subject will appear in the forthcoming biennial report of the State Entomologist, which will probably be ready for distribution this fall. *

* For omitted section see page 8.

In accordance with the propositions of this circular, preparations were made during the summer of 1897 for a thorough and general insecticide treatment of all infested premises, to begin as soon as the leaves had fallen from the trees, this postponement being essential to any reasonable assurance that all the scales on an infested tree would actually be reached.

Description of Apparatus.

The principal apparatus used is a large and complicated machine sprayer consisting of a one-horse power gasoline engine, a three-cylinder force pump, and a large double galvanized-iron tank with a powerful gasoline heater beneath for making the solution of whale-oil soap. Besides this apparatus, intended for use in large orchards or in communities where a considerable number of infested places were separated by short distances, we had in use from one to three hand-sprayers of the kind ordinarily used in orchard work.

The machine sprayer (Plate II.) is mounted on a two-horse baggage wagon, under the seat of which are placed the battery and the gasoline tank to supply the burners. Immediately back of these, on the first third of the floor space, is the engine. The large heating tank comes next. It is set close to the right side that there may be room on the left for the belt which connects the engine with the pump. The pump occupies the remaining room in the back. The wagon thus loaded weighs 2,400 lbs.

The gasoline engine (Plate III., Fig. 1) which drives the pump was manufactured in the University Shops. It has a four-inch cylinder with a four-inch piston stroke. The gasoline vapor is made by the flow of air over a gasoline jet from a needle valve on the right side, this jet being caused by gravitation from a supply tank placed higher than the engine and above the wagon seat. Gas is drawn into the cylinder from the vapor chamber to fill the partial vacuum caused by the previous explosion, a valve to allow this being opened each time the piston passes the center. The vapor when under a back pressure of forty pounds is exploded by an electric spark caused by an inter-cylinder contrivance making and breaking the current from a sixteen-cell battery. The pulley wheel is nine inches in diameter and makes about four hundred revolutions per minute. The engine is rated at one-horse power.

Just back of the engine is the tank, firmly attached to a three-eighths by one and a fourth-inch iron frame raised sixteen inches from the floor of the wagon. There are six legs of the same material as the frame, each bolted to the floor. Beside these legs two braces extend forward from the upper part and are bolted to the flour, one on either

side of the base of the engine. The tank is of heavy galvanized iron, fifty-six inches long by twenty-six inches wide, and twenty-seven inches deep. Its capacity is one hundred and seventy gallons. A partition runs crosswise through the middle, and each section thus made has a twelve-inch opening in the top and a cap for the same. In the left-hand corner, toward the rear, each section empties through an inch pipe into the system leading to the pump. A valve on this pipe admits the shutting off of the section from the feeding system at will. Another valve allows the direct emptying of the section without passing its material through the pump. Each section of the tank is provided with like valve and arrangements, and contains a strainer so placed that all liquid passing to the outlet must run through it.

Beneath the tank are two sets of gasoline burners (Plate III., Fig. 2), each set having twelve burners, all constructed on the same principle as is the common plumber's torch. Gasoline comes to them through a pipe on the right side of the wagon from a tank under the seat. To this tank is attached an air pump and a pressure gauge. While in use a ten-pound pressure is maintained. By means of valves, one or both sets of burners may be in use at one time, and the construction is such that each burner may be shut off or caused to burn low. The floor of the wagon under the tank is thickly covered with asbestos and cement, which protects the wood and forms a foundation for the pipes which support the sets of burners. Within the iron frame are two side- and two end-strips of galvanized iron which protect the burner flames from wind and help retain the heat beneath the tank.

The pump is of the triplex type, having three one and three-quarter inch-cylinders capable of a two and a half-inch-piston stroke. The pumping capacity is 0.07 gallon per revolution of crank shaft, or from 2.8 gallons to 4.2 gallons per minute when run within recommended speeds, and the pump will operate against one hundred and fifty pounds per square inch. A one-inch feed-pipe enters from the tank, which is elevated, in the manner stated, above the body of the pump. The discharge may be through a one-inch pipe or through the series of four quarter-inch cocks arranged on a cross-pipe which is connected with the one-inch discharge. The belt runs on a twelve-inch pulley with a two and a half-inch face. There are two pulleys, one loose on the shaft.

A three-eighths inch pipe is connected up with the discharge and the water jacket of the engine cylinder, and this cylinder again with the feed-pipe, thus allowing a flow through the water jacket. The rate of this flow is governed by a shut-off valve on the jacket feed-pipe near the cylinder. When only two quarter-inch hose are in use this valve

may be opened sufficiently to cause not only the circulation in the water jacket, but also to relieve the increased pressure on the two hose.

Beside the main parts of the outfit, as above mentioned, there are two tool boxes, about one hundred and fifty feet of three-ply quarter-inch rubber hose, poles and extension rods for spraying higher parts of the trees, pails for carrying water, and gasoline cans.

The larger tool box is 8.5 in. x 41 in. x 32 in. outside measure, and was made in this form that it might occupy the space between the tank and wagon box, on the left, when moving from place to place. In this box are the work clothes, a spade, hatchet, nozzles, reducers, wrenches, wire-cutters, packing, screw-driver, and other articles used in connection with the spraying operation. The smaller box is 12 in. x 19 in. x 20 in., and was made to occupy the space between the engine and the tank. It contains the oils and smaller renewal parts for the engine.

A large tarpaulin covers the whole apparatus, and by means of short ropes attached to its edges may be securely fastened to the wagon-box, so that in shipping, engine, tank, and machinery are all under shelter and protected from the weather.

Details of Treatment, with Results.

At Dundee, Kane county, all the trees (apple, peach, and mountain-ash) upon which the San Jose scale could be discovered were dug out and destroyed in the presence of my Assistant, Mr. R. W. Braucher, November 20, 1897. Everything in the block of trees in which this infested stock was found was, in fact, so destroyed at this time except some shade trees—black walnut, horse chestnut, white elm, hard maple, birch, and basswood, and these were thoroughly sprayed with whale-oil soap. A few white-ash seedlings in this block were not sprayed. The apple-, cherry-, and pear-trees in the vicinity, and scattered soft maples, rose-bushes, and syringas next the infested block were sprayed, leaving without treatment only the ornamental shrubbery farthest from the trees infested.

These premises were very carefully inspected again September 7, 1898, by Mr. E. C. Green, of my office, and still more fully, October 28 and 29, 1898, by Mr. E. B. Forbes, the first inspection to ascertain, for my own information, the effect of the insecticide procedure there, and the second, made at the request of the owner, to serve as a basis for a certificate of freedom from the San Jose scale and other injurious insects and fungous diseases. Both these skilled and careful observers reported after this interval of nearly a year from the time of treatment that there was no trace of the San Jose scale to be found on these

grounds; but to make assurance doubly sure I required the destruction of all stock on the infested premises which could possibly harbor and maintain the scale, designating the various lots and kinds of trees and shrubbery objected to. This requirement had been made good by January 16th, and an unqualified certificate of apparent freedom from the San Jose scale and from all other dangerous insects and from fungous diseases capable of being transported with nursery stock to the injury of customers was issued under that date.

At Monroe Center, in Ogle county, the single pear-tree originally first infested had been cut off close to the ground and burned by the owner, and the bark had been removed from the stump for some distance below the surface. Two shoots three or four feet high which afterward grew up from this stump in the summer of 1897, showed no signs of the scale November 18th of that year. Traces of the scale were found, however, on two eight-year old Rocky Mountain cherry-trees and on some sprouts of another pear-tree near by. All the infested bushes and trees on this lot and everything near by were thoroughly sprayed at this time with whale-oil soap—one hundred and fifty trees and shrubs in all, including peach, pear, cherry, apple, and plum, grape, goosebery, currant, Rocky Mountain cherry, etc., and not a scale could be found on these or on any of the surrounding vegetation by Mr. Green, who visited this place September 9, 1898, for the purpose of ascertaining the effect of the treatment.

On Mr. Jacob Winzeler's place, two and a half miles south of Tremont, everything on the premises liable to attack by the scale was sprayed with whale-oil soap by Mr. Green March 28, 1898. Nine hundred and forty fruit-trees and shrubs were thus treated, and also fifteen large maple-trees about forty feet high. On a visit of inspection made nearly six months later (September 14th) Mr. Braucher reported that he found a few living young San Jose scales, about half grown, on three large peach-trees, but that otherwise the premises seemed free from the scale. The large maple-trees had been badly damaged by the spray, many of the lower branches having been killed, evidently by the drip from the branches above.*

On Mr. P. B. Stem's place, three and a half miles north of Manito, two hundred peach-trees and twenty-five apple- and quince-trees were cut out, and also twenty rods of osage-orange hedge. Nine hundred trees were treated in this orchard, ranging in age from six to ten years. As none of these had ever been trimmed, about three days' work of four men was required to prepare them for treatment. The spraying upon the 7th and 8th of April, 1898, was followed by a heavy shower in the

* All infested trees since destroyed.

night, and the whole orchard was consequently sprayed again, the work being finished April 11th. Five months later, September 14–16, 1898, a critical inspection of this whole orchard was made by Mr. Green. On one peach-tree six living scales were found on new wood; on eight other peach-trees one or two scales each were found; and on each of six others from one to seventeen scales remained—mostly on new wood but some under bits of bark on the older growth. On a single peach-tree a colony of one or two hundred scales was found upon a branch, a part of which had evidently escaped the spray. Except for this single colony the total number of scales found on a very careful search of everything in and near this orchard which had been previously infested resulted in the discovery of about fifty living scales.

According to the report of Mr. Braucher, as summarized in my last entomological Report (page 15), about ninety-nine per cent. of the San Jose scale in the orchard of Mr. Kiem, near Quincy, had been killed by two successive sprayings with whale-oil soap, made in the fall of 1896 and the spring of 1897. That this was not an overestimate of the efficiency of the treatment is shown by the report of Mr. Green, who visited this orchard April 13, 1898, and upon a rigid examination could find no living scales on the premises except on the trunk of one small apple-tree. He proceeded, according to his instructions, to treat thoroughly a third time all the trees (twenty in number) which had originally been badly infested, first scraping the trunks and removing the earth from about the bases. Hot soap solution was brushed on with stiff brooms up to the uppermost twigs, and these were sprayed except in a few cases where they were perfectly fresh and bright, evidently never having had any scale upon them. A very critical examination of this orchard made September 20, 1898, by the acute and careful inspector, Mr. R. W. Braucher, showed that the San Jose scale in this orchard was, however, far from being exterminated, living scales being detected on several apple- and peach-trees which had been badly infested when the treatment of this orchard began. One apple-tree had been so badly incrusted with the scale that especial pains was taken to treat it thoroughly. The limbs were cut back to a few short stubs, the bark was scraped, and the tree was thoroughly coated with strong soap solution by means of a brush. Pieces of bark clipped from this tree showed, nevertheless, that it was still slightly infested by the scale.

At Paloma, visited April 17th, where one infested tree had been previously found, no scale could be detected. This tree had been taken out and burned, and others near it had been twice sprayed by the owner with whale-oil soap.

Mr. Lowe's orchard of five acres at Auburn, in Sangamon county,

was found by Professor Summers very generally infested, together with a hedge adjoining. This whole orchard and two rows of another orchard adjacent to it, not infested, were thoroughly sprayed by Professor Summers the first week in January, 1898. The infested hedge was not treated, as the owner promised to destroy it. September 17, 1898, it was found by Mr. Green that this orchard was by no means free from the scale, a considerable number of trees—apple, pear, peach, and plum—still showing from one to a dozen, twenty, or more, living scales. A few scales were also found upon apricot trees in an old orchard near by which was not treated by Professor Summers. The situation at this place was on the whole quite unsatisfactory, and the premises will doubtless become thoroughly infested again within the course of two or three years unless additional measures are taken for the destruction of the scale. The infested hedge mentioned above had been twice cut down, but had not been killed.

The infested trees on Mr. Henry Archer's place, two miles from New City, in Sangamon county, were scattered through the western end of an orchard of about five acres. These were mostly young, but a few of them were large peach-trees, and others were of various sizes intermediate. All the very badly infested trees were, however, very small, and the scale had apparently spread but a short distance from them. About sixty trees were sprayed in this orchard in January, 1898, including, of course, all those visibly infested but going some distance beyond them. September 18, 1898, about seventy trees were found still infested with the scale, commonly not more than from ten to twenty specimens on a tree. It was also found in an old orchard adjoining the one principally infested and which had not been sprayed by Professor Summers in January.

At Assumption, in Christian county, the entire small orchard belonging to Mr. Tobias on a city lot on which a single infested tree had been found, was sprayed February 12, 1898, by Mr. Green, and the pear-tree on which the scale had been brought to these premises was dug out and burned. This tree was one of six obtained by mail from a Philadelphia dealer. The remaining five were found in the hands of other citizens, all free from the scale except one belonging to Mr. Hiram Hooten, which bore a few specimens sufficiently like the San Jose scale to give ground for suspicion. This tree was thoroughly sprayed by Mr. Green. September 20, 1898, on a single tree (a quince) Mr. Green found one San Jose scale; otherwise the trees on Mr. Tobias's lot seemed free from the scale.

At Tower Hill early in February, 1898, two trees on Mr. Grisso's place were cut out and burned, six were thoroughly sprayed with soap

solution, and others adjacent were partly sprayed. On Mrs. Connor's place one tree was dug out and seventeen trees were sprayed. September 21, 1898, Grisso's place was found in rather bad condition. On three of the trees sprayed in February from three to eight living scales were detected by Mr. Green; on two adjacent trees not sprayed the San Jose scale was found, the trunk of one being covered and its upper branches infested; and on another part of the place, a hundred rods from the infested trees above mentioned, three trees were found badly incrusted with the scale, one an apple, one a plum, and one a flowering quince. It is probable that the scale is generally distributed on Mr. Grisso's place, and that only a thorough insecticide treatment of the whole of it can check its spread effectively. On the village lot of Mrs. Connor no scale was found at this time.

At Herrick, in Shelby county, it was found that the owner had removed the infested trees in August, 1898, and burned them up. A very careful examination of eight others, planted near them and separate from the main orchard of the owner, was made by Professor Summers February 12, 1898, but no trace of San Jose scale could be found upon them.

Spraying at Ernst, January 18 to 24, 1898, was attended by unusual difficulties and much delay owing to unfavorable weather, frequent rains probably washing off much of the soap. Work began January 18th and continued through the forenoon of the 19th, but was then interrupted by rain which lasted all the afternoon and into the night. The 20th was too windy for orchard work, but spraying began again on the 21st and was followed by rain—in part violent showers—nearly all the 22d. On the afternoon of the 24th spraying began again, but was followed at night and in the morning by several hard showers. One hundred and sixty-four trees were sprayed in all, ranging from yearlings to trees fifteen feet high; and, besides these, rose-bushes, currants, gooseberries, honeysuckles, etc.

Notwithstanding this unusual exposure to rains, Mr. Green could find March 24th only nine living scales on these premises, six under a bit of bark upon a pear-tree and three on a currant bush. A great part of the premises was, however, sprayed again, seventy-two bushes and trees being included in the treatment. Only about four hours' work was needed, but it took six days to do it on account of daily rains. October 12, 1898, Mr. R. W. Braucher carefully inspected everything on these premises and could not find living San Jose scale upon any shrub or tree. He also observed that the whale-oil soap had generally destroyed the Forbes scale (*Aspidiotus forbesi*), but that the scurfy scale (*Chionaspis furfurus*) was but little affected by the winter application of

whale-oil soap. From seventy-five to ninety-five per cent. of the fruit buds on the peach-trees had been killed by the January treatment, but buds on the other trees were apparently uninjured. Spray applied during the latter part of March had, however, killed many buds on plum- and pear-trees.

At the farm of Mr. E. L. Howard, in Edgar county, a short distance from Sandford, Ind., it was found in January, 1898, that all the infested currant bushes had been dug out and destroyed by the owner, and that the woodland brush next the infested field had been partly cleared off and burned. It was the owner's intention, in fact, to complete this work the following spring as a safeguard against the possible perpetuation of the scale in this situation. A plat of quince bushes and some rows of apple-trees in the vicinity of the infested grounds were sprayed by Mr. Braucher at this time, although no San Jose scale was detected on any of these trees or shrubs. Another inspection made by Mr. Braucher October 11, 1898, gave a similar negative result, and it seems likely that the San Jose scale has been exterminated at this point.

At Mr. A. H. Evinger's place near Vermilion, Edgar county, to which the scale had been transferred by purchase of currant bushes from the premises of Mr. Howard, just mentioned, the San Jose scale was found on only three currant bushes among some four hundred in the plantation, and on these it was so scarce as to make it little likely that it had spread to adjacent plants. All the currant bushes in this plantation, together with eighteen small plum-trees near by, were thoroughly sprayed January 4, 1898, and October 11th no San Jose scale was to be found on this place.

The colony on the place of Mr. Charles Eckert, three miles from Collinsville, was visited by Mr. Green February 18, 1898, with a view to its destruction. It had by this time made considerable progress, as is shown by a comparison of the observer's notes with the statement published on page 10 of my last Report. Trees then slightly infested were found by Mr. Green in the last stages of disease from scale attack; and where one badly infested pear-tree was reported previously sixty pear-trees were now badly infested and some of them dead. Work here was retarded by rain and by the reluctance of the owner to allow his trees to be sprayed. Five trees were finally dug out and burned, however, and forty-eight sprayed. The spraying was, unfortunately, followed within twelve hours by about eight hours' rain. Twenty-two trees were found still slightly infested on these premises September 27, 1898, when revisited by Mr. Green, the number of scales detected varying from one to twenty on each tree.

At Mascoutah the infested premises described as belonging

originally to John Baisch* were found in the possession of Charles Clements. The small orchard contained about one hundred trees of various sizes, and the place was in greatly neglected condition, blackberries, raspberries, and gooseberries having grown unchecked, to form a dense and almost impenetrable thicket under the orchard trees. There were no fruit trees adjacent to this lot except in one direction, across the street, and no scale could be found anywhere in the vicinity. It was abundant, however, on a row of peach-trees about the middle of the lot, and had spread from these to blackberries beneath. The owner declined to allow any trimming of trees or any removal of shrubbery, but Professor Summers made, December 8, 1897, a persistent effort to spray thoroughly everything on this lot, using nearly six hundred pounds of soap. The scale was nevertheless found by Mr. Green September 28, 1898, on about thirty of these trees, the number detected ranging from one to twelve per tree, except in a single instance, apparently overlooked earlier, of a peach-tree thickly infested throughout.

At West Salem, visited by Mr. Braucher February 4, 1898, all the trees known to be infested on Mr. Fishel's premises were sprayed, together with adjacent trees for six rows in one direction and four in another. Sixty-one trees were treated in all, ranging from six to eighteen feet in height. From Mr. Braucher's report of a visit made October 28, 1898, it appears, however, that this spraying was not carried far enough, as he found at the time a few infested trees outside the area sprayed, as well as eighteen within the area which still carried a very few living scales each.

The infested orchard on the farm of Mr. C. S. Frame, three and a half miles east of Alhambra, in Madison county, was treated February 25, 1898, twenty-one trees being cut down and destroyed and thirteen others sprayed after heroic cutting back. The weather continued steady for several weeks after spraying, and the soap could still be seen upon the trees a month after it was applied. Visited September 23d and 24th by Mr. Green, it was plain not only that the treatment was but partially effective but also that the scale attack had extended farther than was supposed at the time the spray was applied. From one to a dozen scales were found on each of twenty-five trees, apple, peach, pear, and plum, still standing in various parts of this orchard. The trees had made an excellent growth, and the living scales remaining were usually found on the trunk beneath a thick crust of the dead or in deep cracks where young shoots started out from the old wood.

At Walnut Prairie both Mr. Cline's and Mr. Kreager's orchards were sprayed by Mr. Green March 15 to 18, 1898, fifty-six trees and

* See Twentieth Rep. State Ent. Ill., p. 10.

fifty-five bushes on Mr. Cline's place and sixteen large trees on Mr. Kreager's. Operations here were much hindered by rains, and part of the spraying was repeated on this account. These premises were inspected by Mr. Braucher, October 13, 1898. Mr. Cline's orchard still gave evidence of having been very badly attacked by the scale, and living scales were found upon it in sufficient number to reproduce the difficulty within two or three years. On Mr. Kreager's place, originally infested from Mr. Cline's, much the same condition of things was found. The transplanted plum-tree by which the scale was brought to these premises had been very severely cut back and very thoroughly treated with whale-oil soap, which was rubbed in by hand and applied so freely that it formed a pool around the base of the trunk. Nevertheless, many living scales were found on this tree by Mr. Braucher in October, especially on the young-growth of the year. Several other trees on these premises were likewise still infested with living scales, which were found also on two peach-trees not sprayed by Mr. Green. The imperfect result of the insecticide treatment of these orchards is doubtless to be attributed mainly to the accompanying rains.

At Mt. Carmel, five trees were dug out and two hundred and sixty-two were sprayed, belonging to eleven different owners living on five adjacent blocks. About eighty feet of infested osage-orange hedge was also cut out and destroyed. Most of the trees were large and full of branches, necessitating much pruning as a preparation for the spray. One owner refused my agent admission to his premises, although an inspection on a previous visit had determined the presence of the scale on his trees.

Subsequent inspection showed that the scale was much more widely distributed at Mt. Carmel than was supposed at the time this spraying was done It was found, indeed, by Mr. Braucher, late in October, on no less than fifteen blocks, many of which had, of course, not been sprayed, and even on those which had been treated with the whale-oil soap it had not been completely eradicated from a single one. The failure of the insecticide to exterminate the scale is well illustrated by the fact that twenty-five trees and bushes were found infested in October upon a lot (Mrs. Deischer's) where forty-eight had been sprayed the preceding March, and that twenty-three were still infested in an adjoining lot (belonging to Mr. R. K. Stees) where thirty-two had been sprayed by Mr. Green.

The situation at Richview proved on continued inspection to be much more serious than was at first anticipated, the scale being so widespread as to make it impracticable for us within the time remaining last spring and with the funds at my disposal, to complete the procedure

for its extermination at this point. Instructions were consequently given to my field assistants, Mr. Braucher and Professor Summers, to spray thoroughly those orchards or parts of orchards in which it was present in destructive numbers, and to treat also all other infested vegetation whence it was likely to spread within a year to new territory, thus arresting the ravages of the insect where it was doing real injury, and preventing the extension of the area infested by it. These measures were taken with the expectation of returning to this locality after the fall of the leaves in 1898 for a final treatment of these premises. All of the infested property on the ground of Mr. J. W. Stanton, where the scale was first discovered at Richview, was thoroughly sprayed with whale-oil soap in February, 1898,—some sixteen hundred trees in all,—except certain badly infested trees which were dug out and burned. In addition to this the premises of Mr. Jasper Wilgus, separated from those of Mr. Stanton by a country road and a high hedge fence, were very generally treated, several badly infested trees being destroyed and many others sprayed. About an eighth of a mile of hedge was cut down and burned, and the stumps remaining were profusely sprayed with kerosene. From the orchard of Mr. Chas. Cooper, all trees originally found infested had been cut out and destroyed, but a few remained infested February 14, 1898.

One of the places worst infested, a mile south of Richview, on the estate of Mr. Newcome, contained about twenty-three hundred trees. The condition of the spring weather and the exhaustion of funds available for the purpose prevented the thorough treatment of these premises, but the trees originally infested were all cut out and extensive spraying was done with the object of exterminating the scale from the orchard worst infested and of reducing its numbers in other parts of these grounds sufficiently to render its spread unlikely. Approximately five hundred trees were sprayed in all upon these premises, leaving only a few partially infested trees scattered here and there. Later all or nearly all of these were infected with a fungus parasite of the San Jose scale, as will be described in another section of this article.

Half a mile north of the Newcome place a single apple-tree, in a garden belonging to Mr. B. F. Johnson, badly infested with the San Jose scale, was sprayed, together with two other trees adjacent to it. A single infested tree which had been detected in an orchard immediately west of Richview, rented by Mr. Hamilton, was dug out and destroyed by the owner. Although no scale could be found on any other orchard tree, eighteen or twenty trees immediately surrounding were thoroughly sprayed by Professor Summers, and a large osage-orange hedge beside this orchard was cut out.

A prolonged inspection of one of Mr. Stanton's orchards at this place, made by Mr. Braucher early in November, showed substantially the same results as in those previously described. The great mass of the scales had been killed, but everywhere enough remained to give origin to a new attack, which in a short period of years would equal in destructiveness the one suppressed by our insecticide operations. Fifteen hundred and forty-four trees were sprayed in this orchard of dwarf pears, and of these, fourteen hundred and nine were examined by Mr. Braucher the first of November. Not less than one hundred and seven of these trees still showed the living San Jose scale—in a great majority of the cases in small numbers only, but quite numerous on here and there a tree.

As a general result of the operations above described it appears that the San Jose scale has been exterminated in seven* out of twenty-one places treated, namely, at Dundee, Monroe Center, Sandford, Vermilion, Ernst, Herrick, and Paloma, but that more or less conspicuous traces of its presence are to be found in all the fourteen others.† On several of these fourteen premises it was wholly killed on many badly infested trees, but in none of them on all. Even at Quincy, where a single small orchard was sprayed, at intervals, three times in a very thoroughgoing manner, enough of the scales survived to reproduce the original condition in three or four years at most. The places where the scale was completely destroyed were those where it had made least headway and where everything seen to be infested was promptly cut up and burned, this destruction being reinforced in most of the cases by a general spraying of everything in the immediate neighborhood on which the scale could live. There seems, on the whole, little likelihood that the spraying method can be depended on even where most thoroughly and persistently applied, to exterminate the scale on any place where it has had a few years to establish itself. On such a place the only sure remedy is the ax and the faggot, applied to every tree and shrub on which the scale is seen to have made a lodgment, supplemented by liberal spraying of all vegetation which may have become obscurely infested. It is true that fumigation with hydrocyanic acid gas has occasionally been recommended as efficient for the extermination of the scale even where the trees are completely and heavily infested, and some experiments lately published, especially in a Report on the San Jose

*Now nine.

†Inspections made since the preparation of this manuscript show that the San Jose scale has apparently been exterminated at Villa Ridge also and on Mr. Winzeler's place near Tremont. At both places, every tree upon which there was any definite reason to suppose that the scale was finally present, was cut out and destroyed.

scale in Maryland,* seem to sustain this recommendation. The general judgment of economic entomologists will, however, doubtless support the following statement quoted from a letter by Dr. L. O. Howard, written December 14, 1898.

"While hydrocyanic acid gas furnishes the most effective means of destroying the San Jose scale and many other scale insects, it is not, as some seem to suppose, an absolutely perfect remedy, and experience for many years has fully demonstrated, and also experience in the East, that here and there an occasional scale will escape this treatment, and, in the course of two or three years, it will be necessary to go over the plants again. In California, treatments are found to be necessary about every three years. Where the work is done with exceptional care, perhaps a longer period of immunity is sometimes gained."

In brief, the San Jose scale can clearly be kept in check by thorough spraying with whale-oil soap or by general fumigation with hydrocyanic gas once in two to four years, according to the situation and the rapidity of its multiplication; but it can be exterminated where it has once effected a lodgment only by drastic measures of destruction supplemented by careful spraying or fumigation, or by repeated treatment applied in every case just as soon and just as frequently as a watchful inspection gives any evidence of the presence of the scale.

Difficulties of Coöperation.

The state legislature, as has already been said, rejected in 1897 a plan of legal and authoritative control and substituted therefor a mere appropriation to the State Entomologist, who was thus provided with funds for an investigation and destruction of the San Jose scale, but was left without authority to compel action on the part of reluctant owners, or to proceed to act in opposition to their wishes. The success of the work of destruction was consequently dependent upon volunteer coöperation between the Entomologist's office and the citizens most immediately concerned. There was commonly no difficulty in securing such coöperation, at least in the form of permission to enter upon premises and the contribution of a considerable amount of labor in the application of insecticides. It was much more difficult, however, to induce the responsible owner to share in any way the expense of operation, some refusing absolutely, declining to acknowledge any responsibility to the community; others declining to bear any share of the expense until satisfied that the insecticide operation was fully successful; and still others agreeing, but neglecting, either to purchase the insecticides or to pay for them when furnished, as proposed in my office circu-

*Bull. No. 57, Md. Agr. Exper. Station, Aug., 1898.

lar. Indeed, three owners out of the thirty or more concerned positively objected to have their premises entered on. Two of these were finally prevailed upon by the use of tact and persistence, but the third successfully resisted the persuasions of the agent of my office, and his premises were necessarily left without treatment. As illustrations of the difficulties encountered, the following items from the reports of Professor Summers and Mr. Green will be of interest:

"Stepping into the yard of Mr. ———," writes Mr. Green, "I met an angry old gentleman who vehemently ordered me to move on, saying that his trees did not need any inspection. I tried to tell him about the scale, and referred him to his neighbors who were having their trees examined, assuring him that there was no charge for the inspection or the work. He would listen to nothing, however, but said that he was old enough to care for his own trees and didn't ask the state to look after him. The last legislature, he said, was a band of thieves and robbers, and had started a scale scare to furnish fat salaries for two of its favorites; then further remarked that a man had been there some time before who had gone across his lot without permission, and that now he would be glad to see the last of me. I finally apologized for troubling him and left."

"At ——— walked out to the place of Mr. ———, three miles from town. The oldest son, a man of about twenty-five, showed me the infested trees, the mother also coming along. Some Japanese plums in one corner of a large peach and apple orchard were in the last stages of disease, completely infested by the scale. In another lot were several pear-trees, all badly infested and some dead. Both mother and son tried to convince me that the trees did not need treatment, or at any rate that they could wash off the scales themselves with their own soft soap. I pointed out the trees which I was sure that it would be absolutely necessary for me to treat with whale-oil soap, but they said nothing. I asked if one of their sons could take me back to town that afternoon and bring out the apparatus if it had come. They said the boys were busy and had no time to spare; but as a friend was to be taken to the train that afternoon, one of the girls hitched up a horse and I was allowed to ride with them. I found my spraying apparatus at the depot and sent back a note by the girl asking that the team be sent for it in the morning. Starting out to the place on foot, I met the team with a girl driving. She said she was going for a load of brick, and would not bring out my material without orders from home. I presently found a neighbor of the family who agreed to bring my apparatus out that day as he returned from hauling a load of wheat to town, and I sent word to Mr. ——— that I would be out to spray his trees, asking him to have

water hot that we might go to work without delay on my return. He looked more surprised than pleased when I came back with the apparatus, and there was no hot water. It threatened rain, and was then too late to begin, so I contented myself with their promise to have hot water ready in the morning. The next day, while the boys were heating the water, I pruned the trees. The boys finally helped in spraying and took the machine back to town, but the owner flatly refused to pay for the soap. The elder son, who took the apparatus to the station, became quite friendly before we separated, and told me that when I came back the second time they talked of getting the shot-gun and driving me off the place."

At another town, where the trees and bushes on a village lot were thoroughly infested by the scale, Professor Summers was met at first by a refusal to give him admission to the grounds. He ignored the refusal, however, and continued his preparations, entering upon a good natured conversation with the owner. Seeing a large soap kettle at hand, he asked the use of it for boiling up his whale-oil soap. This was refused on the ground that the kettle belonged to the owner's father and that it "might be called for any minute." By inquiry in the neighborhood another kettle was found, and this was hired at fifty cents a day. The owner of the infested trees, on his way to town to consult a lawyer, met a neighbor who told him not to interfere with his unwelcome visitor who, if an agent of the state, was probably acting under authority of law. This very reasonable but mistaken supposition served our purpose, and no further objection was made, although all assistance was steadily refused. The work was thoroughly done by Professor Summers, and no charge was made by us for materials used.

As an example of the cordial spirit in which our propositions were commonly received, Mr. Green's account of his experience at Manito may suffice.

"Visited, according to instructions, the farm of P. B. Stem, three and a half miles north of Manito. Walked out in the morning and found the owner plowing, He at once put away his horse and showed me the worst infested section of his orchard, spending the rest of the day with me in examining trees and hedges. We found that the scale was scattered through something more than six acres and had also infested twenty rods of hedge. Learning that the soap necessary to thorough insecticide treatment would probably cost about $30, he asked me if I wished the money at once. The next day he hired an additional man for the work and gave also his own time and that of his son. We all worked two days in pruning trees to be sprayed, and afterwards one of us cared for the fire, another worked the pump, and the remaining two

applied the spray. Everything I asked was cheerfully done. Trees too seriously damaged for treatment were cut down and burned over their stumps, and a row of osage-orange hedge especially valued by the owner because in a year or two it would yield valuable posts was also cut out by my advice and thoroughly destroyed. Mr. Stem made five trips to town on my account, gave five days' work of three men, sacrificed about two hundred trees besides the hedge, and put himself to considerable inconvenience in his farming operations, as his teams were left idle when his oats should have been planted."

General Insecticide Procedure.

The field assistants responsible for the spraying of infested orchards were Professor H. E. Summers and Messrs. E. C. Green and R. W. Braucher. Their methods were, of course, substantially the same. When hand sprayers were used the soap solution (two pounds to the gallon of water) was made in large soap kettles, which it was possible to find in every neighborhood. To diminish the labor and expense, and likewise to insure a more thorough application of the insecticide, trees to be sprayed were pruned and cut back as much as the owner would permit. If the trunks of the trees were rough they were scraped to remove loose bark, and if the scale was found upon the trunk the earth was scraped away to the surface of the upper roots. The assistant always directed the spray himself, depending on the aid of owners for the rest of the work. In distributing the insecticide, limbs and branches were followed out one by one with the nozzle in a way to make sure that the spray reached every portion of the surface. Trees were frequently sprayed from opposite directions, especially if the wind were blowing considerably. Trees so covered with the scale that the surface of the bark was generally concealed were commonly cut out and burned. When the machine sprayer was in use two men from my office traveled with it, and two lines of hose were commonly used at once, with two spray nozzles for each. The soap solution was in process of preparation in one of the tanks while the spraying was emptying the other, and the spraying machine was thus kept continuously at work. For this continuous operation of the apparatus, however, a third man was required to attend to the engine and make the soap solution.

The progress of the work was very much delayed and continuously embarrassed by the unusually wet and open winter. Frequent rains and sleets hindered orchard work or made a repetition of it necessary, and the wretched condition of the roads blockaded the machine sprayer for weeks at a time. We also found this large and heavy apparatus inconvenient for our purpose owing to difficulties of railroad transportation.

It could only be moved on a flat car,—not always to be had at call,—and loading facilities at small stations were sometimes insufficient for the handling of it. These experiences, together with the partial failure of the engine, led towards the end of the season to a substitution of hand equipments entirely for the machine sprayer, three of these being in the field at once during the latter part of our operations.

An Efficient Fungous Disease.*

Notwithstanding the quantity that has been done and written—much of it by myself—concerning the use of the bacterial and other fungus parasites as a means of spreading contagious disease among insects for their destruction, it can scarcely be said that this insecticide method has been reduced to practice with entire success for so much as a single insect species. In the nearest approximation to a practical method yet made, the use of *Sporotrichum* for the chinch-bug, the results have been from the beginning so equivocal and so variable that this method has never yet been recommended from this office as generally available or in any way trustworthy. It is with especial satisfaction, consequently, that I now report a series of experiments with a fungus parasite of the San Jose scale, first successfully applied by Prof. P. H. Rolfs, of the Florida Agricultural Experiment Station, which gave in our hands during the summer of 1898 great promise of usefulness as a strong and steady check upon the increase of this orchard pest.

The conditions of experimentation with this fungus are fortunately very favorable to tangible and precise results. The scale insects being motionless, we are able to keep the identical individuals treated under continuous observation without artificial management; and the fungus used being one not native to the San Jose scale, the results of experimentation are not liable to be clouded by its spontaneous occurrence either before or after the experiment is begun. It has been very easy, consequently, to demonstrate the success or failure in every case, and the results may be accepted as unequivocal.

The existence of this parasite of the San Jose scale was first brought to my notice by a letter from Prof. John B. Smith, written January 5, 1897, informing me that Professor Rolfs, of Florida, seemed to have found a specific organism which "had cleaned out some infested orchards in Florida and promised to control the scale completely." He further quoted Professor Rolfs to the effect that the fungus had withstood quite a low temperature, and that it was a constant parasite of a scale on the oak. He was also kind enough to send me a small quantity

* See Plate IV., Fig. 7, for an illustration of the characteristic growth of *Sphærostilbe coccophila* from the edges of a San Jose scale killed by this fungus.

of a culture received from Professor Rolfs purporting to be that of the scale fungus mentioned.

The condition of this material from Professor Smith was not such as to encourage attempts at cultivating it, and I obtained instead, direct from Professor Rolfs, early in February, 1898, some limbs of the water oak infested by the common scale of that species, *Aspidiotus obscurus*, many of which had been killed by the fungus parasite in question—*Sphærostilbe coccophila* Tul. In the letter accompanying this material Professor Rolfs informed me that in order to introduce this fungus into orchards infested by the San Jose scale it was only necessary to tie a piece of a branch bearing the fungus to some portion of the infested tree. February 27th he also sent me a small amount of *Sphærostilbe* on the San Jose scale itself, the product of an infection made by him the preceding year.

From the dead oak scales (*Aspidiotus obscurus*) received from Florida in February, 1898, cultures of the fungus were begun March 4th, by my assistant, Ernest B. Forbes, at first on gelatine, then on boiled potato, and finally on corn meal and milk, and corn meal and beef broth. Although the inoculations were all made from the insect itself, all the material proved to be much contaminated, containing especially *Penicilium*, *Pestalozzia*, and a liquefying bacillus. Careful separation cultures were thus necessitated, and by transfer from these, perfectly pure cultures of the *Sphærostilbe* were finally obtained.

The arcuate conidial spores of this fungus may germinate within four or five hours, and the growing mycelium acquires a characteristic pinkish color usually within five days. Vigorous growths of the fungus developed identical arcuate spores within a week from the time of inoculation, this fruiting stage being indicated to the naked eye by the appearance of patches of a deep red color in the lighter pink of the mature mycelium. In one case a culture begun May 17th on bread soaked with sweetened milk, developed spores profusely by May 20th. It proved extremely difficult to obtain the conidial stage of the fungus, or fruiting bodies of any kind, on peptonized gelatine, and scarcely less so on boiled potato, but cultures on corn-meal batter made up with beef broth, or on pieces of bread saturated with the same, yielded the spores very readily and in great abundance, the whole infected surface presently becoming a bright scarlet color, and being covered with a thick dense layer of elongate, curved conidia. A considerable amount of moisture seemed necessary to a full development of the fungus, and several of our failures in the beginning were apparently due to the fact that the medium was kept too dry.

By May 21st we had grown a considerable quantity of this fungus

on corn meal and beef broth as a preparation for extensive inoculations of the San Jose scale in the orchards of southern Illinois. In the meantime a personal visit to the peach and pear orchards of northern Florida gave me reason to expect a favorable result in Illinois, and it likewise put me in possession of a considerable amount of fresh material in the form of twigs of trees infested by the oak scale killed by the *Sphærostilbe* spontaneous on that insect.

My principal observations in Florida were made on the 20th of March in the vicinity of De Funiak Springs, when, in company with Professor Rolfs, of the Florida Agricultural Experiment Station, I carefully examined three peach orchards. In the first of these, the Rose Hill orchard, there were but very few of the San Jose scale to be found, the number having greatly decreased within the last four years. These trees had been sprayed with rosin, potash, and sulphur during the winter of 1893 and 1894, but had never been artificially infected with the scale fungus. We found, nevertheless, on a single tree a very few specimens of the San Jose scale with a fungus parasite which seemed to be the *Sphærostilbe coccophila* and was so taken by us at the time. Subsequent study on my return showed, however, that the fungus in this orchard was of a form closely related to *S. coccophila*, but of a species apparently new. It is distinguished not only by the smaller and much more strongly arcuate conidia, but also by strongly marked culture characters. The color of a mature culture, for example, is not red but a dusky brown with a slightly reddish tinge, and identical culture processes and media with those which yield the arcuate conidia of *Sphærostilbe coccophila* give with this only masses of minute oval spores.*

A second orchard, belonging to Mr. Mellish, had originally been heavily infested with the San Jose scale, but this had now almost entirely disappeared. The scale in this orchard had been inoculated in August, 1897, by tying to branches of the infested trees pieces of twigs of the oak bearing the scale fungus. At the time of my visit only a very few living scales could be found, and among the dead occasionally one still remained with an obvious growth of *Sphærostilbe* projecting from beneath the edge. This scale fungus was found not only upon trees to which infested twigs had been tied, but upon others adjacent to them, indicating a spread from tree to tree. According to the owner's statements the surface of many of these trees had been conspicuously reddened by an abundant development of the fungus on the scale, these growths having subsequently been removed, with the dead scales them-

* Letters received from Professor Rolfs since my visit to Florida notify me of the frequent finding of this fungus there on the San Jose scale and other species.

selves, by exposure to the weather. The trees in this orchard were in very good condition, showing but little effect of the scale attack.

The third orchard visited, that of Mr. Thalimer, was in very much worse condition, the fungus having been introduced too late to save many of the trees. The plat contained two hundred and seventy-five peach-trees, three years old, which had become infested two years previously by extension of the scale from the premises of a neighbor. Nine-tenths of the trees in this orchard were dead, according to the owner's estimate, many of them those to which pieces of oak branches had been tied in July of the previous year. Where the trees and the scales upon them were still living, the scale fungus could yet be found

From the history and condition of these orchards and from other observations made upon this visit it seemed clear that the *Sphærostilbe* could be made useful, especially where for any reason immediate insecticide work could not be done, but that it would at best serve only as a strong check upon the multiplication of the scale and not as an efficient means of its complete extermination. I consequently decided to apply it in Illinois on those premises only which we could not reach with the insecticide spray owing to the exhaustion of funds available for this field work. The most important region remaining without insecticide treatment was that at Sparta. Some orchards at Richview likewise had been only imperfectly sprayed, and others remained heavily infested and in condition to afford a means of testing the efficiency of this fungus parasite.

This scale fungus was distributed to orchards at Sparta and Richview by Mr. E. B. Forbes on three separate visits; one from April 30th to May 5th, the second from May 28th to June 7th, and the third on June 23d. Thirty trees belonging to Mr. James Newcome, were thus infected near Richview, and three hundred and fourteen trees, belonging to twenty owners, in the Sparta district, as follows:

S. A. Blair, 6 trees.
Henry Bodiker, 18 trees.
Robert Conch, 1 tree.
James Davison, 8 trees.
Henry Lout, 6 trees.
George Lyons, 4 trees.
Fred Marshall, 1 tree.
John McHenry, 3 trees.
Riley McKelvey, 11 trees.
Sidney McKelvey, 2 trees.
H. A. W. Otten, 5 trees.
Jefferson Porch, 35 trees.
Louis Pritz, 1 tree.
J. W. Robinson, 85 trees.
John Steel, 7 trees.
Jacob Stahlman, 4 trees.
J M. Temple, 76 trees.
Silvenus Wilson, 7 trees.
James Wood, Sr., 8 trees.
James Wood, Jr., 26 trees.

At the earliest visit only infected scales on pieces of bark or twigs of oak obtained from Florida were used. The twig or bark with the fungus on it was tied to the upper side of a limb, as high up on the

branch as the infestation was severe and in such a position that the southwest rains would readily strike it. From one to a dozen pieces were placed on a single tree, according to the size of the tree and the abundance of the scale, three or four being the commoner number. On the second visit, beginning May 28th, only artificial cultures of *Sphærostilbe* were used, mostly those grown on corn meal or on pieces of bread. About a half inch square of the culture material was softened for a short time with water, and mixed with fifty centicubes of water, and the liquid was spread with a sable brush on the spot selected. The infected spot was then covered by wrapping the branch with a strip of wet duck four inches wide and forty inches long, the wrapping being fastened with a string. These strips were wet a second time on the following morning and were removed in twenty-four hours after application, the object of this procedure being to keep the culture material continuously moist until the spores had time to germinate. That this was done was shown by the fact that particles of the fungus were generally whitened by a mycelial growth from the germinating spores by the time the cloth was removed. The infected spot was then marked by a white string for convenience in subsequent inspection.

The first such visit of inspection was made at Sparta by Mr. Forbes May 27th, three weeks after the infected twigs were put in place. At this time a few dead scales were found in the vicinity of the twigs, but no certain evidence of the spread of the fungus was obtained. On the next inspection, June 21st, a scale dead with *Sphærostilbe*, and showing the fungus in the form of a fruiting growth, was found on a tree to which a corn-meal culture had been applied May 28th. The cloth wrapping had been accidentally left on this tree, and the fungus had grown under its protection. July 6th, about two months after the first infection of these trees, the fungus had taken effect upon adjacent scales in practically every case where they had been originally abundant and the infection material had been liberally applied, but in no case was the growth on the tree profuse nor even generally visible even on the scales immediately adjacent to the infection material. When only a few scattered scales were present no start had been made. Returning to the same trees September 1st, we found the fungus was by this time growing vigorously everywhere, spreading downward in some cases as far as five or six feet and on lateral branches from the one to which the infection had been applied, as far as a foot beyond the fork. The upward spread, however, was not so great, the spores being evidently disseminated mainly by washing down; and there was nothing to indicate the spread of the fungus across an air space. On one tree six inches in diameter, for example, on Mr. Temple's place, the fungus had spread downward about two feet,

as far as the scales extended, and upward not at all. From another piece on the same tree the fungus had spread upward a foot and a half, downward two and a half feet, and thence an equal distance on a lateral branch. From still a third piece it had spread downward three and a half feet and out six inches on a branching twig. Another tree five inches in diameter, to which six pieces of bark had been tied, was so generally covered with the fungus infesting the scales that it was difficult to say whence and how far it had spread. Excepting the smaller and upper twigs and branches, the entire tree was infected. In some places on this tree the lateral spread must have been at least six feet. Another tree in this same orchard, to which five twigs had been attached, showed the scale fungus distributed upward from points of infection to distances varying from six inches to a foot, downward from sixteen inches to three feet, and laterally from six to twenty-six inches.

The results of infection by means of artificial cultures were equally favorable, and on the whole more marked, owing especially to the fact that pieces of the culture medium remaining on the tree continued to grow the fungus and to produce the spores for an indefinite time. On one tree, for example, the scales on which were infected June 17th by smearing on a thick paste of spores from a culture of broth and corn meal, the fungus had made a visible start by the 5th of July. A few scales were then dead with a noticeable growth of the fungus, and by September 1st this growth had become very profuse spreading in various directions from two to four feet from the point of infection. On another tree, similarly treated at the same time, the fungus growth September 1st (about two and a half months after infection) had become very profuse, extending downward more than six feet and upward about sixteen inches and crossing an air space of at least three feet. The infection material was still growing in good condition and bearing large numbers of spores.

On the final visit of the season, made by Mr. E. B. Forbes to Sparta November 2d, it appeared that there had been no great increase in the growth and abundance of the fungus since the September inspection, but that in a number of cases it had spread from limb to limb in such a manner as to suggest that the spores had been conveyed by the blowing of rain drops in a high wind. An occasional washed-out appearance and pale color of the fungus suggested the probability that the recent weather had been too cool and wet for its rapid spread.

The fact should be carefully noted that however generally the fungus was distributed, it was easy to find everywhere in the infected area scale insects still living and apparently not invaded by it, and even young scales crawling about in considerable number. It remains to be

seen, consequently, how completely even thoroughly infected areas may be cleared of the scale by this fungus, since it is possible that only those scales which were in some way comparatively deficient in vitality were actually destroyed by the parasite. Contrary to this supposition we have only the observations made in Florida, where, again, it is not impossible that other and inconspicuous causes have conspired with the *Sphærostilbe* to reduce the number of the scale.

No instance could be found either at Sparta or at Richview of the appearance of the fungus on trees not immediately infected by Mr. Forbes, a fact doubtless due to the hard and tenacious character of the fruiting growth, which is such that the spores of this fungus are little likely to be carried by the air. Doubtless, however, after a time birds and insects passing from tree to tree would effect these transfers accidentally. On the other hand, it is but little work to snip off twigs from an infected tree and tie them to branches of those adjacent, thus securing and hastening the infection process which a single season should suffice to make general on any badly infested premises. Indeed artificial cultures are so readily made in quantity and capable of being so rapidly applied that it would be a matter of little difficulty to treat a large orchard completely, provided only that the supply of the cultivated fungus could be had by the orchardist. As the cultivation of this fungus parasite requires the expert methods of the bacteriological laboratory, it is beyond the reach of the farmer, who must depend upon the simpler method of infection except where the state or some private expert can furnish the fungus cultures to him as required.

Thinking it possible that scales killed by the fungus would be generally removed from the tree, and the dormant fungus with them, by exposure to the winter weather, I took measures to prevent a removal by this means of all the fungus growth upon infected trees by having selected portions of the infected surfaces on each tree wrapped with cloth early in November, to be left on all winter. I have thus made sure that each infected tree will have upon it a considerable area of the fruiting fungus in the spring in condition to renew the infection in 1899.

Attempts at infection of the San Jose scale with the new fungus (*Microcera sp.*) detected in the Rose Hill orchard in northern Florida were not wholly successful, owing perhaps in part to the small amount of the fungus available for experiment. Applications of a culture made on corn meal and beef broth were so far successful as to infect the scales to which the spores were applied, but there was no considerable spread, in the single experiment made, from the infected area to the adjacent scales.

As a result of this field work with the above-mentioned fungous

disease of the San Jose scale it is evident that the distribution of *S. coccophila* under conditions prevailing in southern Illinois this year is likely to prove a valuable adjunct to more energetic measures for the destruction of this insect. Indeed, we may go so far as to say that if the scale should finally become a permanent resident in this state, it is quite possible that this and similar enemies will form a permanent check upon its multiplication such as to reduce its injuries to comparative insignificance. It must be noted, however, that the summer of 1898 was favorable to the growth and reproduction of this fungus species, both with respect to temperature and rainfall. An abundance of rainfall was, in fact, shown by my laboratory culture experiments to be indispensable to the profuse fruiting of the fungus, cultures made on a comparatively dry medium often growing freely but remaining sterile for weeks, while those made in a saturated atmosphere would fruit with excessive abundance within four days from the sowing of the spores. In a dry season, consequently, we cannot expect a rapid spread of this fungus from scattered infection points.

Field Notes on Fungous Infection.

More definite details with regard to the spread of this fungous infection in the field are presented in the following items abstracted from the notes of Mr. E. B. Forbes, the Assistant in charge of the experiments.

Neighborhood of Sparta.

Orchard of J. M. Temple.—Twigs and bark of oak from Florida bearing infected scales were tied April 30, 1898, to seventy-six trees in this orchard. May 27th, a large number of scales were examined microscopically, but no positive case of death from the fungus was found. A few dead scales were detected near the infected places, but they either contained no fungi or a fungus not resembling *Sphærostilbe* in any form known to me.

July 6th, examined trees infected April 30th and May 2d with *Sphærostilbe coccophila*. In every case where scales were abundant and the infection material thrifty and plentiful the fungus had spread from the bark or twig tied to the tree. The growth was nowhere profuse, nor was it even generally present on the scales in the immediate vicinity of the infection material. A slight start had been made in quite favorable situations, but where only a few scattered scales were present no growth was made, and in no instance had the fungus spread from the immediate surface originally infected.

September 1st, fungus growing everywhere vigorously. Sometimes spread downwards as much as five feet, and on laterals as much as one

foot, though upward spread is less than downward. The spores are evidently carried by rains and no spread across an air space was here noted. On one tree six inches in diameter I placed originally four pieces of infected material. The fungus had now spread from one piece downward two feet, as far as the patch of scale extended, but upward not at all. By no means all the scales were killed, however, on the area showing the fungus growth. From another piece the fungus had spread upward on two branches a foot and a half, down on one branch two feet and a half to the trunk of the tree, and out to an equal distance on a lateral branch. From the third piece it had gone downward three feet and a half, out six inches on a twig, but upward not at all. From the fourth piece it had spread upward six inches and downward a foot and a half. On another tree, five inches in diameter, to which six pieces of bark had been tied, the spread of the fungus has been so general that it cannot now be traced. Except for the smaller and upward twigs and branches the tree is now thoroughly infected. In some cases the fungus must have gone laterally as much as six feet or else the spores were carried across an air space. In another tree, seven inches in diameter, to which five pieces of the infected material had been applied, the fungus had spread from the first piece eighteen inches upward at an angle of 45°; directly upward six inches; ten inches upward on another branch at an angle of 40 : and downward fully three feet. From a second piece it has gone downward twenty inches and thence out on a lateral twenty-six inches. From a third it had spread a foot obliquely upward and ten inches horizontally. From a fourth it had gone upward a foot on three branches and down sixteen inches. From a fifth it had spread upward six inches, down two feet to rough bark free from scales, and out sixteen inches on a lateral branch.

November 2d, wrapped with cloth strip and tied with string one spot on each infected tree. No great increase in quantity of fungus since my visit September 1st, although in a number of cases the infection has gone from limb to limb in a way to suggest that the spread has been due to the blowing of spores in rain drops from an infected surface to one previously free. In some situations the growth has a faded color and a washed-out look, from which I am led to suspect that the weather has been too cold and rainy for a profuse growth and rapid spread of the fungus.

Orchard of James Wood, Jr. —May 28th, twenty-six trees infected with *Sphærostilbe* grown on corn-meal batter. For a description of the method of application of this fungus culture see page 34. June 21st, found in this orchard a single scale which had died from the fungous infection. In this tree the cloth wrappers were accidentally overlooked

and had remained in place since May 28th. Two clubs of conidial spores were borne by this single scale. July 6th, conditions as to fungous infection the same as on Mr. Temple's place, already reported. Sept. 2d, *Sphærostilbe* growing well in this orchard. Nov. 5th. To-day placed cloths for the protection of fungus on trees.

Farm of John Robinson.—June 17th, a single tree infected by smearing on conidial spores of *Sphærostilbe* in a thick paste made from culture on corn-meal and broth. Kept moist forty-eight hours with wet cloths. July 5th, very few scales dead from fungous infection. Disease has not spread far. No spore masses observed. Sept. 4th, growth very profuse; spread from source of infection in various directions from two to four feet.

Another tree infected by tying on pieces of fresh fruiting culture grown on corn-meal and broth. June 20th, this infection material riddled by ants, but fungus growth not eaten. July 5th, slight start of fungus near point of infection. Bears immature conidial spores. Sept. 1st, growth very profuse, extending downward over six feet and upward sixteen inches. In one place spores had been carried across an air space of three feet—probably by birds, insects, or rain. Culture material originally applied to the tree still growing in good condition. This is the most successful infection experiment I have seen, the growth probably being the most profuse because of an abundant and constant supply of conidial spores continuously developed from the original infection material.

Richview, Ill.

Farm of James Newcome.—June 23, 1898, the San Jose scale on thirty trees was infected in this orchard with material grown on meal and broth, applied directly from the culture flask without ever having been dry. The conidial spores had been mature for about two weeks. The gummy mass of the culture was simply smeared upon the tree with a little water, and the branch treated was wrapped with canvas which was allowed to remain upon the trees for three weeks. The trees treated were not very badly infested, and were scattered here and there through a large orchard. There was consequently little opportunity for the fungus to spread from tree to tree.

July 13th, when the first inspection was made, the fungus had started in every place, and it had already formed conidial knobs in several places, although generally its occurrence was made evident only by a white mycelial growth around the edge of the infected scales.

August 31st, a careful inspection of a number of trees selected at random was made. On the first tree examined the infection was practically complete where the surface had been covered by a cloth band.

every scale showing the red growth of the fungus, which had also spread down the branch about six inches. Scales of all sizes were attacked, but there was no apparent spread upward or to the adjacent branches. The external growth was most commonly in the form of erect clubs or knob-like protuberances, but sometimes in that of a thick welt surrounding the scale. On another tree the fungus had spread very profusely along the limb for about thirteen inches. On one, where the scale was very scarce, it had spread but three inches; on two others twelve inches; and on still another fifteen inches. On the next tree examined it had spread two feet on a main branch, and also slightly upon lateral twigs. On one tree carefully examined it had grown down a main branch for about ten inches from a profusely infected area, and laterally from a little below this area about an inch. Here, as elsewhere, the fungus was most abundant upon the spots originally treated. Here several pieces of paste remained with the fungus fresh and apparently still growing. November 1st, when the winter bands were put in place, there had been little if any extension of the infected area, and the growth generally seemed to be somewhat less vigorous than on August 31st, probably because the very heavy rains had washed away the spores.

Experiments with Insecticide Sprays.

During the intervals of other field employment a few minor experiments with insecticide sprays were made by Mr. E. B. Forbes in the infested orchards near Sparta, Randolph county, in the months of June and July. No final conclusions were reached, but as the work was thoroughly and carefully done the results are deemed worthy of report.

June 17th to 20th, pure kerosene was applied to fifteen peach-trees, sometimes with the "Eclipse" sprayer and "Deming Vermorel" nozzle, sometimes with the "Success" sprayer and "Bordeaux" nozzle. The results were in every case unsatisfactory. If applied in sufficient quantity to kill all the scales the trees were usually so severely injured that they were dead by September 1st, or if not dead their vigor had been so impaired that they had been very heavily attacked by the fruit bark beetle (*Scolytus rugulosus*). In one case a peach-tree thus sprayed had borne a good crop of fruit and held its leaves without apparent injury until September 1st, but its bark was everywhere peppered with the punctures of the fruit bark beetle, from which particles of gum had exuded in such quantity as nearly to cover the surface in many places. In but two cases had the trees escaped such injury, and in these only the scales exposed to direct contact with the spray were dead, all concealed or protected in any way remaining alive and producing young continuously.

Three small sets of experiments were made with mechanical mixtures of kerosene and water, the Success sprayer and the Bordeaux nozzle being used. Mixtures containing five, fifteen, and twenty per cent. of kerosene so applied did not hurt the trees and neither did they kill all the scales. A thirty per cent. mixture applied to a single tree July 6th killed very nearly all the scales (living individuals being very rare), and did not visibly hurt the tree This was, however, so nearly dead from scale-attack that the effect of the spraying was left somewhat in doubt.

Tests of the "Success Kerosene Sprayer," bought of the Deming Company, Salem, Ohio, made with a view to determining the accuracy of the percentage indications of the scale, gave results showing that the percentages varied considerably according to the action of the pump and the fineness of the spray. With the indicator of the dial set at 10% the amount of kerosene in the mixture would vary from 7.5% to 13.13%, the lower percentage when the pump was vigorously worked with a very fine spray, and the higher when it was vigorously worked with an open stream. With a fairly fine spray and moderate action the kerosene in the mixture was 12%. With an indication of 5% of kerosene the actual delivery varied from 4.07% to 6.92%. Additional details of these tests are given in the following table:

TEST OF "SUCCESS KEROSENE SPRAYER."

Indicated percentage.	Actual percentage in spray.		
	Open stream, pump worked vigorously.	Fine spray, pump worked moderately.	Very fine spray, pump worked vigorously.
5	6.92	5.94	4.07
10	13.13	12	7.5
15	18.9	17.4	11
20	22.75	21	17
30	32.8	30	20.5
40	43.4	40	
50	48	46.6	

Mixtures of carboleum—an insecticide sent us for experimental use by the Prescott Chemical Company, 134 Van Buren St., Chicago—were too little tried to warrant a final conclusion. One, two, and four per cent. solutions were without pronounced effect upon the scale and did no permanent harm to the trees. This insecticide mixes freely with water in all proportions except for a heavy substance which settles to the bottom of the mixture as a heavy brown oil. This filters out readily, and the remaining liquid is then a stable emulsion of a light coffee

color. The carboleum should be diluted with rain water, as otherwise a troublesome gummy precipitate forms.

Miscellaneous Field Memoranda.

From Mr. Forbes's miscellaneous notes I cull the following minor observations of interest:

Male scales were just beginning to hatch at Sparta, in Randolph county, April 30, 1898, two winged specimens having been first seen on that day. Under a greater part of all the male scales examined were winged insects nearly ready to emerge. Of a hundred such scales examined May 5th, eighty were empty, eight contained winged males, and twelve contained pupæ not yet transformed.

Female scales had just begun to give birth to young at Sparta May 27th. Probably none of these were more than two days old, as all were still in the active stage. On the other hand, reproduction had nearly ceased November 2d, at which time, although no active larvæ were seen, a few scales could still be found so young that it was evident that they had fixed themselves only a few hours before.

Observations made in spring and early summer, especially on Mr. J. M. Temple's grounds, showed that a very large number of the partly grown young San Jose scale of the preceding year had perished, nearly all of those on the tree trunks and on the older limbs being, in fact, dead the first of June. Those on the young growth, however, throve, matured, and multiplied. As a general result of observations of this character, it appeared that very many of the scales of 1897 were dead in nearly all the orchards visited, and that many of the old trees in that region were seemingly in a better condition on this account than in the preceding year. There was no appearance here of any other cause of death than mere starvation, due, as was surmised, to the protracted drouth and excessive heat of the summer of 1897.

Experiments made June 17th at blowing the young scales in the active stage from the surface of the tree made it evident that they might be occasionally detached by a very heavy wind and carried thus to considerable distances. It was noticed, however, that when exposed to strong wind the young scales sought the sheltered side of the limb. At this date scales were found attached and growing on ragweed (*Ambrosia*), peppergrass (*Lepidium*) and horse-nettle (*Solanum*), all under infested trees.

The rate of travel of the young was tested June 20th by transferring ten active specimens to a piece of painted glass, watching them for a minute each, and carefully measuring the distances traversed. These

ranged from 1.9 to 3.4 centimeters, with an average rate of 2.75 centimeters (1.1 inch) to the minute.

Where strips of damp cloth were tied around branches of a tree to protect the fungus beneath, it was noticed May 28th that the traveling young would accumulate along the lower edge of the band in a way to form a yellow circle around the limb. Such an accumulation was rarely seen above the band. None of the young attempted to cross the cloth.

The only insect enemy of the San Jose scale noticeably abundant in the Sparta region was *Pentilia misella* (Plate IV, Fig. 4, 5, 6), which became so common in badly infested orchards by November 2d that the number on a heavily infested tree was estimated at several thousand. They had, notwithstanding, produced no visible effect upon the number of scales in any orchard visited. The twice stabbed ladybird (*Chilocorus bivulnerus*, Plate IV, Fig. 1, 2), was seen occasionally, but was nowhere abundant.

EXPLANATION OF PLATES.

Plate I.

Map of Illinois showing known distribution of San Jose scale, with extent and effects of treatment.

Plate II.

Machine sprayer, with gasoline engine, triplex pump and double tank for whale-oil soap solution.

Plate III.

Fig. 1. Gasoline engine of machine sprayer.

Fig. 2. Battery of gasoline burners used under each tank for boiling whale-oil soap solution.

Plate IV.*

Parasites of the San Jose Scale.

Fig. 1. *Chilocorus bivulnerus*, larva.

Fig. 2. *Chilocorus bivulnerus*, adult beetle.

Fig. 3. *Aphelinus diaspidis.* Not a parasite of the San Jose scale, but closely allied to *A. mytilaspidis*, which is parasitic upon this scale.

Fig. 4, 5, 6. *Pentilia misella*, beetle, larva, and pupa.

Fig. 7. *Sphærostilbe coccophila.*

*Figures 1, 2, 4, 5, and 7 are original. Figures 3 and 6 are re-drawn from Bulletin No 13 n. s , U. S. Department of Agriculture, Division of Entomology, "The San Jose Scale: its Occurrences in the United States, with a full Account of its Life History and the Remedies to be used against it," pp. 51 and 52.

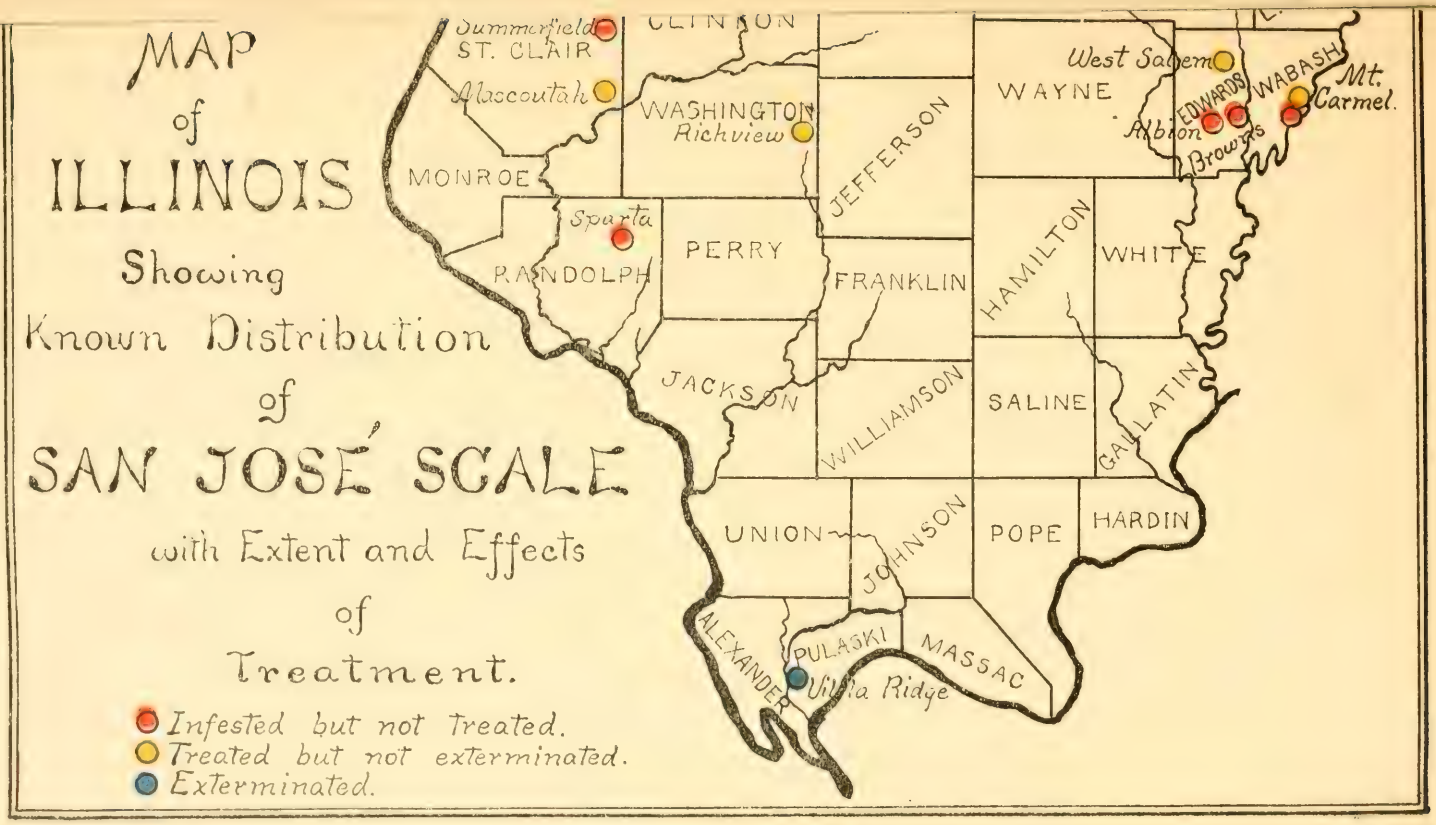
MAP
of
ILLINOIS
Showing
Known Distribution
of
SAN JOSÉ SCALE
with Extent and Effects
of
Treatment.
Infested but not treated.
Treated but not exterminated.
Exterminated.
Summerfield
ST. CLAIR
CLINTON
Alascoutah
WASHINGTON
Richview
MONROE
Sparta
RANDOLPH
PERRY
JEFFERSON
FRANKLIN
JACKSON
WILLIAMSON
UNION
JOHNSON
ALEXANDER
PULASKI
Villa Ridge
MASSAC
WAYNE
West Salem
EDWARDS
Albion
Browns
WABASH
Mt. Carmel
HAMILTON
WHITE
SALINE
GALLATIN
POPE
HARDIN

PLATE I.


MAP
of
ILLINOIS
Showing
Known Distribution
of
SAN JOSÉ SCALE
with Extent and Effects
of
Treatment.
Infested but not Treated.
Treated but not exterminated.
Exterminated.
WINNEBAGO
BOONE
McHENRY
LAKE
CARROLL
OGLE
DE KALB
KANE
DU PAGE
COOK
LEE
KENDALL
WILL
ROCK ISLAND
HENRY
BUREAU
LA SALLE
GRUNDY
MERCER
PUTNAM
STARK
MARSHALL
KANKAKEE
HENDERSON
WARREN
KNOX
LIVINGSTON
PEORIA
WOODFORD
IROQUOIS
McDONOUGH
FULTON
TAZEWELL
McLEAN
FORD
HANCOCK
Manito
ADAMS
SCHUYLER
MASON
LOGAN
DE WITT
CHAMPAIGN
VERMILION
Quincy
BROWN
CASS
MENARD
Monticello
PIATT
MACON
MORGAN
SANGAMON
DOUGLAS
EDGAR
PIKE
New Berlin
Auburn
CHRISTIAN
MOULTRIE
Assumption
COLES
Vermilion
GREENE
SHELBY
Tower Hill
CLARK
Eyrs
MACOUPIN
MONTGOMERY
CUMBERLAND
Walnut Prairie
CALHOUN
JERSEY
EFFINGHAM
JASPER
CRAWFORD
BOND
FAYETTE
MADISON
CLAY
RICHLAND
LAWRENCE
MARION
CLINTON
WASHINGTON
WAYNE
EDWARDS
WABASH
Mt. Carmel
JEFFERSON
RANDOLPH
PERRY
FRANKLIN
HAMILTON
WHITE
JACKSON
WILLIAMSON
SALINE
GALLATIN
UNION
POPE
HARDIN
ALEXANDER
PULASKI
MASSAC
Mound City
Monroe Center
Dundee
Tremont
Pana
Sparta
Chester
Cairo
Ullin
Vienna
Metropolis
Mt. Vernon
Carmi
Shawneetown
Cairo

Plate II

PLATE III.

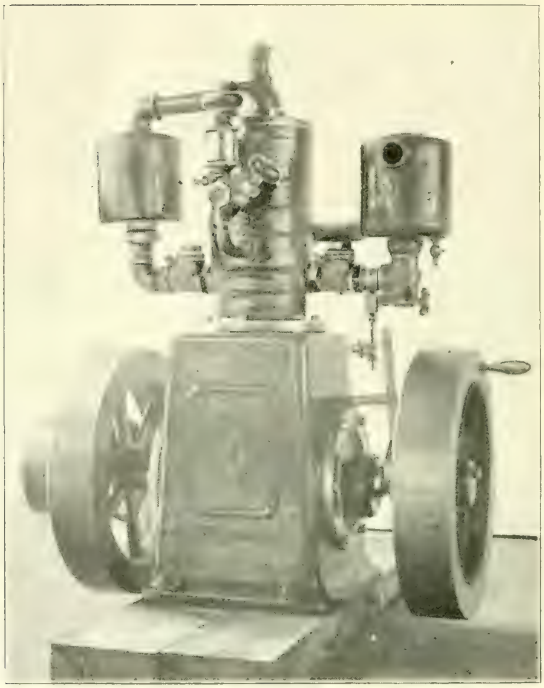

Fig. 1.

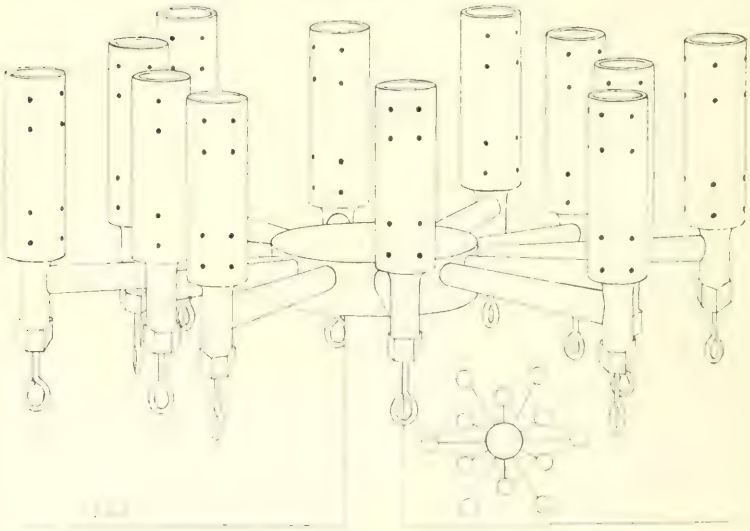

Fig. 2.

PLATE IV

PARASITES of the SAN JOSE SCALE.

THE ECONOMIC ENTOMOLOGY OF THE SUGAR BEET.*

New enterprises,—new difficulties; new crops,—new insect enemies and old enemies in a new rôle. The recent introduction and rapid extension of sugar-beet culture in America have brought to general notice several insect species not before known as injurious, and have given a new food to others well known for their attacks on the older crops.

The beet plant is very similar as food for insects to some of our commonest weeds, and hence it has attracted the prompt attention of several species which, if we have noticed them at all, we have hitherto regarded as our friends; and it has also served to give additional variety to the diet of several crop insects of somewhat general feeding habits. It has thus already recruited a large entomological following—about one hundred and fifty species in America, if we put upon the list everything which has thus far been found to feed upon the beet in the field. Most of these, of course, can hardly be called injurious in the economic sense, but with our present knowledge of the subject about forty species may be definitely so classed. Furthermore, we may expect additions to this list from time to time, since the necessary concentration of beet culture in the neighborhood of factories and the consequent devotion of large areas to this crop year after year for an indefinite period give opportunity for an extraordinary multiplication and a continuous maintenance

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*This paper (printed also as Bulletin No. 60 of the Illinois Agricultural Experiment Station) consists essentially of a summary of published knowledge concerning insect injuries to the sugar beet in the United States, but includes also the results of studies of beet insects made at the office of the State Entomologist and under his direction during the years 1898 and 1899, together with various data concerning the species treated taken from the office records of observation and experiment. It is my intention to follow the preparation of this preliminary report with continuous studies of the subject year after year, and especially to make insecticide experiments with a view to ascertaining the best and cheapest poisons and methods and apparatus of application for use in the sugar-beet field.

I shall be extremely obliged to sugar-beet growers of Illinois and adjacent states for prompt information of the appearance of insect injuries in their beet fields and for any other helpful data.

of its insect enemies. Doubtless, also, many beet insects which in the short period since beet culture began in America have been present in small or moderate numbers only, will from time to time exhibit that tendency to extraordinary and alarming multiplication common among the injurious species generally.

It must not be inferred, however, that the beet plant is especially liable to insect injury. On the contrary, taking the country at large, it is at present less subject to such damage than corn or wheat, cabbage or potatoes. It is a fact particularly favorable to this crop that the marketable part of the plant is but little subject to injury by insects, by far the greater part of the species which feed on it infesting only the leaf, and relatively few injuring the root.

The critical period of insect injury to the beet is in the beginning of the season, while the plants are still small and slow of growth. There is at this time so little vegetation on the ground that a comparatively small number of insects may serve to lay the field completely bare; and poisons are often not available since a leaf-feeding insect may completely devour the little beet while getting a fatal dose of poison for itself.

The principal injurious groups are the leaf-miners, the web-worms, the cutworms, the woolly bears and several other leaf-eating caterpillars, the wireworms, the white grubs, the flea-beetles, the blister-beetles, the plant-bugs, the leaf-hoppers, the plant-lice, and the grasshoppers. The web-worms, the cutworms, the flea-beetles, the blister-beetles, the leaf-miners, and the root-lice have done the greater part of the mischief in the states beyond the Mississippi, but in Illinois the only considerable injury seen by us in 1898 and 1899 was that done by the pale striped flea-beetles, the grasshoppers, and the blister-beetles.

Insect injuries to the underground part of the beet commonly take the form either of a cutting of the tap-root, an eating away of the smaller roots, or a burrowing or excavation of the mass of the beet itself. They are commonly due either to wireworms, to white grubs, or to the beetles of one of the muck-worms (*Ligyrus gibbosus*). More rarely root-lice seriously damage the plant in summer by sucking the sap from the roots. It is probable that larvæ of some of the flea-beetles will also be found to infest the plant under ground.

Injuries to the leaf may be done either by bugs with a sucking beak, or by beetles, grasshoppers, or insect larvæ, with biting mouths. The former abstract the sap from the stem or the blade of the leaf, often making discolored spots, dwarfing the growth and causing the leaf to curl, or even killing it completely. Beetles and their larvæ, caterpillars, grasshoppers, and the like, commonly make holes in the leaf, the smaller insects small circular holes as a rule, and the larger ones either gnawing away the edge of the leaf, eating out irregular holes, or, if cutworms, cutting off the stalk near the ground. Small holes made in the young

growing blade may greatly enlarge as the plant expands, becoming longest in the direction of the most rapid growth. Certain maggots of flies (the leaf-miners) eat out the interior substance of the leaf in patches, leaving the cuticle unbroken.

EXAMPLES OF INSECT INJURY TO THE BEET.

The first injury to the beet reported in America was a mining of the leaves by the maggots of certain flies in a New York vegetable garden, an injury sufficient to prevent the use of the leaves for "greens." Later, serious and extensive damage was done by these leaf-miners to fields of sugar beets in California. The leaf is penetrated by the insects, and the tissue is eaten out between the upper and lower layers of the cuticle, colorless blister-like spots being thus produced.

Perhaps the most destructive of the beet insects in the West are the garden web-worms (*Loxostege similalis* and *L. sticticalis*). The latter was in 1892 the chief depredator in the beet fields of Grand Island, Platte Center, and several other Nebraska localities, where many of the plants were entirely defoliated.

The garden Mamestra (*Mamestra trifolii*), a caterpillar allied to the zebra-caterpillar of the cabbage, has been reported by Professor Lawrence Bruner, of Nebraska, to be quite common in his state, and is sometimes considerably injurious to the beet.

Cutworms have been noticed wherever beets are raised. Bruner reports them in 1891 as occasionally quite destructive to the plant while it is small, continuing their injury more or less throughout the summer. They commonly cut off the leaf at or a little below the surface of the ground, but some of them merely feed upon the blades. In 1892 they almost entirely destroyed sugar beets growing upon two Experiment Station plats at Lincoln, Neb., on one of which only about twenty per cent. of a stand was obtained. It was noticed here that little injury was done on land plowed the preceding fall and a second time in spring. Osborn noticed cutworms in Iowa doing serious injury to young beets in 1891.

The army-worm (*Leucania unipuncta*) has occasionally attacked the beet, with other vegetation; and grasshoppers are frequently responsible for a considerable injury in the latter half of the season. They are not especially fond of this plant, however, and rarely injure it seriously except when their numbers are excessive. The caterpillar known in the West as the army-cutworm (*Chorizagrotis agrestis*) destroyed beets, with many other plants, in Montana in 1897, traveling by night like the eastern army-worm, and collecting in masses in irrigation ditches to a depth of six to twelve inches. The western Laphygma or beet army-worm (*Laphygma flavimaculata*), related to the grass-worm of the East, almost completely defoliated hundreds of acres of beets in

Colorado in 1899. Several of the flea-beetles—readily distinguished from other beetles infesting the beet by their leaping habit when alarmed—seriously injure the leaves by riddling them with small holes. The worst of these is the pale-striped flea-beetle (*Systena tæniata*), abundant in beet fields in Illinois in 1898 and 1899. Two insects hitherto little noticed by the economic entomologist, and known locally as French bugs (*Monoxia puncticollis* and *M. consputa*), have made a serious attack upon this plant, the first of these species in New Mexico and the second on the Pacific coast—especially in Oregon. The former sometimes riddles the leaves, leaving only a network of veins, and of course checking the growth of the plant or even killing it.

The well-known blister-beetles of various species have infested beet fields with serious consequences in many places, especially in the northern Mississippi Valley. They are most destructive, as a rule, after a period of unusual abundance of grasshoppers, on the eggs of which their larvæ feed. The muck beetle (*Ligyrus*) has occasionally been somewhat injurious to beets over limited areas in western Nebraska, working underground and gnawing the beet from without, sometimes entirely imbedding itself in the root. White grubs and wireworms are less injurious than might be supposed from their great numbers and general feeding habits, owing, no doubt, to the fact that beets are rarely planted after grass, in which these insects mainly breed. A root aphis (*Pemphigus betæ*) sometimes does serious injury, frequently attributed by beet growers to the more active and conspicuous ants which live in its company. The most noticeable instance of this injury known to us was reported from La Grande, Oregon, where both the quantity and the quality of the crop were seriously affected in 1899. A considerable injury has been done by one of the green plant-bugs or stink-bugs (*Lioderma*) locally abundant from South Dakota to California and Mexico.

PRINCIPAL PREVENTIVE AND REMEDIAL MEASURES.

The more important measures of *prevention* of insect injury to the beet are clean culture and a suitable system of rotation. So many of the insect enemies of this plant depend largely upon certain common fleshy weeds, that the growth of these in or near a beet plantation is a menace to the crop. The red or spiny pigweeds (*Amarantus*), white pigweed or lamb's-quarters (*Chenopodium album*), purslane, and the cocklebur are the principal examples. Weeds of this description should not be allowed to gain any foothold or even to make a start in or about a beet field, for if they do they are likely to attract their special insects, which, when these weeds are destroyed, transfer their attentions to the beet, sometimes with highly destructive effect. Many beet insects pass the winter on the ground under the protection of fallen leaves and other

vegetable rubbish, while others hibernate in the earth of plowed fields. The raking and burning of vegetable trash in fall to destroy the winter harborage of injurious insects, and fall plowing to break up the earthen cells of underground species are consequently useful general measures of prevention. The preparation of the soil now commonly preferred by beet growers, that is, plowing thoroughly both in fall and spring, is an important safeguard against insect injury, especially against cutworm attack.

Beets should not be preceded on the same ground by any crop especially liable to breed and feed the more prominent beet insects. Thus a system of rotation in which beets follow upon grass would be highly objectionable, since some of the worst insect enemies of the beet—the cutworms, the wireworms, and the white grubs, for example—commonly breed in sod. Either oats or corn may precede the beet without objection from the entomologist, the choice to be made between these two on general agricultural principles.

There is no direct *remedy* available for injuries to the underground part of the beet*, but injuries to the leaves may commonly be arrested by the use of one or the other of the ordinary insecticide sprays; kerosene for plant-lice, leaf-hoppers, and other insects which pierce the leaf with the beak and suck the sap, or one of the arsenical poisons for those which eat the leaf. Kerosene may be applied as an emulsion with soap-suds; or, more conveniently, as a mechanical mixture with water, thrown upon the plant by means of one of the special sprayers now constructed to deliver fixed proportions of water and kerosene intermingled in a very fine spray. The smooth surface of the beet leaf makes it difficult to apply fluid poisons successfully, since they are likely to run off, leaving no residue sufficient to serve as a fatal dose. This difficulty may probably be met by using either Bordeaux mixture or soap-suds instead of water as a medium for conveying arsenic or Paris green. In this case a quarter of a pound of Paris green and an equal quantity of lime should be kept thoroughly stirred up in the tank or barrel with fifty gallons of the Bordeaux mixture or the soap-suds, the latter of a strength to be determined by preliminary experiment. When the beets are small the arsenical poisons may probably be best applied, as advised by Professor Gillette, by mixing one part by weight of Paris green with twenty parts of flour and then dusting over the plants before sunrise on a dewy morning. This application may, if more convenient, be made while the leaves are moist from a recent shower. "To apply the poison," he says, "make a small cheese-cloth sack about five inches in diameter and ten inches deep. Fill it with the mixture of poison and flour and walk

*In Europe, volatile poisons like bisulphide of carbon are sometimes applied underground, especially for the destruction of root-lice and wireworms; but this measure is doubtless too expensive of time and labor for the American beet-grower, especially as injuries by these insects may be mostly avoided here by a proper general management.

along a row of plants shaking the sack over them. This can be done quite rapidly when one has learned how, and is economical of poison and does not require wheelbarrow or wagon to carry pump and tank. * * * If a spray is used, apply either Paris green or London purple in the proportion of a pound to a hundred gallons of water and add two pounds of fresh lime for each pound of poison. The lime should be slaked and strained through a sack to take out lumps. Then use a nozzle that throws a fine spray, and do not continue the application in any place long enough so that the drops sprayed upon the leaves will run together and flow off, carrying the poison with them.

"If white arsenic is used, prepare according to the following directions: Put two pounds of white arsenic and eight pounds of sal-soda together in a dish and boil for twenty minutes in two gallons of water, and keep as a concentrated solution. *It is extremely poisonous and should be placed at once where there is no possibility that children or domestic animals can get it. Also, label it 'Poison' in large letters.* Then, in each forty gallons of water, first slake four pounds of lime and then add slowly one quart of the concentrated solution while the whole is being stirred. The mixture is then ready for application, as in case of Paris green. The lime should be strained through a cloth to take out the lumps." *

Cutworms may usually best be destroyed either by hand-picking, with lanterns at night, or by the use of poisoned baits. The most convenient and effective of these is a bran mash or dry bran, poisoned with London purple or Paris green. For the preparation of the poisoned mash the insecticide should be thoroughly mixed with dry wheat bran—a pound or two to twenty-five pounds of bran is a suitable proportion—with water enough, sweetened with molasses, to form a mash sufficiently stiff to be dipped out without dripping. This is distributed, a large table-spoonful in a place, along the row of plants, beginning while they are still very young. Dry bran is poisoned by first dampening the bran very slightly with sweetened water and adding the Paris green,—one pound of the poison to fifty of bran,—shaking it on a little at a time and stirring it in until the whole mass is evenly mixed. This poisoned mixture may be conveniently distributed by the use of a seed-drill, filling the seed box with poisoned bran and running lines of it close to the rows. As a comparatively crude but more rapid method, for use on a large scale, clover or fleshy weeds may be sprayed with Paris green, cut with a scythe or mowing machine, and pitched in small quantities from wheelbarrows or small wagons wherever desired. The piles of poisoned herbage should be placed at nightfall a few feet apart between the rows of plants.

The blister-beetles can often be driven out of a field by whipping

* Press Bull., No. 3 (May, 1900), Agr. Exper. Station, Col., pp. 2, 3.

or brushing the plants attacked by them, and once expelled they return slowly or not at all. The very common striped species is usually quite easily expelled in this way, but the margined blister-beetle is not so easily driven. The injuries of these beetles should be arrested, if practicable, without destroying them, as in the larval stage they are extremely useful enemies of grasshoppers. Indeed they are commonly numerous enough to be injurious only when grasshoppers are themselves abundant or have been so very recently. The blister-beetles are also subject to poisoning by Paris-green sprays. Mechanical measures for the collection and destruction of leaf-eating insects are sometimes resorted to in Europe, but have not as yet become necessary in this country.

These general suggestions of insecticide measures must suffice for this preliminary report, since few exact experiments have been made in this country with insecticide applications to the sugar beet, and there is very little expert testimony upon this subject to draw upon.

CLASSIFICATION OF THE SUGAR-BEET INSECTS.

As the beet grower usually cannot become an entomologist, and probably does not wish to become one if he could, it is important that he should have a means of identifying and recognizing insect injuries to his beets without being compelled, more than is really necessary, to make himself acquainted with the names and habits of the insects concerned. This end he may accomplish in great measure by a careful observation of the injuries to the plants themselves, by which means he may readily limit his inquiries to a comparatively small number of insect species capable of doing the kind of injury under observation. Thus, if he finds the underground part of the beet eaten into or gnawed away he of course excludes at once from consideration those species which infest the plant only above ground, and also those which infest it under ground but which merely pierce it with their beaks and suck out its juices; and similarly, if he finds the leaves ragged and evidently being eaten away by biting insects, of whatever kind, his search for a remedy is greatly simplified. He needs only to see whether the injury is being done by blister-beetles, which should be driven from the field, or by cutworms or grasshoppers, which may best be destroyed by poisoned baits. If he finds neither of these, he may proceed at once to spray his plants with an arsenical insecticide, knowing that whatever the insect agent of the injury may be this will be the proper method of attack. In this paper the insects likely to do any single kind of injury have been brought together for discussion in an economic group the members of which are few in number and readily distinguishable from each other, and the inquirer is thus brought by the shortest and easiest route to the sources of the practical information which he desires.

The following classification of insect injuries to the beet and arrangement of injurious insects under them in economic groups is intended as an aid to these identifications.

KEY FOR THE RECOGNITION OF INSECT INJURIES TO BEETS.

1 Plant apparently injured, but its substance above ground not evidently eaten in a way to account for the injury. . . . . 2.
Substance of leaf evidently more or less eaten away. (Injuries by biting insects; arrested by arsenical poisons.) . . . . 7.

2 Leaves discolored—that is, specked, spotted, or blotched with whitish, yellowish, or purple; often more or less wrinkled or curled. (Injuries by sucking insects or by mites; arrested by kerosene sprays.) 3.
Leaves not specked, spotted, wrinkled, or blistered to account for injury; under-ground part of plant affected. . . . . 6.

3 Under surface, when very closely examined, seen to be covered with a very fine loose dirty web. Discolored blotches large, more or less cupped beneath. Minute oval reddish specks moving on surface of leaf. *Red Spiders*, p. 58.
Surface of leaf not webbed. . . . . 4.

4 Small blister-like cavities in the thickness of the leaf, making colorless translucent spots. . . . . *Leaf-miners*, p. 59.
Leaf without blister-like spots. . . . . 5.

5 Many small greenish, yellowish, or grayish soft-bodied hopping insects on leaves. Empty skins of the same usually scattered on the surface. Discolored specks of the leaf small. . *Leaf-hoppers*, p. 62.
Leaf-hoppers not abundant. Discolorations usually larger. *Plant-lice, leaf-bugs, plant-bugs, and other Hemiptera*, pp. 80–100.

6 Small sluggish greenish insects numerous on underground growth, usually associated with ants. . . . *Root-lice*, p. 159.
Roots eaten, excavated, or burrowed. *Wireworms, white grubs, muck-beetles,** pp. 161–165.

7 Leaves cut off at ground. . . . . *Cutworms*, p. 100.
Leaves not cut off. . . . . 8.

8 Leaves rolled or folded. . . . . 9.
Leaves not merely rolled or folded. . . . . 10.

9 Leaf rolled at edge, small striped green caterpillar within the roll. *Leaf-rollers*, p. 105.
Leaf folded lengthwise at middle, sides closely webbed together, small green caterpillar usually in fold beneath web. *Leaf-folders*, p. 106.

10 Plant more or less covered or inclosed with loose open web, leaves eaten by spotted or striped caterpillars. . . *Web-worms*, p. 106.
Plant not webbed, leaves free. . . . . 11.

11 Leaves riddled by small, usually circular holes. Many small hard leaf-beetles present. . *Plant-beetles, flea-beetles, etc.*, pp. 112–128.
Leaves ragged by coarse irregular openings or eaten away irregularly from edges. . *Grasshoppers, beetles, caterpillars, etc.*, pp. 128–158.

*See also the dark-sided cutworm (*Carneades messoria*), p. 102, foot-note.

DETAILED DISCUSSION OF GROUPS AND INJURIES.

The imperfect state of our knowledge of the sugar-beet insects in America has made it important that both the beet grower and the investigating economic entomologist should be considered in the preparation of a detailed account of species and injuries. For the benefit of the beet grower the species have been discussed, so far as possible, in economic groups, and those which do the principal harm, or seem likely to become important enemies to this plant, are treated with especial fullness. As an aid to investigation, however, even relatively insignificant species have been noticed, and at least mention has been made of every insect known by us to be to any extent destructive. Considerable attention has also been given to the bibliography of the subject, and every bibliographical reference of any importance in our possession is contained in the list of papers presented herewith.

Especial acknowledgments are due to Professor Lawrence Bruner, of the State University of Nebraska, for a complete list of insect species known to him as injurious to the sugar beet and for other useful information without which the difficulty of preparing this paper would have been very much increased.

Copies of published figures have also been received from Professor Bruner and from others as follows: from the Division of Publications of the U. S. Department of Agriculture, through the kindness of Dr. L. O. Howard, Chief of the Division of Entomology; from Prof. H. E. Summers, State Entomologist of Iowa; from Prof. Otto Lugger, State Entomologist of Minnesota; from Director C. D. Smith, of the Michigan Agricultural Experiment Station; from Director Jas. H. Shepard, of the South Dakota Agricultural Experiment Station; from R. W. Doane, Assistant Zoölogist of the Washington Agricultural Experiment Station; from Prof. M. V. Slingerland, Entomologist of the Cornell University Agricultural Experiment Station; from Dr. Jas. Fletcher, Dominion Entomologist and Botanist to Government Experimental Farms, Ottawa, Can ; from Director Chas. D. Woods, of the Maine Agricultural Experiment Station; and from the J. B. Lippincott Publishing Company, Philadelphia.

To Mr. Theo. Hapke, formerly of the Illinois Sugar Refining Company at Pekin, and to Prof. P. G. Holden, Superintendent of the Agricultural Department of this Company in 1900, we are indebted for many courtesies shown and assistance given during visits to their premises for the study of beet insects in the field.

Leaves of plant discolored, and lower surface covered with a delicate, loose, and dirty webbing.

THE RED SPIDERS.

The Common Red Spider.

Tetranychus bimaculatus Harv.

About the first of September, 1899, during a period of uncommonly dry weather, in sugar-beet fields near Tremont and Pekin, Ill., plants were observed here and there, most commonly near the margins of the fields, which were conspicuously paler than the rest, many of the leaves, especially the larger ones, being spotted and blotched with pale yellowish. The under surface of the leaf beneath these faded spots was unusually dirty, and with a magnifier was seen to be coated with a fine loose web containing many minute particles; and moving over the surface of the leaf were minute oval translucent reddish mites, usually marked on each side of the back with a darker blotch. Many of the dust-like particles in the web on these leaves were evidently empty egg-shells of the mite, and others were its globular excreta. Careful comparison of these specimens and of those found abundant on hemp in the vicinity of beet fields in 1900, showed that all belonged to the species mentioned above.

The injury was not serious here, and no other instance of the occurrence of the "red spider" in beet fields came to our knowledge last year; but the very severe injury which many kinds of vegetation suffer from these mites, particularly in hot and dry weather, makes it desirable that the attention of beet growers should be called to them. Although they are commonly more injurious to greenhouse plants than to growths in the open air, their occurrence on trees, shrubbery, and herbaceous vegetation generally is well known.

A correct idea of the form and structure of this mite may be got from Fig. 1, 2, 3, and no extended description need be given here, especially as other species of the genus will very likely be found abundant on the beet leaf. The life history of these mites has not been thoroughly worked out, but they are believed to winter as adults among dead leaves, in the crevices of sticks, and in similar shelters. They begin to breed as soon as the weather favors their multiplication and continue active throughout the season, but the number and succession of generations is as yet unknown. According to the observations of Prof. F. L. Harvey,* by whom this species was described, it infests an unusual list of plants, distributed through no less than twenty-four of the botanical orders. Those worst injured at Orono, Me., were beans, fuchsias, wedding bell (*Brugmansia*), castor-oil plant, and Boston smilax (*Myr-*

*Ann. Rep. Me. Agr. Exper. Station, 1892, p. 133.

siphyllum). Among the other host plants are mignonette, pinks, roses, apricots, cucumbers, musk-melons, fever few, verbenas, sage, heliotrope, cypress vine, moon-flower, morning-glory, tomato, egg-plant,

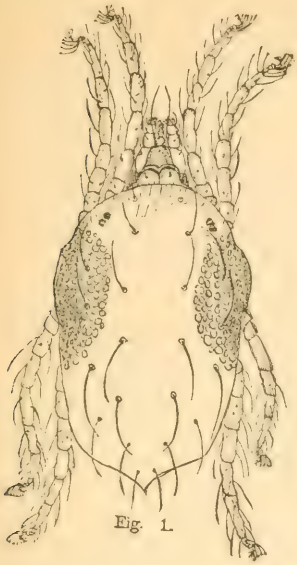

Fig. 1.

The Red Spider, *Tetranychus bimaculatus*, male, greatly magnified. (Harvey.)

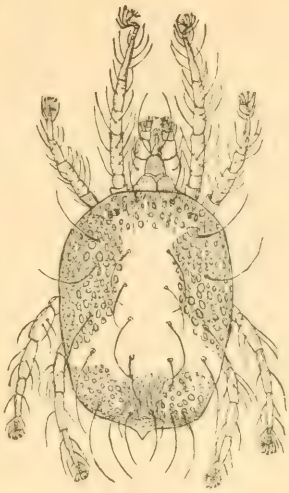

Fig 2.

The Red Spider, *Tetranychus bimaculatus*, female, greatly magnified. (Harvey.)

Fig 3.

The Red Spider, *Tetranychus bimaculatus*, foot. (Harvey.)

hop, and calla. If an insecticide operation is required for the destruction of the red spider in beet fields, the usual kerosene sprays (see page 53) would probably be effective if so applied as to reach the under side of the leaves.

Leaves marked with irregular blister-like blotches, due to removal of substance between the upper and the lower cuticle.

THE BEET LEAF-MINERS.

Chortophila floccosa Macq.
Chortophila betarum Lintn.
Pegomyia vicina Lintn.

The beet leaf-miners are the larvæ or maggots of small flies which mine out the interior substance of the leaf in blotches of various shape, leaving the cuticle entire until it is ruptured later by the escape of the full-grown larva for pupation in the earth. The abandoned mines then become dried, shriveled, and discolored, and are further torn by the subsequent growth of the leaf.

The three species known to injure the beet in America were reported from a single vegetable garden in New York by Dr. J. A. Lintner

in 1881*. "A leaf free from eggs," says he, "could rarely be found, and so large a number of the leaves were blotched by this means that they could be no longer used for 'greens'." The attack continued throughout the greater part of the season, and a similar instance was noticed in 1882 by Dr. Lintner in Vermont.

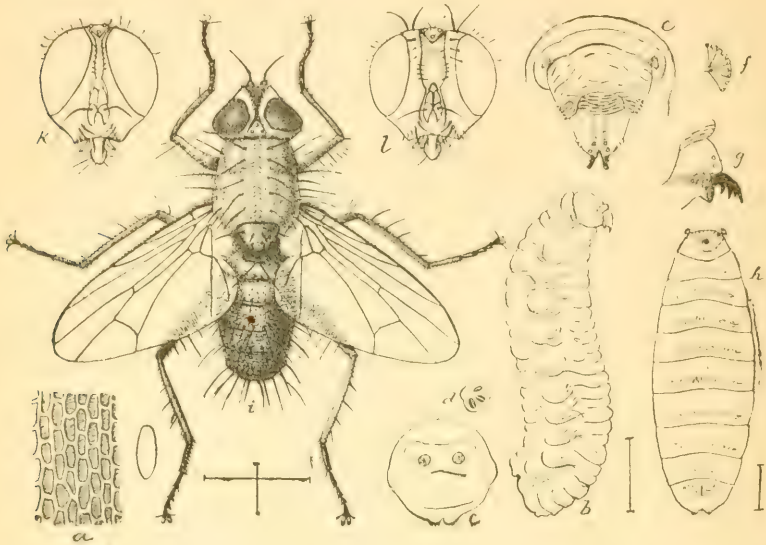

Fig. 4. The Beet Leaf-miner, *Pegomyia vicina*: *a*, surface of egg, very highly magnified; *b*, larva; *c*, last segment of same; *d*, anal spiracles; *e*, head; *f*, thoracic spiracles; *g*, cephalic hooks of larva; *h*, puparium; *i*, adult fly; *k*, head of male; *l*, head of female. (From Howard, U. S. Dept. of Agriculture.)

A much more serious injury by these insects occurred in California in 1891 on the plantation of the Western Sugar Beet Company, where about a thousand acres of promising beets were all more or less damaged by one of the species above mentioned (*P. vicina*). In 1894 and 1895 the same species did much harm to spinach in New York, as reported by F. A. Sirrine.† These or related species feed also on the common white pigweed or lamb's-quarters (*Chenopodium album*), in which they are often extremely abundant, and from this plant they are likely sometimes to spread to the beet.

The eggs are placed by the female on the under surface of the leaf, sometimes singly, but most commonly in numbers varying from two to five together. From thirty to forty have sometimes been counted on a single leaf. The larvæ enter the leaf at once on hatching, making a burrow which is in the beginning scarcely wider than the diameter of the egg shell, but which expands within a short distance into an irregular blotch. When two or more eggs are placed side by side the larvæ from them occupy the same cavity. When they become so crowded as

* First Ann. Rep. State Ent. N. Y., p. 203.

† Fourteenth Ann. Rep. N. Y. Agr. Exper. Station, p. 619.

to interfere with each other's food supply, some of them may leave their native mines and form others elsewhere. The leaf-miners observed by Dr. Lintner usually entered the earth for pupation, although a few formed their puparia between the leaves. From existing accounts it appears that the species hibernate in the puparia, from which the flies emerge in April and May. The work of the larvæ has been seen in the field from the middle of May until November 20. In Howard's breeding experiments the life cycle of a generation was about a month in length, and there are evidently several broods in a season, six or seven in New York, according to Sirrine's opinion. The great variation in the numbers of these insects in different years is probably to be explained, in part at least, by the destruction of their eggs and larvæ by other insects. Most of the eggs examined by Lintner in September, 1881, had been destroyed, apparently by some insect which punctured them and fed upon their contents. A common predaceous insect, *Coriscus ferus*, was observed by Sirrine apparently puncturing the larvæ from the outside as they lay in the mines.

The following general description of *Pegomyia vicina* in its several stages, given by Mr. Sirrine, will serve for the identification of these insects.

"The eggs are white, about .03 of an inch in length, delicately reticulated and nearly cylindrical in shape. The white reticulated portion of the egg is an outer covering, and is easily removed in little scale-like particles. When the eggs are deposited this covering is apparently viscid and aids in attaching them to the leaf. Beneath this reticulated covering is a semi-transparent membrane.

"The maggot or larva is about five-sixteenths of an inch long when full grown, larger at the posterior than at the anterior end. When first taken from the leaf they have a white, glassy appearance. In the posterior half of the body the green contents of the intestine show quite distinctly, while the black, hook-like jaws, or what answers for jaws, can be seen as a curved line at the anterior end.

"The puparium, or resting stage, is about .21 of an inch long, chestnut-brown in color when formed, but soon changing to a dark brown and difficult to distinguish from the surrounding soil.

"The flies are quite variable in size. They usually carry the body in a slightly curved position. The front of the head is silvery white with a reddish brown line extending vertically through the center. The females are of an olivaceous ash color, and can be distinguished from the males by the following characters: The eyes are smaller and placed further apart than in the male. The legs, excepting the tarsi, are yellow or reddish yellow. The body is not as hairy as in the males, nor are the hairs as long, except at the end of the abdomen where there is a distinct tuft of long hairs. The males are darker colored than the

females, more hairy; the femora of the front pair of legs are nearly the same color as the body, the remaining legs are the same color as in the females. The eyes are large and nearly meet on the crest of the head." *

No serious attempt has yet been made to destroy these insects or to prevent their multiplication. Sirrine applied kerosene emulsion to infested spinach leaves in 1895, but without success. It was by him at first supposed that deep plowing and rolling of infested fields in fall would bury the pupæ to a depth such that the flies emerging could not escape, but experiments showed that they could work their way through at least eight inches of dirt. Leaves of beets in badly infested fields should undoubtedly be destroyed, since many of them will contain the insect at the time of beet harvest; and the presence of this insect serves to emphasize the general recommendations made with respect to suppression of pigweeds and other fleshy vegetation, in the leaves of which certain of these flies are said to breed.

Leaves not eaten, but definitely and minutely specked or blotched with white or yellowish. Small green, yellowish, or grayish, hopping insects on the leaves.

THE LEAF-HOPPERS.

Jassoidea and *Delphacinæ.*

Everywhere in the fields and grass-lands and on the leaves of trees, from early summer onward, small, rather slender, soft-bodied and very active insects may be found in abundance, usually greenish or grayish, often prettily marked with black or with brighter colors, the younger ones wingless, the adults with wings like those of grasshoppers in position when at rest. They vary from an eighth to half an inch in length, most of them being of the smaller size. They infest a very great variety of plants, and about thirty different species have been found on beets. These are the leaf-hoppers—a name given them because they are found mainly on leaves and because they hop vigorously when alarmed.

Their mouth parts form a sharp-pointed beak, directed downwards and backwards between the fore legs when at rest, and with this beak they puncture the leaves and soft stems of plants, sucking out the sap for food. Individually their injuries are insignificant, amounting to scarcely more than the draining of a few plant cells of sap for each meal; but the total effect of their attack for the entire season, especially when circumstances favor an extraordinary increase of their numbers, is sometimes serious and may become destructive. The immediate effect of their presence is seen in the appearance of small pale specks

* From the Fourteenth Ann. Rep. N. Y. Agr. Exper. Station, pp. 629, 630.

on the surface of the infested leaf, each speck representing a point of plant tissue deadened by the withdrawal of its living substance. A multiplication of these dead blotches interferes with the performance of the function of the leaf, checks the growth of the plant, and, if excessive, may cause parts of it to die. Sometimes on the young leaf the injurious effect extends some distance beyond the puncture, as shown by a discolored stripe extending towards the tip of the leaf. The attack begins in early spring, and is continued without cessation until fall, the numbers of these insects increasing with the advance of the season as the various species breed in successive generations.

The eggs are laid, as a rule, in the stems and leaves of plants or between the leaf-sheaths and stems of grass-like plants which have ensheathing leaves. In an outdoor breeding-cage containing blue-grass and timothy a large number of grass leaf-hoppers in considerable variety were placed September 10. From September 19 to October 22 numerous minute eggs were found inserted side by side in a symmetrical row in the sheaths of the timothy. They were slightly curved, slender-elliptical in form, at first translucent yellowish and later reddish. These eggs were not hatched, but their resemblance to known eggs of leaf-hoppers appears sufficient for their identification. The various species hibernate as eggs or as adults, with which larvæ are sometimes mingled. Those which pass the winter as adults begin to deposit their eggs in spring as soon as the season opens, and the young from these and from hibernating eggs of the preceding year become abundant in early summer. As some species are single-brooded while others of similar habit produce two and three or more generations in a year, all stages of these insects can be found at almost any time, and systematic discrimination of generations can be made by careful breeding experiments only. A comparison of dates of collections made by us in Illinois with those made by Professor H. E. Summers in the Southern States goes to show that species two-brooded in Illinois are frequently three-brooded farther south.

The leaf-hoppers are, on the whole, unusually free from insect enemies. Two bugs of predaceous habit feed on them freely, namely, the damsel-bug (*Coriscus ferus*) and the glassy-winged soldier-bug (*Hyaliodes vitripennis*). Certain parasites also check their multiplication by destroying the sexual organs of the adults.

Leaf-hoppers have not thus far been reported as sufficiently injurious to the sugar beet to require special measures for their destruction. The program of agricultural management included under the general head of clean culture—not only for the beet plantation but for the entire farm—will tend to keep their numbers down. If, however, they become seriously injurious it may profitably be remembered that they may be destroyed by the use of kerosene sprays—either the emulsion with soap

or the mechanical mixture with water already referred to on page 53. This might perhaps be successfully applied by a simple apparatus recommended by Professor John B. Smith for the destruction of leaf-hoppers in potato fields. Four nozzles suitable for producing a fine profuse spray are carried on a horizontal bar suspended from the back of the wagon, the nozzles being directed forward and a little downward. A light board is hung three or four feet in front of the horizontal bar to stir up the leaf-hoppers and expose them to the fine kerosene spray with which the air is filled. Arsenical insecticides would of course be without important effect, since these are internal poisons and could not reach the digestive organs of a sucking insect.

The general aspect of the leaf-hoppers may be easily recognized after an examination of the various figures in this text. There is no special economic value in a discrimination of the numerous species infesting the beet or in the details of the life history of each, but these will nevertheless have a certain general utility as an aid to observation and record by economic entomologists, and an attempt is therefore made here to give the most conspicuous distinctions of each group without entering into difficult structural details.

It will first be necessary to separate the leaf hoppers known to infest the beet into four groups, distinguished in part by the position of the bead-like ocelli which always lie somewhere between the compound eyes.

The first group (Pl. I.), belonging to the family *Fulgoridæ*, subfamily *Delphacinæ*, are small, with clear membranous wings bearing various dark markings. The head and thorax are acutely ridged, and the antennæ have a stout finger-like base, with a thread-like terminal bristle. The ocelli are close in front of the lower angle of the compound eyes, and there is a conspicuous movable spine at the tip of the hind tibia. The same species sometimes presents both long-winged and short-winged forms.

The remaining groups belong to the superfamily *Jassoidea*, with opaque or tinted wings, the antennal bristle rising from a merely thickened base, and the ocelli higher up on the head. In the second group (Fig. 5–7) the species of *Agallia* only are included. These are small brownish strongly wedge-shaped insects, with head obtuse in front, and the ocelli well up on the face but below the front margin of the head.

The third group (Fig. 8, 9) includes the large species treated in this paper, those belonging to *Oncometopia*, *Diedrocephala*, and *Gypona*. They range from three-sixteenths to half an inch in length. The most distinctive characteristic is the position of the ocelli which are on the flat top of the head, between the eyes.

The fourth group (Fig. 10, 11; Pl. II.; Pl. III., Fig. 1, 2) contains a large number of species, nearly all quite small and variously colored,

with the ocelli wanting or, if present, situated on the front edge of the head.

The three species of the first group on our list have been but little noticed by economic entomologists. *Stobera tricarinata* (Pl. I., Fig. 1) and *Liburnia ornata* (Pl. I., Fig. 3) have a broad brown cloud in the shape of an inverted V near the tip of each wing. In *Stobera* the wing veins are all spotted alternately black and white, and there is a brown spot on the lower edge of the wing within the inverted V. The head and thorax are yellowish or brownish above, and the face is barred with black. *Liburnia ornata* is most quickly recognized by a conspicuous narrow white line from the middle of the back over the thorax and head, with a black line each side. It has a clearer wing, with black dots on the basal part only of some of the veins. Narrow brown lines extend from the V-shaped cloud along some of the veins.

Liburnia puella (Pl. I., Fig. 2) has a black head and thorax and transparent wings, each wing with a brown spot at its upper edge near the middle of the length of the body, making, when the wings are folded, a distinct brownish blotch near the middle of the body.

Four species of *Agallia* taken on beets comprise the second of our groups. In these the narrow upper surface of the head bears at least a pair of round black dots, and the prothorax usually has one or two pairs of dots, anterior and posterior, with sometimes a longitudinal black line between them.

Agallia 4-punctata (Fig. 5, *a*) is yellowish brown, the dots on the head distinct as well as a pair on the prothorax close to its hind margin. A pair of prothoracic dots in front of these and a median dark line are also sometimes present. The wings are brown, with pale veins. *Agallia novella* (Fig. 6, *a*), a common Illinois species, is also yellowish brown, the imago often more or less suffused with bronze. The head bears four distinct black dots above, an additional one on each side being placed behind the eyes. The posterior pair of thoracic dots are well marked but commonly rather small, placed about half way between the front and hind margins, and the median longitudinal thoracic line is also usually present. The wings are pale, with paler veins. *Agallia sanguinolenta* (Fig. 7, *a*), our commonest species of the genus, is commonly darker brown; the dots on the head, and usually the first pair on the prothorax, are large and distinct, the other markings not so evident. The prothorax and the head above are commonly streaked with darker bands, the scutellum bears a W-shaped dusky mark, and the wings are more or less dusky brown with the veins partly black and partly white. *Agallia uhleri*, a western species, is a pale insect with two dots on the head and only a trace of the first pair on the thorax. The wings are whitish with the veins darker posteriorly.

The nymphs of these species of *Agallia* present also some evident

distinctions. That of *4-punctata* (Fig. 5, *c*) is dark with a pair of subquadrate horn-like processes projecting forward between the eyes, and there is a serrate crest along the middle of the back of the abdomen. The nymph of *novella* (Fig. 6, *c*) is similarly crested, and the top of the head projects somewhat upwards but scarcely forward; that of *sanguinolenta* (Fig. 7, *c*) has neither crest nor cephalic projections, but the black head-dots are visible. The nymph of *uhleri* we have not seen.

Of the third group, *Oncometopia undata* (Fig. 8) is a full half inch in length, the wings are purplish, and the head and scutellum are orange reticulate with black. *Diedrocephala versuta* is about three-sixteenths of an inch long, dark yellowish green, with one greenish blue and two orange stripes on each wing and some marginal black dots near the tip. The head is ornamented above with a yellowish submarginal stripe, often bluish, and one down the middle, both sharply defined by fine black lines. *Diedrocephala mollipes* (Fig. 9), a very common species, is similar to the foregoing but larger, from a quarter to three-eighths of an inch long, the wings dark green with bluish veins and yellow edges, the head, scutellum, and front of thorax yellowish, the first with some fine black lines irregularly placed. *Gypona octolineata* is a broad, oval, straw-colored species, three-eighths of an inch long, the thorax indefinitely lined with yellow or reddish, and the ocelli bright, but pale red.

The last and largest of the four groups is difficult of satisfactory analysis. Among the larger forms *Platymetopius acutus* (Fig. 10) is bright brown with ivory-whitish spots and a notably broad and pointed head. The wings have a series of oblique black dashes along their lower edge, and are so shaped that they diverge behind the body when folded, leaving a broad notch between them at the tip. *Eutettix seminuda* has a short, broadly rounded head and a whitish back with a large light brown saddle-mark. *Phlepsius irroratus* (Pl. III., Fig. 2) is whitish with a very fine dark brown network on the upper surface, giving the general effect of a uniform light brown shade. It is three-sixteenths of an inch in length, or more. *Deltocephalus inimicus* (Fig. 12) is best known by the three similar pairs of large black dots, one on the head, one on the prothorax, and one on the triangular scutellum. The wings have a whitish ground-color with brown margins to the cells.

Among the small green species *Deltocephalus melsheimeri* (Fig. 11) is gray-green without distinct markings, and its head is unusually flat and triangular above. *Deltocephalus nigrifrons* (Pl. II., Fig. 2) has a row of six small black and nearly equal dots along the front of the head as seen from above, and the face is barred with black. The two species of *Gnathodus* here mentioned are plain dark green with very short heads, the surface visible from above having the form of a curved band of

nearly equal width throughout. In *G. abdominalis* the back of the abdomen is brownish, while in *G. impictus* it is green like the rest of the body. *Cicadula sexnotata* (Pl. II., Fig. 1) has a pair of black dots at the back of the upper surface of the head, and in front of each of these a pair of black cross-bars. The genus *Empoasca* includes the tiny yellowish green forms excessively abundant in beet fields and elsewhere. *E. mali* (Pl. II., Fig. 3) has six white spots along the front of the prothorax; *E. flavescens* (Pl. II., Fig. 4) has only three larger spots in that situation; and *Dicraneura fieberi* is somewhat amber tinted, with a pale cloud on the prothorax. Late in fall we once found a number of grape-vine leaf-hoppers (*Typhlocyba*—Pl. III., Fig. 1) on young beets. These, like the forms just mentioned, are very small and delicate, but are brightly marked with black, ivory-white, red, and other colors.

Stobera tricarinata Say.

(*Delphax tricarinata* Say, *Liburnia intertexta* Uhl. MS.*)

(Pl. I., Fig. 1.)

This common leaf-hopper ranges from Canada and New Jersey as far south as Texas and west to California. We have taken it occasionally on sugar beets, and Bruner has recorded it as a beet insect under the name *Liburnia intertexta*. We have collected it in sweeping grass and weeds and once saw it puncturing a blade of corn.

It hibernates as an adult. Our data indicate that this leaf-hopper is two-brooded. Adults have been taken by us principally in the fall months and December and again in April and May (the hibernating brood), and at the end of June and in July (the second brood).

Liburnia ornata Stål.

(Pl. I., Fig. 3.)

This pretty little insect ranges from the Mississippi to the Atlantic coast; and it is not rare in the sugar-beet fields of Illinois. Its life history is apparently like that of the preceding species. It has been taken by us in large numbers in November in central Illinois, and in April in the southern part of the state. It thus seems to hibernate as an adult. We have again found it abundant on grasses, grains, and weeds in central Illinois in July and in southern Illinois in August—a plain indication of a second brood.

*Concerning this name Mr. E. P. Van Duzee writes us under date of October 20, 1899, as follows:

"In the National Museum is a pale specimen that so far as I can discover does not differ in any respect from the females of *Stobera tricarinata* Say, bearing a label *Liburnia intertexta* Uhler. The name seems never to have been published. If no transposition has been made at the Museum you will be perfectly safe in quoting this as the female of Say's species. This is taken from some unpublished notes of mine on this family."

Liburnia puella Van D.

(Pl. I., Fig. 2.)

This species is recorded from Iowa, Mississippi, New York, and New Jersey, and seems to have a more southerly range than *L. ornata.* We have taken it repeatedly on sugar beets on the University farm in July and October. In our general collections it is recorded for central Illinois from grass, grains, and various low plants in July and again in the fall up to about the middle of November; also, in August, for extreme southern Illinois. It is thus probably two-brooded, hibernating as an adult.

Agallia 4-punctata Prov.

(*A. punctata* Kenyon.)

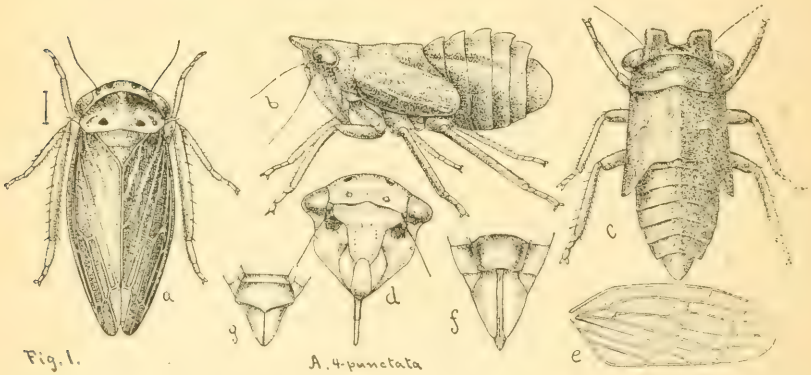

Fig. 5. *Agallia 4-punctata: a,* adult; *b,* nymph, side view; *c,* nymph, dorsal view; *d,* face; *e,* elytron; *f,* female, *g,* male genitalia. (Osborn and Ball.)

This seems to be a northerly species, ranging from Canada and New York to Colorado, Arkansas, and Kentucky. It is moderately common in Illinois, but did not appear in our last summer's collections from the sugar beet. It has been found on beets in Iowa, however, by Professor Herbert Osborn, whose studies have contributed much to our knowledge of the leaf-hoppers of this genus. The species under consideration he says is "single brooded, the adult appearing in early spring, the females remaining until into July. The eggs are probably all deposited by the middle of June, from which the larvæ appear in July, and by fall are nearly or quite full grown, passing the winter and issuing as adults again early the next spring." This species has been found on a great variety of plants, mostly *Compositæ*, such as sunflower and boneset (*Eupatorium*), *Cruciferæ*, *Chenopodiaceæ* and their garden relatives, beets, horseradish, cabbage, spinach, etc. "The larvæ remain on or near the ground and conceal themselves in the rubbish and humus, for which their color and appearance is peculiarly adapted." They usually occur in woods and similar shaded situations, but also on

plants, as mentioned above, whose abundant foliage furnishes the requisite shade. The adults are usually found on the younger portions of the stem.

Agallia novella Say.

(*Macropsis nobilis*, 14th Rep. State Ent. Ill., p. 22.)

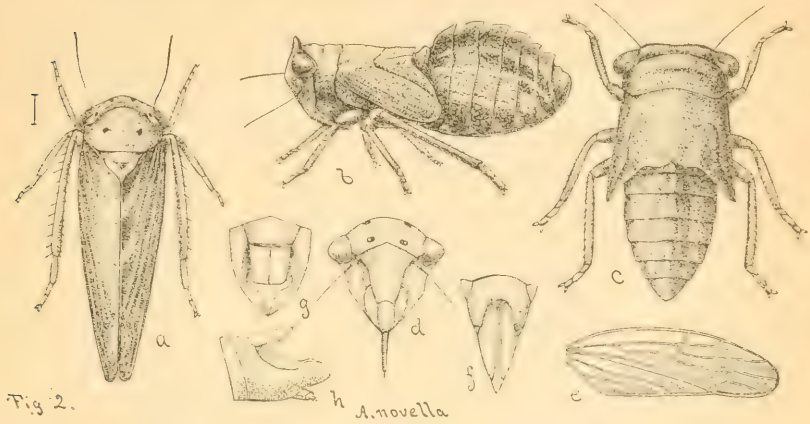

Fig. 6. *Agallia novella: a*, adult; *b*, nymph, side view; *c*, nymph, dorsal view; *d*, face; *e*, elytron; *f*, female, *g*, male genitalia; *h*, male, side view. (Osborn and Ball.)

Osborn reports this species also as occurring on sugar beets in Iowa. Its recorded range is similar to that of the preceding species, and it also occurs in Mexico and Vancouver, having evidently a very wide distribution over this country. We have collected it both in fields and woods, from rye, blue-grass, strawberries, various grasses and weeds, and from grape-vines, red cedar, apple, and pear. In the Fourteenth Report from the Office of the State Entomologist of Illinois (p. 22) it is referred to as injurious to corn. Specimens sent to Uhler previous to that time had been named by him *Macropsis nobilis* Harr., and this name—by which *M. novellus* Say was probably meant—was there used to designate it. It is a common Illinois species, but did not appear last summer among the leaf-hoppers seen by us on sugar beets. Like the preceding, it winters over in the nymphal stage. The hibernating nymphs transform more slowly than those of *A. 4-punctata*, and the adults from them are common till near the end of July. These produce young in August—about a month later than *4-punctata*—which approach maturity by fall, and winter over in leaves and rubbish.

Agallia sanguinolenta Prov.

(*Bythoscopus siccifolius* Bruner.)

This species, our commonest *Agallia*, seems to range over nearly the whole United States, and is also found in Mexico and British America.

It was first recorded as a sugar-beet insect by Bruner, and on account of its abundance and its fondness for beets this leaf-hopper may now and then give trouble. Osborn speaks of it as a persistent beet feeder,

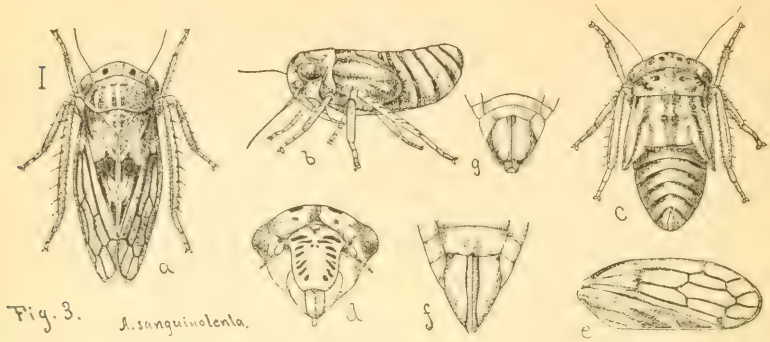

Fig. 7. *Agallia sanguinolenta:* *a*, adult; *b*, nymph, side view; *c*, nymph, dorsal view; *d*, face *e*, elytron; *f*, female, *g*, male genitalia. (Osborn and Ball.)

and in the sugar-beet plats on the Illinois University farm it was frequently noted, becoming very abundant in October.

Unlike *A. punctata* it prefers open sunny localities, avoiding damp shady woods. It is particularly destructive to clover, and in addition to sugar beets attacks also celery, turnips, cabbage, strawberries, blue-grass (to some extent), and a variety of weeds—especially pigweed and lamb's-quarters (*Amarantus* and *Chenopodium*). Its punctures cause small white spots on blue-grass leaves. The larva keeps near the ground and hides under rubbish. Its life history differs a little from that of the species of the genus mentioned above. It seems to hibernate mostly as an adult, under various sorts of rubbish—old boards, hay, and other like shelter. We have taken it in such situations in December. In Osborn's breeding-cages eggs were found inserted beneath the cuticle of the clover leaf along the midrib of the blade, though most were probably laid in the leaf stems or in the bases of the plants. The first larvæ from spring eggs appeared May 20th, and began to mature by July 1st. Later, all stages could be found together until on the approach of winter the young all gradually became adult.

Agallia uhleri Van D.

This western species is recorded from garden and sugar beets in Colorado by Gillette and Baker ("Hemiptera of Colorado," p. 81), and also from *Sisymbrium canescens* and alfalfa. Various dates are given from May 7th to October 15th. The life history is not known.

Oncometopia undata Fabr.

This largest of our leaf-hoppers was found on sugar beets at Urbana during the latter part of June. It seems to be especially a grape insect,

Fig. 8. *Oncometopia undata.*

sometimes seriously injuring the vines and the fruit—according to Walsh, laying its eggs in the stems, thus checking the growth, and puncturing the stems of the clusters, thus causing them to drop off. It is a greedy feeder, in many cases seemingly pumping out more sap than it needs, and ejecting this backward in a rapid succession of tiny drops. It is not confined to the grape, but may be seen clinging in numbers to the stems of the blackberry, raspberry, corn, okra, sunflower, and some common weeds. Being a very large and common leaf-hopper, pretty well distributed over the eastern United States, it may well deserve attention. It is more especially a southern species, and in Illinois is commonest in the southern part.

Very little is known of its yearly history. Walsh surmises that it hibernates as an egg, the slits which he attributes to this species containing empty shells in July. Our dates for the adults range from the middle of May to the middle of July in Illinois, and to September 10th in the Southern States.

Diedrocephala versuta Say.

This green-and-blue-striped leaf-hopper of the Southern States ranges north into central Illinois, but is not so common here as in the southern part of the state. Examples were found at Urbana early in October on sugar beets in the Experiment Station plats. It has a variety of food plants, and in the South is very abundant on cotton but not seriously injurious. Osborn says that it is similar in habits to *D. coccinea*, feeding in quiet sheltered spots near thickets or woods.

Diedrocephala mollipes Say.

We have in this large dull green leaf-hopper one of the commonest of our larger species, rarely abundant enough, however, to be economically important. Its range includes the United States, Canada, Mexico, and Cuba. It was found frequently on sugar beets in October at Urbana, but it feeds principally on sedges, grasses, and grain plants, including corn. The nymphs are light green or yellowish, with sharply pointed heads as in the adults.

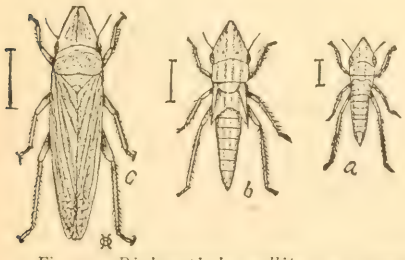

Fig. 9. *Diedrocephala mollipes*: *a*, young nymph; *b*, older nymph; *c*, adult. (Osborn.)

There are two broods of this species in a year. The eggs are laid in rank grasses and sedges on low grounds, and although we have found the adult in winter shelter as late as December 18th, the winter is passed mostly in the egg stage. Probably a few nymphs also hibernate.

Most of the eggs hatch in May, the larvæ becoming common in early summer. In June these begin to transform to adults. We have taken the latter in large numbers at electric lights in the first half of June, and found them laying eggs for a second brood July 16th and 22d. The eggs were placed in the pith and woody tissue of bulrushes (*Scirpus fluviatilis*) and in the substance of the leaf sheath and blades. June 23d to 25th these insects were noted as common on corn, and one was seen in the act of laying its eggs in a corn leaf. The second brood of larvæ appear in August and September, transforming in fall to adults. These, again, gather in low grounds, and most of them lay eggs and die before cold weather.

The species abounds especially on reedy grasses of the salt marshes of the Atlantic coast. In Kentucky it suffered severely in late July and early August from a parasitic fungus, *Empusa grylli*. It is probable that the burning of slough grass and the like vegetation in winter would be a useful measure of protection against injury by this insect.

Gypona 8-lineata Say.

This leaf-hopper, fairly common in Illinois, occurs over the eastern United States from Canada to Texas. It has occasionally appeared in our sugar-beet collections from the Experiment Station farm. Osborn says that it does not seem to be confined to any particular food plant, but may be found almost everywhere, preferring rank growths in shaded situations. The color deepens and changes with the season's advance, most of the first brood and the earliest of the second being light green with indefinite yellow lines and weak elytral reticulations; and the last of the first and nearly all of the second, dark green, with strongly reticulate elytra. In September and October the lines tend to become red, and females may be found almost wholly scarlet dorsally. (Osborn.) Although our other species of *Gypona* are apparently one-brooded, this has two broods in a year. The adults of the first brood appear in late June and in July, and those of the second in fall. They are most abundant with us about the end of June, when they have been taken in large numbers at electric lights. The nymphal stages of these broods are commonest in June, and in August and September, respectively. There is no record of the capture of hibernating adults, and the species probably winters in the egg. The head is noticeably wide, broadly rounded in front, and slightly shovel shaped. The front of the head in the larva is more elongate and very thin, the sides parallel in front of the eyes, and the tip broadly rounded.

Platymetopius acutus Say.

This leaf-hopper is notably different from the other small beet-species in the pointed elongate head which has the form of an equal-

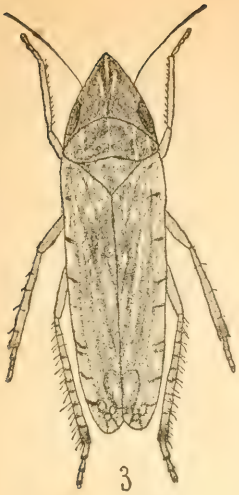

Fig. 10. *Platymetopius acutus*, adult.

side triangle. The nymph has a light stripe down the center, red at the middle and tending to separate into two spots upon the back of the abdomen, with a black marginal stripe on each side. Gillette reports it from sugar beets, sumach, clematis, and oak. It occurs mostly on grass and weeds, especially in shady situations. Davis lists it among the celery leaf-hoppers. We have taken the nymph on apple May 15th. The species is found in Canada and the United States as far west as the Rocky Mountains. There are two broods annually, adults of the first commonly occurring from June 15th to July 15th, and of the second from the early part of August to the approach of winter. Nymphs are common late in May and in June and again in July and August. Its stage of hibernation is not definitely known.

Deltocephalus melsheimeri Fitch.

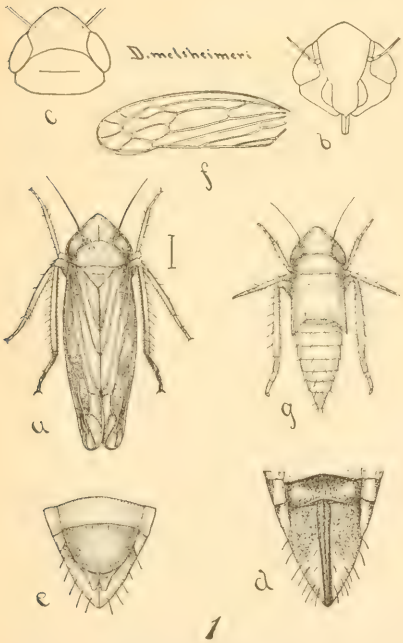

Fig. 11. *Deltocephalus melsheimeri:* *a*, adult; *b*, face; *c*, head and pronotum from above; *d*, female, *e*, male genitalia; *f*, wing; *g*, nymph. (Osborn and Ball.)

This was one of the leaf-hoppers taken in summer and fall on sugar-beets at the Experiment Station farm. It is especially a grass insect, sometimes present in myriads in lawns and pastures, but avoiding shaded situations. The eggs are laid in fall in grass, and the adults do not survive the winter. There are apparently three broods in the year. Adults, presumably from hibernating eggs, occur in late May and in June, and there is a brood of nymphs from the last of May into July, becoming adult in July and August. The next brood of nymphs is produced in August and early September, maturing and laying eggs by the close of the season. These successive changes are about two weeks earlier than those of the following species (*D. inimicus*).

Deltocephalus inimicus Say.

(*Jassus inimicus* Say.)

This is one of the four or five species of leaf-hoppers most abundant in beet fields, and most likely to cause trouble there. It is widely distributed over this country and into Canada, and is one of the most persistent and destructive leaf-hoppers of pastures and meadows. It was especially common last season on beets during the early part of October, and has also been reported from celery, corn, and buckwheat; but its preferred food is evidently grass.

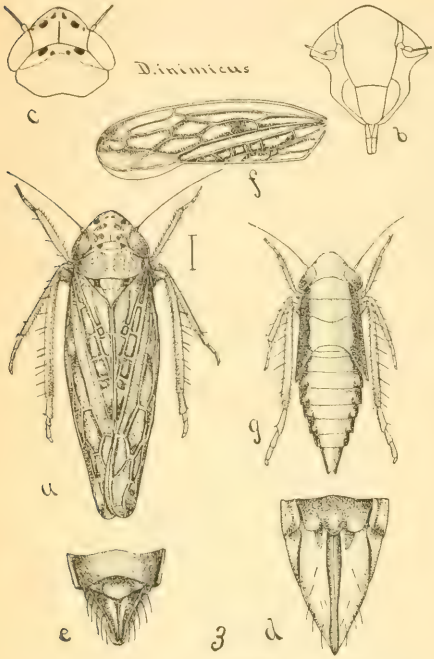

Fig. 12. *Deltocephalus inimicus: a*, adult; *b*, face *c*, head and pronotum from above; *d*, female, *e*, male, genitalia; *f*, elytron; *g*, nymph. (Osborn and Ball.)

Its life history has been very thoroughly studied by Osborn. The eggs, he says, have been found inserted beneath the epidermis of blue-grass blades, forming minute blister-like swellings near the tips of the leaves, the end of the leaf beyond this invariably turning yellow and dying. Webster secured the eggs in wheat leaves. The nymphs are mostly light yellowish, with a broad black margin each side, the head obtusely rounded in front. At intervals of seven to eight days they fix themselves upon the grass blades, head upward, and shed their skins, which split along the back, permitting the insects to struggle out. The cast skins remain for some time clinging to the grass blades. Three molts occur (Osborn, Webster) from the egg to the adult.

Like most jassids this species winters in the egg stage, hatching in great numbers in grass-lands early in May. The young mature during the first half of June, the adults thus produced mostly disappearing by the middle of July. These lay eggs which hatch after ten or fifteen days, the nymphs becoming adult in about a month, beginning, that is, about the middle of August. Eggs are then laid for the next season's brood, and the adults laying them perish by the time winter sets in. There are thus two broods yearly, the larvæ being most numerous in late May and in August, and the adults in June and in the fall. Large numbers of the latter appeared here at electric lights June 3–18.

Osborn noticed that as many as ten per cent. of the larvæ found in spring were infested by red mites.

Deltocephalus nigrifrons Forbes.

(*Cicadula nigrifrons* Forbes.)

(Pl. II., Fig. 2.)

This leaf-hopper, abundant in Illinois beet fields, is also a destructive grass pest and has been recorded as injurious to corn, wheat, and oats. It is known from New York, Louisiana, and California, and intermediate localities, and is very common in Illinois. Two forms exist, one larger and lighter colored than the other, with defective wing venation, and using its wings comparatively little. These differences are perhaps to be connected, like those of the two broods of *Oncometopia undata*, with differences of brood and season.

No adults of the species have been taken in winter, and it almost certainly hibernates in the egg. There are probably two broods, adults of the first generation being abundant in June and July and those of the second in fall. We noted them here in large numbers at electric lights June 3d to 7th and again June 15th. Nymphs are common about the first of June and in August.

Athysanus sp.

Bruner reports an undetermined genus of this species as occurring upon the beet in Nebraska.*

Eutettix seminuda Say.

This is not a very common leaf-hopper, but as it has frequently been observed on beets it is included here. It is found in the eastern United States and in Canada, and has attracted economic notice only as a cotton insect. It is often seen on cotton stalks in Mississippi, and has been observed to feed upon this plant by Mr. Ashmead, who remarks that it is a very omnivorous feeder, not likely to cause serious injury to any one plant. It is also recorded on birch, wild black cherry, and various bushes and low trees. Little is known of its life history, but the season of occurrence of adults corresponds fairly well with that of the next species. It has been taken in the South from the middle of May, and in Illinois from about the middle of June to the end of October.

Eutettix tenella Uhl.

Recorded by Gillette and Baker as common on sugar beets in August. The species probably does not occur in Illinois.

*Bull. No. 23, U. S. Dept. Agr., Div. Ent., p. 17.

Phlepsius irroratus Say.

(*Allygus irroratus* Say.)

(Pl. III., Fig. 2.)

This also is not especially a grass insect, but attacks a great variety of plants. It ranges from Canada and Massachusetts on the east to Iowa and Kansas on the west, and is abundant in Illinois. A number of specimens were taken on sugar beets in various parts of the state in June, September, and October. It is recorded on low herbage (Say), on willows and other plants in damp places (Uhler), on bushes and trees (Van Duzee), on celery (Davis), on apple (Gillette and Baker), on hickory (Packard), on grasses and grains (Osborn), and in dry weedy grass-lands (Van Duzee). We have found it abundant in young wheat in Illinois. It causes the dark purple spotting often seen on the leaves of lamb's-quarters, and probably a similar discoloration common on beet leaves (U. S. Bull. 23, p. 17). Bruner mentions an undetermined *Allygus* —very likely this or some other *Phlepsius*—as frequent on beets and causing the spotting of lamb's-quarters. We once found a small bass-wood brush swarming with this species in October. The leaves were noticeably faded and spotted with blackish points. The adults seem quite uniformly distributed through their season, which is from late May to about the middle of October, though they are especially abundant in June and the first part of July, and again in fall. There are probably two broods, and the winter is presumably passed in the egg stage as there is no record of winter collections of the adult.

Thamnotettix belli Uhl.

This is recorded only from Canada, Michigan, and Colorado. It is included here on the authority of Gillette and Baker, who have reported its occurrence on cultivated beet, alfalfa, and *Artemisia tridentata* in Colorado, the dates given ranging from May 8th to August 18th.

Gnathodus abdominalis Van D.

Gnathodus impictus Van D.

The two species of this genus here mentioned are recognizable by their short transverse heads and somewhat dull green color. They are about an eighth of an inch long. Both seem widely scattered east of the Rocky Mountains, and have been taken with other leaf-hoppers on sugar beets, but they are not common enough as yet to be of any economic importance. Both occur in Illinois on corn and rye. We have taken *abdominalis* from wheat and grass, and Gillette and Baker record it from sugar beets and barley. We have found *impictus* on sugar beets, wheat, rye, blue-grass and other grasses, and in groves. The

data as to their life history are too scanty to show the number of broods. *Abdominalis* has been taken mostly in June and August, while our specimens of *impictus* were nearly all captured in May and July.

Cicadula 6-notata Fall.

(*Cicadula 4-lineata* Forbes.)

(Pl. II., Fig. 1.)

The two pairs of black bars and two dots on the head above form the unmistakable trade-mark of this little green species, one of the most abundant in Illinois beet fields throughout the season. It has a wide but rather northerly distribution,—reaching to Canada, Connecticut, Mississippi, California, and Alaska,—and a great variety of food plants, among which the grasses and small grains take a prominent place. Davis records it as the most abundant of the celery leaf-hoppers. We have reported it as especially injurious to wheat (Fourteenth Report, page 68), and have also collected it from oats, corn, sorghum, blue-grass and other grasses, apple, elm, willow, cucumbers, dog-fennel, and other weeds. No adults have been taken later than the middle of November or before the middle of May. The species doubtless hibernates as an egg. Apparently there are two broods, the adults being most abundant in the latter half of May and in June, and again in the fall months—from September 1st to the close of the season.

Dicraneura fieberi Loew.

This leaf-hopper closely resembles the species next mentioned, but it is slightly larger and more amber-colored, and without definite markings on the thorax, the most important difference being in the wing venation. It has occasionally been taken by us on sugar beets in Illinois. It is found from Massachusetts to Kansas, but it is not very abundant. We have taken it also on grass-lands and in woods, and on elm and soft maple-trees. Specimens have been taken from late in May through July, and again from near the end of August to early in November, thus indicating two broods and hibernation in the egg.

Empoasca mali LeBaron.

(*Empoa albopicta* Forbes.)

(Pl. II., Fig. 3.)

Although not destructive in grass-lands, this delicate little shining-winged, yellow-green insect is probably our worst all-round leaf-hopper pest, so excessively abundant that notwithstanding its varied diet it is able to make a serious attack on quite a number of the cultivated plants of its list. It is extremely abundant on sugar beets everywhere, both in the nymph and adult stages, thus showing its ability to breed on this

plant. It is probably the species mentioned by Bruner in his list of beet insects as *Erythroneura* sp. It was first named and studied as an apple insect, and as such in nurseries probably does the greatest damage; but it is also injurious to raspberries and garden vegetables, especially potatoes and celery, to clover, corn, and sorghum. It is further recorded in our notes on black walnut, *Ptelea trifoliata*, and elm, as well as on oats, rye, grass, and some weeds, and by Gilette on beans, plum, wild grape, and cottonwood. Nymphs have been observed on celery and other plants, as well as on apple.

On infested young apple-trees the injury is very evident. The leaves curl and crinkle and the internodes are shortened, showing retardation of growth. No local effect of their punctures on beets has been recognized, but in view of the large numbers usually present in beet fields there is good reason to believe them capable of injury to beets. What we supposed to be the eggs of this species were found in slight swellings in the green twigs and the midrib and leaf stem of the apple. The nymphs are pale green.

There is considerable uncertainty in using the statements of others concerning this insect because of the frequency with which it has been confused with other small greenish or yellowish species of its own and related genera, descriptions and figures of which may be found in Gillette's article on the *Typhlocybinæ* in the Proceedings of the U. S. National Museum, Volume XX., page 709. The row of six (or even eight) white dots along the front margin of the prothorax are evident as a rule even in alcoholic specimens, and at once distinguish the species. If this character is unsatisfactory, reference should be made to the wing venation, good figures of which are given by Gillette in his article. Specimens in alcohol can be conveniently examined by spreading out the wings, when wet, on a glass slide. The species most likely to be confused with this are *Aletra albostriella*, without distinct markings, bred by us from basswood, and reported on pear and cherry; *Typhlocyba rosæ*, yellowish without markings, found by us common on rose, gooseberry, and apple, and reported by Gillette also on cherry, currant, plum, grape, oak, and cottonwood; *Dicraneura fieberi*, already described above; *Empoasca obtusa*, bred by us on apple and collected on willow, having similar venation, but of larger size and with the head scarcely longer at the middle; and, finally, the species next to be treated, *E. flavescens* (Pl. II., Fig. 4), which has been found with *mali* on apple and sugar beets, and in which there are usually three pronotal spots instead of six.

Observations on this or a related species show a rather rapid development—from the laying of the egg to the imago within a month. The adults were noted as very abundant in late April and early May; common and more numerous than the nymphs early in June; on June 26th,

"rising in clouds," nine tenths of them nymphs. None of the imagos are recorded in Illinois from November 1st to the last of April, and it is almost certain that they pass the winter in the egg. It can only be surmised from present data that there are four or more broods in a season in central Illinois.

Empoasca flavescens Fabr.

(Pl. II., Fig. 4.)

This is closely related to the preceding species and similar to it in habit and food plants, so far as these are known to us. It was not found among the sugar-beet leaf-hoppers until fall, but became very common in October, more so indeed than *mali*. It is whiter than *mali*, and has only three spots on the margin of the thorax. These are not always distinct, and indefinite markings resembling them may be noted in some similarly colored species of related genera, which may be distinguished by their venation, as mentioned above. The species is common and widespread, and is reported from localities ranging from New York and the District of Columbia to California and Mexico. Its smoky-winged variety, *birdii*, is recorded from New York, Michigan, Illinois, and Iowa, on apple, hops, walnut, beans, and weeds.

It has been collected December 16th, and again among leaves in the woods in early spring. We have taken it as early as April 20th. This indicates hibernation as an imago, and considering its abundance in late fall it is evident that its life history is unlike that of *mali*—perhaps more like that of the *Typhlocybas* next to be treated.

The Grape Leaf-hoppers.

Typhlocyba.

(Pl. III., Fig. 1.)

Early in October, on sugar beets on the University farm, the species *Typhlocyba vulnerata* Fitch was very common, and a few of *T. comes* Say and its variety *vitis* Harr. were also seen. These and a number of other tiny leaf-hoppers finely marked in various patterns with scarlet, orange, ivory-white, etc., on a pale yellowish white ground color, are commonest and very injurious on wild and cultivated grape-vines, Virginia creepers and redbud, and also occur on raspberry and a few other plants. They are widely distributed throughout the country.

These leaf-hoppers spend the winter as adults in large numbers among dead leaves and other trash upon the ground, coming out and laying their eggs on the vine leaves when warmer weather comes in April and May. By the middle of June the adults become numerous, and continue in increasing numbers until the leaves fall at the end of the season. All stages may be found on the vines at once, and the succession and number of broods has never been made out.

THE TREE-HOPPERS.

Membracidæ.

Acutalis calva Say.

As might naturally be expected, the tree-hoppers live mostly on trees. A few, however, may occur on herbaceous plants, such as the present species, which we noticed on the sugar beet in the latter part of June. It is about an eighth of an inch long, triangular when seen from above, blunt in front, acute behind, black above, the wings on each side yellowish white. Its favorite food seems to be the "Joe Pye weed" (*Eupatorium purpureum*), but we have taken a few on honey-locust and it is reported on buckwheat by Webster.* Our specimens were mostly taken in the latter part of June. The life history of the species is not known to us. It is found throughout the United States east of the Rocky Mountains and in Mexico.

Leaves variously spotted and blotched and sometimes minutely specked. Suctorial insects present which are not leaf-hoppers.

PLANT-LICE.†

Aphididæ.

Occasionally where the beet leaf is visibly but obscurely injured, as shown by a blotchy discoloration of the surface or by a crinkling and curling of the leaf, small, sluggish, inactive bluish green or blackish insects known as plant-lice (*aphides*) may be found clustered in patches on the under surface of the affected leaf. These leaf-lice are oval or somewhat egg-shaped, their bodies are soft, their legs and antennæ are well developed, and at the back of the abdomen, near the hinder end of the body, a pair of prominent tubes—the so-called honey-tubes—projects backwards or upwards like miniature stove-pipes. The greater part of them are without wings, but, among these, winged individuals will occasionally occur, with large, delicate, few-veined wings. Ants of various species are likely to be found with and among them, and, indeed, wherever ants are abundant on or about the beets, the presence of plant-lice may always reasonably be suspected. They do their injury to vegetation by sucking the sap through a stiff, jointed beak by means of which the tissues of the plant are pierced. Three species have hitherto been reported on the beet leaf in America, and to these three more are added in this paper.

We have not yet found in Illinois any plant-louse species infesting the leaf of the sugar beet in sufficient numbers to do appreciable injury,

*Rep. Comm. Agr., 1886, p. 577.

†Two additional species of plant-lice infesting beets, *Aphis middletonii* and *Pemphigus betæ*, are described on a later page under the head of insects affecting the roots of this plant.

but their rate of multiplication is enormous, and under especially favorable circumstances almost any species may rapidly become so abundant locally as practically to destroy its food plant for the time being. Most of the species hatch from eggs in the spring, all of this first generation being females capable of reproducing without copulation, and giving birth to living young as soon as they themselves become adult. Several generations are ordinarily brought forth in like manner in a single season, only the last of which is composed of both males and females, and these produce the eggs by means of which the species is carried past the winter.

These insects are commonly kept in check by their natural enemies, the ladybugs, the lace-wing flies, and a number of rapidly-breeding parasites. It is only occasionally, consequently, that remedial measures are likely to be necessary. In that case tobacco-water, kerosene emulsion, or a mechanical mixture of water and kerosene should be used, as prescribed for leaf-hoppers on page 64. The arsenical poisons, London purple, Paris green, and the like, are inadmissible, since they do not take effect on the plant-louse, but will kill many of its insect enemies. They are thus likely to increase the danger instead of diminishing it.

The Melon Aphis.

Aphis gossypii Glover.

(*Aphis cucumeris* Forbes.)

This is the common melon and cucumber aphis of the central United States. It abounds on a large variety of plants throughout all the United States except the extreme northern part, and also in Mexico, the West Indies, and Australia. It was found in Nebraska by Mr. T. A. Williams in 1890 breeding abundantly on beets in the vicinity of infested cucumber vines. An injury attributed to ants, reported from Nebraska, was perhaps due to this species. Its leading food plants are melons, cucumbers, and other vines of the cucumber family, crops of which it sometimes almost destroys. It is also abundant on cotton, beans, pear-trees, European dogwood, orange-trees, hothouse plants, and a large number of the commonest weeds, including purslane, shepherd's-purse, pepper-grass, pigweed (*Amarantus*), lamb's-quarters (*Chenopodium*), plantain, dock, dandelion, Jamestown weed (*Datura*), etc.; also, in lesser numbers, on hops, spinach, tomato, red clover, and burdock.

The eggs have been found on purslane, and are at first yellowish or greenish, but soon become jet-black. The color of the wingless lice varies all the way from yellow or green to black; the antennæ, about half as long as the body, are mostly pale, and the honey-tubes are black. The winged ones are similarly varied, but are never entirely black; the

head, antennæ, and honey-tubes are black, together with some bars on the thoracic segments and some lateral abdominal spots.

Eggs and many wingless females have been found in midwinter; in May the lice gradually increase in numbers on the plants; and in the latter half of June, according to Professor J. B. Smith, if sufficiently numerous and favored by fine weather, an extensive migration of winged individuals occurs, rapidly enlarging the infested area. After the first week of July this movement of dispersal ceases under ordinary circumstances; but winged lice have been seen as late as August. The sexually mature forms have not yet been distinguished. Ants assist to some extent in transporting and distributing the lice in summer.

Aphis atriplicis Linn.

Both in America and Europe this is a common species on plants of the order *Chenopodiaceæ*, especially orache (*Atriplex*) in Europe, and lamb's-quarters (*Chenopodium*) in America. It is reported by Bruner as common on beets in Nebraska. The effect on *Atriplex* is peculiar. The leaf-lice cluster along the midribs, mostly on the upper surface, causing a tubular longitudinal rolling up of the leaves.* The species is listed from Illinois and Missouri. It is closely related to the preceding, and further study may show that the two forms are not distinct.

The eggs are of the usual form and color, and were found with sexually perfect individuals in dry rolled leaves of *Atriplex*. The summer females vary from green to black, but are mostly blackish spotted with white. The sexually perfect individuals are wingless and much smaller than the viviparous form.

Aphis sp.

A number of wingless females were swept in July from beets in a field near Tremont, Ill., the species of which we have not found described. Not having winged individuals and not being sure of the host plant, it seems best to leave the species unnamed. It seems to belong to the *Nectarophorini* of Œstlund, and is easily recognized by two dark rings on the antenna, which include the sutures between segments III, IV, and V, and by the dark color of the apex of V and the basal part and tip of VI (the so-called VI and VII); by the broad conical cauda, widest at base; and by the long honey-tubes and antennæ, both surpassing the tip of the body. The antennæ are raised on low tubercles. The setaceous part of VI is about twice as long as III; the honey-tubes are as long as the anterior femora.

Myzus achyrantes Monell.

This was originally described from specimens found on *Achyrantes*, a plant belonging to the pigweed family, and might naturally be looked

*Kaltenbach, *Die Pflanzenfeinde*, p. 508.

for on beets. It is at present, in fact, our commonest beet leaf-louse in Illinois. Though not especially abundant, it occurs in small colonies on the under side of the leaves in the latter part of June and in July, being most numerous about the end of June. The first winged individuals were noted July 5th. It is a green aphis, with but little dark coloring in the wingless female. The winged female has the thorax and antennæ black and a large dark patch on the abdomen between the honey-tubes. The species is also recorded from *Amarantus* (Williams) and *Malva rotundifolia* (Œstlund), and we have collected it in abundance on corn.

Nectarophora erigeronensis Thos.?

Specimens were taken in sweepings from sugar beets July 13th, 14th, and 26th in the vicinity of Pekin, Ill., and on the University farm (on the first date mostly wingless) which agree fairly well with the descriptions of *erigeronensis* except as to the tibiæ. These are usually pale with black tips, and not entirely black as stated for *erigeronensis*. The honey-tubes are either entirely dark or with the basal portion pale. The antennæ are dark except at base, the femora with the apical part, or even more than half the length, black.

Nectarophora pisi Kalt.

The "green dolphin" is a rather common garden pest in the United States. Its body and appendages are almost entirely green. It infests principally plants of the pea family (*Leguminosæ*), especially the garden pea, sweet pea, and clover, but has also been taken in the pupal and winged stages on beets in Nebraska, and in Europe on shepherd's-purse, nettles, and *Spiræa*. In Illinois it occurs mostly about the end of May.

THE FLATAS OR LANTERN-FLIES.

THE MEALY FLATA (*Ormenis pruinosa* Say).

THE GREEN FLATA (*Chlorochroa conica* Say).

Although these odd looking insects, closely related to the leaf-hoppers, are common and injurious in Illinois and elsewhere, they have not received the attention from economic entomologists that they deserve. They are from a quarter to half an inch long, with broad flat wings, held vertically and meeting behind the body. As the insect is broad in front, the general form when at rest, seen from above, is that of a wedge. The young are covered with a white woolly excretion. Like some plant-lice they collect in patches on the under side of leaves or on their stems, and do their injury by sucking out the sap. These young are rather short and blunt at the ends, very broad across the wing-pads, and pale greenish beneath the woolly coating. This latter rubs off easily, but those which have lost it reproduce it within a few days.

The green Flata is clear yellowish-green throughout, about three-eighths of an inch long, and the wings about one-fifth of an inch broad. The head is pointed in front between the eyes. The mealy Flata is smaller than the above, about one-fourth of an inch in length and one-eighth of an inch across the wings. Its color is at first pale bluish-green, sometimes darkening to a slate-color or sooty brown, dusted over with a whitish coat. The head is short and cut squarely off across the front between the eyes.

Fig. 13. The Green Flata, *Chlorochroa conica.*

Both the above species have been found on sugar beets and on a variety of other plants, sometimes in number sufficient to do injury, although in general they are not very common insects. Many adults of both were seen by us in July on sugar beets with beaks inserted in the leaves. They were most abundant near a hedge of Osage orange, one of their favorite food plants, on which they had very likely bred. The eggs of the mealy Flata are laid in the bark of twigs within a lengthwise slit with raised edges, and are placed end to end in a continuous row an inch or more in length. Those believed to belong to the green Flata, on the other hand, are placed in a series of short slits, placed nearly end to end, within each of which is an egg which has been pushed sidewise under the bark, causing a noticeable elevation of the bark over the eggs.

Fig. 14. The Mealy Flata, *Ormenis pruinosa*, eggs: *a*, form and arrangement; *b*, insertion in twig; *c*, row of eggs in twig.

The mealy Flata is recorded by various authors as abundant and injurious on grape-vines, apple-trees, gooseberry, rhubarb, privet (*Ligustrum*), maple, hackberry, red clover, fleabane, and various other weeds. Miss Murtfeldt * found it on a large variety of plants, but especially on dahlias, which were injured beyond recovery. We have bred it from nymphs on apple, elm, box-elder, and observed it in numbers on blackberry, sugar beet, and Osage orange, on the first of which it was seen actually to feed. Riley found the eggs in sassafras twigs. The green Flata probably has a similar list of food plants. Miss Murtfeldt observed it on Osage orange and lilac. It was found by an assistant of this office, Mr. C. C. Adams, breeding abundantly (June 30th) on the stalks of corn in a corner of a field, and was later found in numbers on ragweed, catnip, milkweed, and the Osage orange in the same vicinity.

Probably these species hibernate in the egg, which, according to Riley, hatches about the middle of May. Nymphs of the mealy Flata found by him June 20th were full grown July 3d. Our largest rearings of both species—the green Flata on corn and the mealy species on box-

*Bull. No. 13, U. S. Dept. Agr., Div. Ent., p. 61.

elder—were from colonies first observed June 30th. The latter began to emerge July 1st and nymphs were still numerous July 12th. The former (*conica*) was a little later, adults not appearing till July 21st. An examination July 27th of the place where these specimens were found, revealed a large number of adults and only a single nymph. Nymphs of this species taken on various plants July 8th to 15th emerged from the 17th to the 19th. Our earliest date for the imago is July 6th. Adults of both species were seen by us on sugar beets July 14th; and they were abundant in the early part of August on their favorite food plants. We have collected adult *pruinosa* up to the middle of September, and have taken single individuals of *conica* October 3d and of *pruinosa* November 14th. This record strongly indicates that there is but one annual brood, nymphs occurring from about the middle of May to late in July, and imagos from July to the end of the season.

These insects are especially sensitive to the effects of rainy weather, as was strikingly shown by colonies of *C. conica* on corn. After a heavy rain very few could be found on stalks where they had been common before, while on plants which afforded them better shelter their numbers were not so much diminished.

THE PIGWEED BUG.

Piesma cinerea Say.

This small, gray, rough and much-flattened, somewhat diamond-shaped bug, well shown in Fig. 15, was very abundant on pigweed (*Amarantus*) in sugar-beet fields in central Illinois July 13th, yet scarcely one was seen on the beet itself. Experience has shown, however, that it will attack the beet energetically if its favorite food plant becomes scarce. In Iowa, and especially in Nebraska, it has been noticed by Osborn and Bruner respectively as very common on beets, sometimes doing much harm. It lives also on smartweeds, grasses, and a variety of trees,—among which the buckeye may be especially mentioned,—and occasionally injures the blossom of the grape in spring. The effect of its work upon the plant is very evident on badly infested pigweeds, where whitish dots thickly mottle the surface, the plants evidently suffering from loss of effective leafage. Its life history is not peculiar. Adults are very abundant from late May to early July in central Illinois, and again from October onward. They winter under any convenient shelter, but are abundant under the loose bark of trees, a situation to which they are especially adapted by their flattened form. Their occasional abundance is illustrated by the fact

Fig. 15. The Pigweed Bug, *Piesma cinerea*. (Osborn, U. S. Dept. of Agriculture.)

that an immense swarm of this species was noticed at Normal, Illinois, October 3d, the insects flying in great numbers high in the air from three to five in the afternoon.

Clean culture and the burning of trash—the first to reduce the food and the second to destroy the winter quarters—will check the multiplication of this species as well as that of a great number of similar insects.

THE COMMON FLOWER BUG.

Triphleps insidiosus Say.

This is an insect of so uncertain habit and varied food that its insertion in a list of species injurious to the beet is of doubtful propriety. The fairly common occurrence on the beet plant throughout the season of both old and young render it, however, an object of suspicion and worthy of brief treatment here. It is a minute flattened bug, black, with yellowish wing tips, everywhere distributed, and on a great variety of plants. It has been charged with serious injury to chrysanthemum shoots, causing them to curl and stopping their growth, and Osborn reports it as actually puncturing clover blossoms with its beak;* but most of the evidence concerning its food habits indicates insectivorous propensities. It has been seen devouring young chinch-bugs, the *Phylloxera* of the grape, young *Thripidæ*, and the eggs of the cotton boll-worm. We have observed it also feeding on the minute soft larvæ of the clover midge, and in confinement individuals of this species will attack each other. The available data do not determine its stage of hibernation. We have not found it as an adult earlier than April 30th nor later than October 26th. Most of our specimens were taken in May and during the late summer and fall. Young have been seen by us on beets as late as September, and adults occur on this plant throughout the season, mostly out of sight between the bases of the leaves.

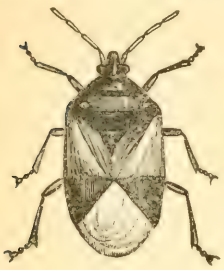

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Fig. 16. The Common Flower Bug, *Triphleps insidiosus*. (Osborn, U.S. Dept. of Agriculture.)

THE LEAF-BUGS.

Capsidæ.

Among the suctorial insects which sometimes do a rather indefinite but serious injury to beets by sucking out the sap from leaf and leaf-stalk, the large and varied group known as the leaf-bugs, or *Capsidæ*, may usually be recognized by their flat backs, their comparatively soft bodies, their active movements and ready flight, and the yellowish

*Insect Life, Vol. I., p. 122.

green or red frequent in their coloration. From the next group, the *Lygæidæ*, representatives of which are also found in the beet field, they may be distinguished on close examination by the character of the veins in the membranous part of the fore wing. In this membrane in the *Capsidæ* the only veins are at the outer (anterior) edge of the wing, where they inclose two small areas or so-called cells, while in the wing membrane of the *Lygæidæ* there are four or five unbranched veins, some of which start from a single cell at the base.

Most of the plant-bugs whose life history is known, winter as adults under fallen leaves and similar rubbish, emerging in early spring to lay their eggs, and perishing soon after this function is performed. Their injuries increase with the growth of the young and with the appearance, in some cases, of later broods.

The observer of beet insects may learn to distinguish the more abundant species of leaf plant-bugs of the beet field by attending to a few conspicuous differences. The false flea-hopper (*Agalliastes associatus*—Pl. III., Fig. 3) is about a sixteenth of an inch in length and of a uniform dull blackish color, only the semi-translucent membranous tips of the wings lightening to a sooty brown. It hops actively when disturbed, like a common flea. The garden flea-hopper (*Halticus uhleri* —Fig. 17), also about a sixteenth of an inch in length, is shining black and jumps readily like the preceding. It is in two forms; one with long wings, with an obscure white point at the tip of the thickened part of the wing, and the other with short black wings not marked with white. *Plagiognathus obscurus* is about an eighth of an inch long, dull blackish, with bicolored legs—the thighs dark and the tibiæ pale—and a narrow pale bar across each wing near its tip. *Garganus fusiformis* is nearly a quarter of an inch in length, bordered with yellowish red, with a white streak down the middle. The neck is white, the legs are red, and the middle joint of the antennæ is greatly swollen and black. *Eccritotarsus elegans* is about a sixteenth of an inch long, varying from dusky to velvety black and gaily marked with white. One of the commoner species on sugar beets is the tarnished plant-bug (*Lygus pratensis* —Fig. 18). It is about a fifth of an inch long, of a variable brassy brown, with black marks on the thorax above. The young (Fig. 19) have two or three pairs of round black dots on the back. This plant-bug is abundant everywhere throughout the year, especially on low-growing vegetation, excepting grass. *Calocoris rapidus* (Fig. 20) is longer and narrower than the foregoing, with parallel sides, uniform dark brown above, very narrowly edged with yellow. It is further marked by a carmine shade across the tip of the leathery part of the wing. The young (Fig. 21) are more or less colored with bright red on the antennæ, the legs, the front part of the body, and the abdomen. The green leaf-bug (*Macrocoleus chlorionis*—Pl. IV., Fig. 1) is under a

fifth of an inch in length, nearly uniform grass-green, the thorax only being dark green, the legs and antennæ yellowish, and the wing membranes slightly dusky with changeable tints of purple and green.

The False Flea-hopper.

Agalliastes associatus Uhler.

(Pl. III., Fig. 3.)

This minute, active, black hopper is common in the beet field, but much less so than the following species, with which, indeed, it is likely to be confused unless closely examined. It is narrower and a little longer than the other, and may be further distinguished by the absence of the dull white point on the wing. The adults of this insect were commonest in our beet fields in July, the earliest fully developed specimens being noticed June 25th. From July onward the number gradually diminished until October 3d, when the last of the species were seen. In Colorado full grown specimens have been taken from May 14th to August 24th, mostly in late July and early August. It occurs throughout Illinois and is reported from New York, Colorado, and Utah.*

The Garden Flea-hopper.

Halticus uhleri Giard.

This important injurious insect has been treated at some length by Chittenden,† and we have but little to add to his account except to record it as a common beet insect in Illinois in company with the "false flea-hopper" above mentioned. It has occurred especially in our collections on clover, pigweed (*Amarantus*), and beets. It is injurious, according to Chittenden, to beans, peas, egg-plants, chrysanthemums, and a large number of common weeds. The visible result of its work is a deadening and whitening of the leaf where the beak is inserted to pump out the sap, the leaf becoming finely mottled with white whenever the injury is considerable.

It is a tiny insect, about a sixteenth of an inch long, shining black sprinkled with minute tufts of short yellow hair which may be easily rubbed off. The cuneus of the wing is minutely tipped with dull white in the long-winged form. In the short-winged form the wings are uniform black and destitute of the membrane, and do not cover the tip of the body. The species can be most readily distinguished from *Agalliastes associatus* by the shorter, broader body, which has an oval outline, that of the other species being relatively slender, with parallel sides. The adults appear rather early as a rule, occurring in the beet

*Popenoe has reported what is probably this species as associated with the garden flea-hopper in Kansas. He reports his specimens, on Uhler's authority, a s*Agalliastes bractatus* Say; but as Say's *Capsus bractatus* is a *Halticus* close to *uhleri*, this is probably a slip of the pen.

†Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., p. 58.

field about the middle of May, becoming abundant in July, and continuing until October. Chittenden suggests that there may be two broods

Fig. 17. The Garden Flea-hopper, *Halticus uhleri;* *a*, short-winged female; *b*, long-winged emale; *c*, male; *d*, head, side view, showing beak. (Chittenden, U. S. Dept. of Agriculture.)

in a season, the species passing the winter in the egg. We have never obtained it in our numerous winter collections, and this surmise is probably correct.

The Dusky Leaf-bug.

Plagiognathus obscurus Uhler.

Although this is a fairly common Illinois species, it has not often been found by us on beets. It is a small, funereal, faded-black insect, shaped like the very abundant tarnished plant-bug but of much smaller size. It is generally distributed over the United States east of the Rocky Mountains, and is recorded from a considerable variety of plants. Its time distribution in our collections indicates the development of two separate broods and hibernation in the egg. Over fifty lots have been collected by us, and all occurred either between June 14th and July 20th or between August 14th and October 8th, with the exception of a single collection made November 1st.

The Green Leaf-bug.

Macrocoleus chlorionis Say*.

(Pl. IV., Fig. 1.)

Except the tarnished plant-bug, this little grass-green insect is the commonest leaf-bug on the sugar beet in Illinois. Young were taken on beets in the latter part of June, and in July it was mostly adult. It was at this time very common in beet fields, flying up from the larger plants whenever these were disturbed. Later it became less abundant, and by September 1st had almost disappeared, although occasional specimens were taken on beets as late as October 10th. A common whitish mottling of the leaves was attributed by us to the abundance of this leaf-bug. It seems to have a special liking for the beet, as we have not found it common on other plants although we have taken it in small numbers at many localities in central and southern Illinois. It is nearly a uniform green, the thorax only a little darker, the legs and antennæ yellowish, and the eyes and the tips of the antennæ blackish. The wing membranes are dusky and the upper surface of the body is sparsely covered with short black hairs. It is to some extent nocturnal, and it has been taken by us at electric lights.

Garganus fusiformis Say.

Very little is known of the habits of this handsome and not very common leaf-bug. It was taken by us on sugar beets in September, and the adult has occurred elsewhere in our collections from June 10th to October 8th. It is widely distributed over the eastern United States.

Eccritotarsus elegans Uhler.

This beautiful little capsid is comparatively rare, but as two-thirds of the specimens in our collections were taken on sugar beets it is deserving of mention here. It is reported from Illinois, California, Texas, and Kansas.

The Tarnished Plant-bug.

Lygus pratensis Linn.

Chief among the leaf-bugs is this very abundant and widely distributed insect. It is nearly a quarter of an inch long, brassy brown, minutely and variably streaked and spotted with yellow, often with black marks on the thorax which are darkest and thickest in front. The young are greenish, of course without wings, the older of them with two pairs of round

*Mr. Ashmead has informed us that specimens sent him by us represent a new species of the genus *Macrocoleus;* but among Say's unrecognized descriptions of *Capsidæ* is one of *Capsus chlorionis* (Leconte edition, I., p. 346) which sufficiently characterizes our specimens to warrant the adoption of his name for the species. The coloration of our specimens and the relative lengths of the antennal joints are exactly as described by him.

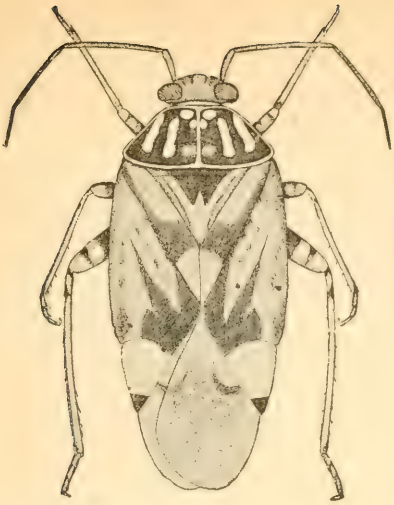

Fig. 18. The Tarnished Plant-bug, *Lygus pratensis*, adult.

black dots on the back of the thorax and one dot on the abdomen. It swarms on nearly all kinds of cultivated plants, flying up readily when disturbed. It is very common in beet fields, where every observing fruit-grower must have noticed it, and frequently occurs at electric lights. These insects have been accused of manifold injury to a variety of fruits and plants, but notwithstanding their abundance in beet fields no well-marked injury to beets has been traced to their presence. It is not impossible, however, that the mere drain of their appropriation of the sap of the plant may be burdensome to it while it is laying up its enormous store of nutrition in the root.

This species is found during the winter in sheltered situations, under boards, beneath the basal leaf tuft of the mullein, dead grass, beds of leaves, and the like. At this season most of these leaf-bugs are adult, but a few young may sometimes be found among them. They emerge with the first warm days of spring and lay their eggs about the plants on whose sap they are feeding. The young of the year appear late in April or early in May, and the earliest mature in the latter month, at which time all ages are to be found together. The successive broods have not as yet been distinguished. They continue active and abundant until the approach of frost, when their breeding ceases and the remaining young mature for hibernation.

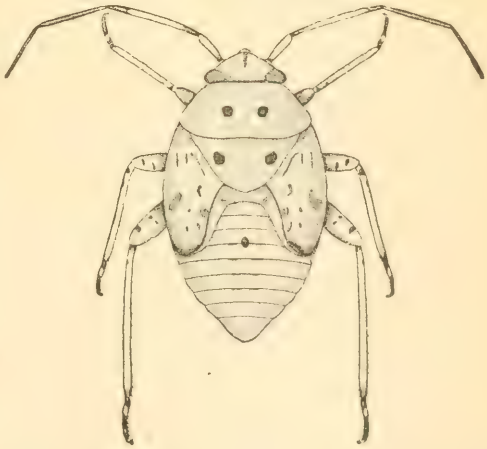

Fig. 19. The Tarnished Plant-bug, *Lygus pratensis*, nymph.

The burning of vegetable trash, especially in cold weather, when insects are sluggish, will destroy many of this species, and a spray of

some suitable kerosene mixture will be found an effective means of attack if this should become necessary on the beet.

The Dusky Leaf-bug.

Calocoris rapidus Say.

This insect is similar in form and size to the preceding, being, however, longer and a little narrower. It is blackish brown with a very narrow yellow border at each side, the prothorax yellow and red with a central black cross-bar, often divided. The antennæ are conspicuously barred with black, yellow, and red. The young are pale green, with

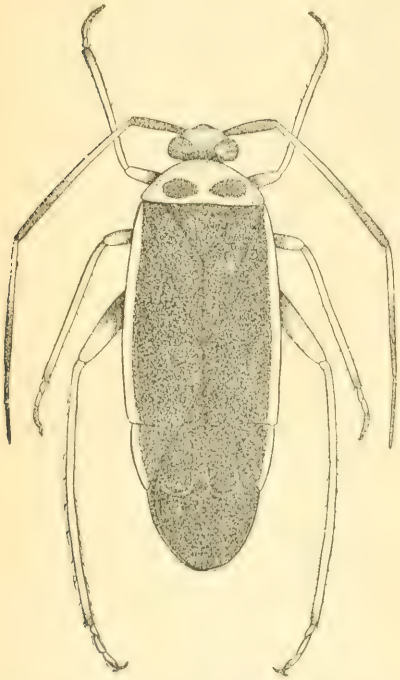

Fig. 20. The Dusky Leaf-bug, *Calocoris rapidus*, adult.

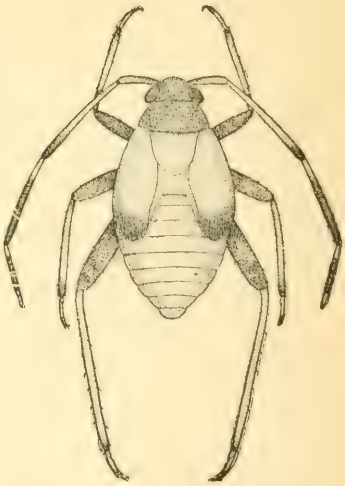

Fig. 21. The Dusky Leaf-bug, *Calocoris rapidus*, nymph.

much of the head, most of the prothorax, the thighs, and the middle of the abdomen red. Their antennæ are red ringed with white.

This is a common species, less abundant than the tarnished plant-bug, but extremely like it in its economic relations. It continues throughout the season until October.

Hadronema militaris Uhl.

An inhabitant of the country west of the Mississippi, reported by Bruner as very common on beets in some localities in Nebraska in the

latter part of July. The adult has been taken in Colorado from June to September. It infests pigweeds (*Amarantus*), and hence probably its liking for beets.

THE SMALLER PLANT-BUGS.

Lygæidæ.

The species of this large and important family have a hard and brittle cuticle, with colors usually varying from grayish to black and seldom marked with red, green, or yellow. The membranous tip of the anterior wings has four or five unbranched veins, some of which usually start from a single closed cell at the base. Although this family contains some of the most destructive agricultural species,—the notorious chinch-bug among them,—its injuries to the beet have hitherto been insignificant, at least in Illinois. The frequency with which adults of this family have been taken in the winter warrants the assumption that they hibernate as a rule in the imago stage. The young are produced in spring, and the adults become relatively more abundant with the progress of the season, although no general statement can be made concerning the number of broods annually.

Six species of this family are on our list of beet insects, and doubtless others will be added after further studies in the field. Owing to their generally similar pepper-and-salt coloration they are distinguished to an ordinary observation with considerable difficulty—a fact of no practical importance, since whatever the species the injuries are essentially the same. Some of the most noticeable differences of those hitherto observed on the beet may, however, be indicated for the benefit of the student of the insect enemies of this crop.

Our beat-leaf species belong to four genera. They are of similar size, ranging from one-eighth to three-sixteenths of an inch in length. *Emblethis* and *Sphragisticus* (Fig. 22, 23) have an even, long-oval form, the outlines of the thorax flowing without break into those of the abdomen, both laterally and dorsally. The second of these two genera is pale gray and black with the gray more or less sprinkled with black dots. *Geocoris* and *Nysius* (Fig. 24, 25) are colored like the above, but the thorax and abdomen are more distinct, with a break in the outline at their juncture. *Geocoris* (Fig. 24) is easily distinguished by its very large head and eyes, together equal in breadth to any other part of the body. *Emblethis griseus* (Fig. 22) is dull grayish brown with black points or dots and yellowish legs. *Sphragisticus nebulosus* (Fig. 23) has the head and front part of the prothorax dull black, the hinder part of the prothorax and the leathery part of the wings gray sprinkled with black points, and the wings also with some black spots. The membranes of the wings are whitish. *Geocoris bullatus* (Fig. 24) is gray with some

black spots, the thorax and wings with black points, and the antennæ black. *Nysius angustatus* (Fig. 25) is gray with black dots and points and some dark marks along the line of union between the leathery part and the membranous part of the wings.

Emblethis griseus Wolff.

(*E. arenarius* Fieber.)

This species occurs, according to Bruner, in Nebraska on the white pigweed and on beets and has been found about the roots of stink-weed (*Eragrostis major*). It is found in Illinois and several other American states from Nevada to Massachusetts, and occurs also in Europe. It is recorded from Colorado at various dates from February 19th to August 6th.

Fig. 22. *Emblethis griseus*, adult. (Bruner.)

Sphragisticus nebulosus Fall.

(*Trapezonotus nebulosus* Fall.)

This insect has been found, according to Bruner, on beets and quite commonly also on other plants of the beet family, but is especially abundant on the white pigweed. It is abundant in Illinois and is extensively distributed over the United States, British America, and Europe. Bruner has recorded (U. S. Bull. 22, p. 95) an unusual outbreak of this species in company with the large-eyed plant-bug (*Geocoris bullatus*) and the false chinch-bug (*Nysius angustatus*) in the neighborhood of Lincoln, Nebraska, on land which had been allowed to grow weeds during the latter part of the season preceding. The following spring was dry, and swarms of these insects injured seriously what foliage appeared, especially that of grape-vines and various cultivated trees. Gillette and Baker in their "Hemiptera of Colorado"* give dates for the adult in that state ranging from February 9th to September 2d. We have found it in December in Illinois.

Fig. 23. *Sphragisticus nebulosus*, adult. (Bruner.)

*Bull. 31 (Tech. Ser. No. 1), Col. Agr. Exper. Station, p. 25.

The Large-eyed Purslane Bug.

Geocoris bullatus Say.

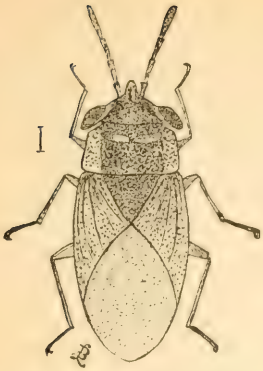

Fig. 24. The Large-eyed Purslane Bug, *Geocoris bullatus*, adult.

This species ranges from Canada to the Rocky Mountains. It is common in Illinois on sugar beets, but is especially abundant west of the Missouri River, where it seems to be one of the commonest insects of the sugar beet. It apparently prefers purslane, but it is common on the pigweeds (*Amarantus* and *Chenopodium*) and on smartweed and other weeds as well. Its injuries to grapes and small trees have been mentioned in the preceding paragraph. It is sometimes called the ground-bug because of its habit of collecting under low-spreading plants and running over the surface of the ground.

Geocoris pallens Stål.

This western species, closely related to *G. bullatus*, is reported by Gillette and Baker* to have been taken on sugar beets in Colorado. Their collections of the imago were made between May 7th and August 24th.

Nysius minutus Uhl.

This insect is said in Gillette and Baker's "Hemiptera of Colorado" to be common from that state to the Dakotas, and to occur also in California and Texas and in some of the Atlantic states. It was taken from June 4th to October 15th on sugar beets, *Bigelovia*, and mustard, being especially injurious to the last-mentioned plant.

The False Chinch-bug.

Nysius angustatus Uhl.

This destructive species is widely distributed, attacks freely many cultivated crops as well as weeds, and not infrequently makes a destructive attack on plants of economic value. It commonly does its most serious injury in spring, especially in dry weather, the hungry adults swarming on the young foliage after their fast of hibernation and destroying it before it is fairly unfolded. The late generations produce a less serious effect upon the more abundant leafage of the summer and fall.

Fig. 25. The False Chinch-bug, *Nysius angustatus*: *a*, appearance of injured leaf; *b*, nymph; *c*, adult.

*Bull. 31 (Tech. Ser. No. 1) Col. Agr. Exper. Station, p. 25.

It was especially injurious to corn near New Holland, Illinois, late in May, 1898. It often collects on beets and other garden plants, and injures strawberries, apple grafts, potatoes, turnips, radishes, cabbages, lettuce, and mustard. It is said to prefer plants of the cruciferous family, but purslane is a favorite with it. It is often mistaken for the chinch-bug. It is commonly reported to winter as an adult, and we have taken it under the spreading leaves of dock in December and by sweeping as early as April 11th. On the other hand, both Webster and Osborn have reported the pairing of adults in November, and Mr. Webster believes that he found its eggs at this season under *Euphorbia*, where it had taken shelter. From this he supposes that it probably hibernates in the egg, the young hatching in the spring. Osborn has found the eggs among the blossoms of pigweed (*Amarantus retroflexus*). We have bred the imago by May 16th from young collected May 11th. The number of generations annually is not certainly known, but there are apparently at least two, and very likely three.

If insecticides become necessary for these insects diluted kerosene emulsion may be used. The usual precautions of clean culture and the destruction of rubbish during the fall and winter should of course be taken.

THE SQUASH-BUG FAMILY.

Coreidæ.

Two species of this widespread and abundant family may receive mere mention here because of the possibility rather than the certainty of their being injurious to the beet. *Corizus lateralis*, a yellowish insect about a quarter of an inch long, with small spots on the wings and head, and resembling in shape the common squash-bug, is not even known certainly to feed upon plants. It is fairly common in beet fields late in the season, and the nature of the reports of its occurrence on other vegetation makes it likely that it is of vegetarian habit. *Acanthocerus galeator* is mentioned here because of Bruner's statement that he has found it several times on beets in Nebraska. This is also shaped like a common squash-bug, but is much larger, with greatly swollen thighs and slender tibiæ. The back is brownish gray, and the wing membrane nearly black. It is widely distributed and occurs on various kinds of vegetation, and has been reported as destructive to the orange in Florida.

Corizus lateralis Say.

Too little is known of the habits of this common insect to permit it to be included positively among injurious species, but as it occurs not infrequently in beet fields late in the season together with other species of its genus, it may be mentioned here at least as a hint to the student. Gillette and Baker list several species of the genus found in Colorado

on barley, alfalfa, and various weeds. Webster reports *lateralis* as common on buckwheat, and Uhler found it on rank vegetation at the borders of woods. It inhabits the United States east of the Rocky Mountains, hibernates in the adult stage, and, according to Uhler, is two-brooded, the first generation of adults appearing from late May to early July, and the second from August to October, inclusive.

Acanthocerus galeator Fabr.

(*Euthoctha galeator* Fabr.)

Little has been published of the biological relations of this insect, common in Illinois. It is mentioned here on the authority of Bruner, who reports that he found it several times on beets as well as on the wild cucumber. It has much the form and colors of the common squash-bug (*Anasa tristis*), but is readily distinguished by its greatly swollen thighs and slender tibiæ. Its back is brownish gray, and the wing membrane is nearly black. It is found throughout the United States east of the Rocky Mountains. The eggs, which are attached by one side in irregular clusters to leaves and stems of plants, are of a ruddy, golden color, and of an oval shape, subtriangular in cross-section. The young are purple-black, very spinose, with orange heads and crimson abdomens. We have found this insect on blackberries and raspberries and on forest undergrowth. It has been reported by Hubbard as very destructive in Florida. It seems to hibernate as an adult. It has been taken by us under bark and leaves November 2d, and again April 20th. There is probably but one generation in a year. The greater part of our specimens were taken in June and July, and again in fall.

THE STINK-BUG FAMILY (*Pentatomidæ*).

The Western Green Stink-bug.

Pentatoma uhleri Stål (*Lioderma uhleri* Stål).

Members of the family represented by this species are well known to every one by their broad and flattened form and by their habit of visiting blackberries, strawberries, and the like, upon which they leave a distasteful excretion familiar to all who have eaten those fruits when freshly picked. The present species belongs in the West, from South Dakota to California and New Mexico. It has occasionally become extraordinarily abundant and destructive, attacking cultivated crops almost without discrimination. Corn, wheat, oats, beets, cabbage, and a great variety of garden produce were destroyed by it in South Dakota in 1897,* although it seemed to prefer turnips, radishes, potato blossoms, and young sweet-corn. In Texas it has destroyed entire plantings

*Bull. 57, Agr. Exper. Station S. Dak., p. 36.

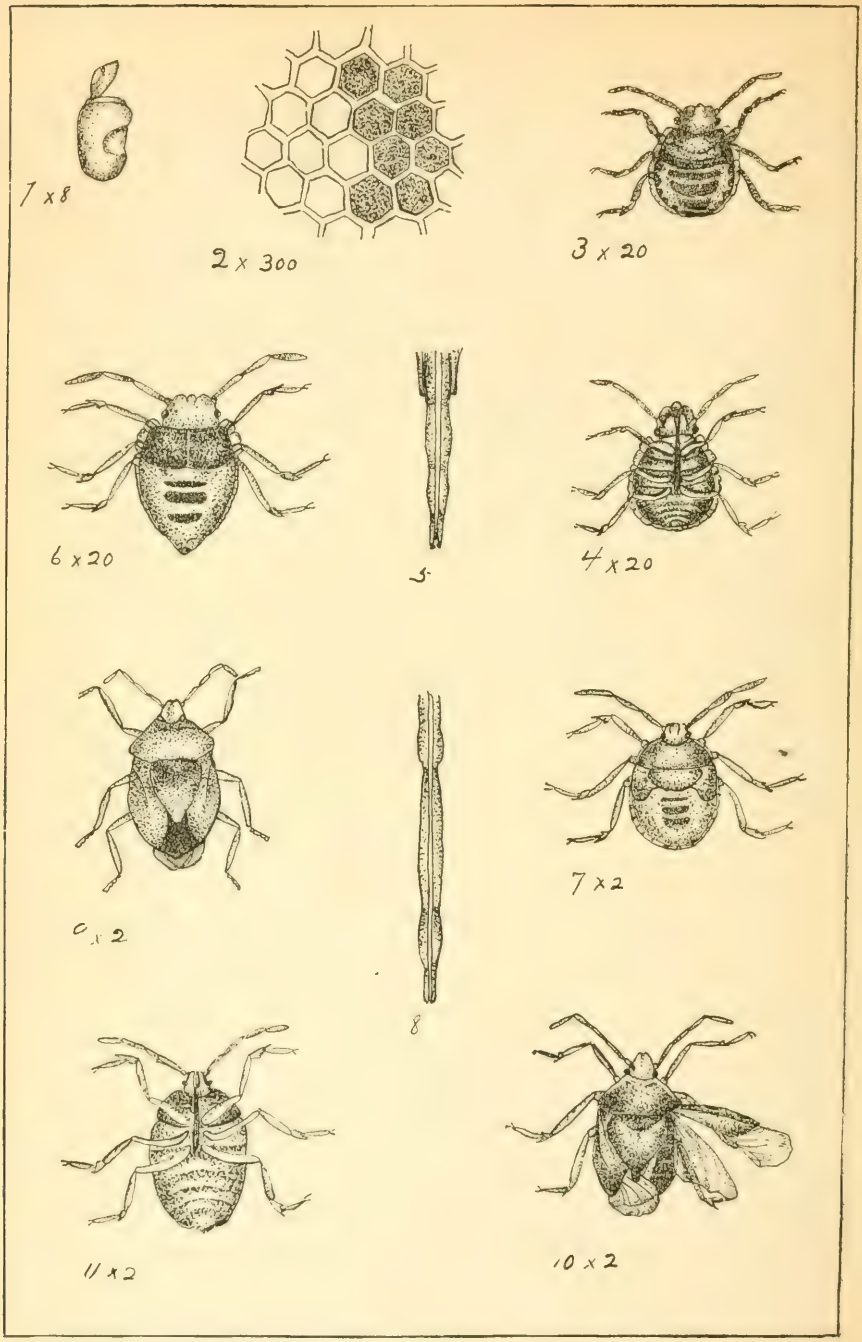

Fig. 26. The Western Green Stink-bug, *Pentatoma uhleri:* 1, egg (enlarged 8 times); 2, surface of egg, greatly magnified (300 times); 3, nymph one week old, dorsal view; 4, same, ventral view; 5, beak of two-weeks old nymph; 6, nymph two weeks old; 7, nymph ten weeks old; 8, beak of adult; 9 and 10, adult, two color-varieties; 11, adult, ventral view. (Saunders.)

of peas and Lima beans, and has been particularly injurious to corn, attacking plants an inch and a half in diameter so heavily as to cause them to wilt and break down. It has become locally very destructive to wheat also, infesting the heads when the kernel is in the milk. At least four thousand acres of grain were thus destroyed in South Dakota.

This insect is irregular broad-oval in form, about half an inch in length by a quarter of an inch wide. During the early part of the season it is uniformly green except the end of the scutellum and a narrow band along the sides of the thorax, which are a light straw-yellow. There are also a few white flakings over the upper part of the body. Later the color changes through light olive to dark red, and, finally, to dark magenta with occasionally one or more indefinite patches of black on the thorax. The eggs are laid in a single layer of from twenty to fifty. They are white and perfectly smooth, the free end opening by a cap-like valve.

The life history of this species has been very well made out. In fall the adults burrow, as a rule, a few inches into the soft earth under weeds and rubbish, sometimes going as far as eight inches under ground, and in one case observed three feet. They have also been found in crevices and under bark, and occasionally in piles of manure. In late March and early April they appear in South Dakota under weeds and rubbish, and in a few days begin laying eggs, which hatch within a fortnight. By the middle of June the half-grown young begin to overspread the fields and injure cultivated plants. By July 10th the adult stage was reached in 1897, and the bugs began to gather on the wheat. About August 1st eggs for a second brood were laid on various plants, especially the Russian thistle, wheat, and corn stalks, the thistles being sometimes conspicuously whitened by continuous layers of the eggs. The adults of this generation commonly hibernate. They have, however, in confinement laid eggs in November of the same year. These facts show clearly the dangerous character of this insect with respect to any vegetation which it freely feeds upon.

THE NEGRO-BUGS (*Corimelænidæ*).

The Common Negro-bug.

Corimelæna pulicaria Germ.

This extremely abundant and widespread little insect, about a tenth of an inch across, nearly hemispherical, shining black, occurs throughout the summer and fall upon a great variety of vegetation, including farm crops and common weeds, and has been occasionally found by us on the sugar beet. It bears a strong general resemblance to the small black lady-bugs, but is peculiar in the fact that the fore wings are reduced to narrow

strips beside the large scutellum, and are marked by a slender line of white. The young are similar to the adults, but with the grayish brown back of the abdomen visible, and the wings, of course, wanting or rudimentary. It is often abundant in grain fields and in grass, but congregates especially upon certain common weeds, the Spanish needle (*Bidens*) being apparently its favorite food. Smartweed, pigweed, and rib-grass (*Plantago lanceolata*) are also much resorted to by it. We have found it on young corn in May doing considerable injury, and also in blue-grass meadows, apparently injuring them. Unlike most equally abundant *Hemiptera* this insect seems to develop but one brood a year. It winters as an adult, begins to breed in May and June, and by the end of July the young are practically all full grown.

Fig. 27. The Common Negro-bug, *Corimelæna pulicaria*, adult, natural size and enlarged.

Substance of leaf or stem more or less eaten away. Injuries by biting insects.

Leaves cut off at ground.

THE CUTWORMS.

Agrotis, Noctua, etc.

The true cutworms, distinguished by the peculiar method of their injury to plants, are well known to all farmers, gardeners, and horticulturists, but the details of their life history, the conditions under which their injuries are most likely to be done, and methods of prevention and remedy will bear frequent repetition. They are all nocturnal in their feeding habits, remaining secreted by day, usually in the vicinity of their food plant. Coming forth at night they eat fresh buds and foliage, cut off young plants and tender stems, often wasting more than they consume. There are several species of cutworms, rarely distinguished by the ordinary observer with any accuracy, most of them plump, soft-bodied, cylindrical caterpillars, dirty grayish or whitish and variously spotted and striped.

Young beets suffer considerably from these pests, which in Nebraska have at times destroyed entire crops, devouring three or four successive plantings before they cease their work. They are essentially grass and clover insects, and by far the greater part of them are bred in pastures and meadows. The life histories of the various species differ considerably. The eggs are laid in summer, as a rule mainly on grass, but, at times, on almost any kind of vegetation growing on suitable ground, and even on trees or vegetable trash or on the ground itself.

The newly hatched larvæ have but four pairs of abdominal legs, and move at first like measuring-worms, acquiring a fifth pair later. When full grown the cutworms most commonly pupate under ground, each forming a smooth, dark brown chrysalis, from which in three weeks or more comes some one of several species of dull brownish or grayish moths about an inch and a half across the spread wings. This hides by day, like the larva, and flies only at night. These insects are usually single-brooded, although some species have two or three generations in a year. They hibernate almost invariably as partly grown larvæ, doing their principal damage to vegetation during spring while finishing their growth.

They are much subject to the attacks of parasites and other predaceous enemies. Tachina flies fasten their white eggs to the back of the larva near the head, and from these the young parasitic maggots penetrate to the interior. Small hymenopterous parasites hatch from eggs deposited within the bodies of the caterpillars, and at maturity leave behind the shriveling body of their host, together with a little tuft of tiny yellow or white cottony cocoons on a blade of grass or the stem of a weed. Larger hymenopterous parasites, such as *Ophion*, also attack them; predaceous beetles, like the caterpillar-hunter (*Calosoma*), destroy numbers of them; and insectivorous birds, especially the robin and meadow lark, greatly aid in keeping them in check. Ground-squirrels also feed freely upon them, thus compensating by their protection of the meadows for their occasional raids upon corn fields in spring.

Common experience enforces the conclusion to be drawn from the foregoing life history, that beets should not be planted on a spring-plowing of sod, since this is very likely to be infested with cutworms, which will commonly continue their attack upon the young crop at least until the early summer months. A sod plowed in late summer or early fall, is, however, commonly free from these insects, especially if it be broken so early as to offer no temptation to the female moths flying abroad in summer in search of suitable situations for the deposit of their eggs. The margins of fields may notwithstanding be invaded, and the crop be seriously injured by cutworms coming in from grass-lands adjacent, and in this case either collecting by hand or poisoning may be resorted to. A very useful poisoned bait for cutworms, and for grasshoppers as well, is made by stirring together fifty pounds of bran and a pound of Paris green, and making of this a rather stiff mash with sweetened water. If a tablespoonful or two of this mixture be placed at close intervals along the rows of beets in the evening, the cutworms will eat it in preference to the living plant, and will thus be killed. Sirrine, of New York, recommends especially a mixture of one pound of Paris green to twenty pounds of a mixture of equal parts of bran and middlings, and this he says is most effective when used dry. About

the same results may be obtained by heavily spraying a patch of clover with Paris green stirred up in water, and then mowing this poisoned vegetation and scattering it here and there among the plants in small bundles or packages.

Only four kinds of cutworms* have so far been reported as attacking beets in America, but it is altogether probable that most of our common species will be found to feed upon them, as upon other vegetation. Two of the above are common Illinois species; the greasy cutworm and the spotted cutworm. The former (*Agrotis ypsilon*—Fig. 30) is a somewhat greasy-looking smooth caterpillar, dirty gray to blackish, with small darker dots and faint indications of a paler stripe down the middle of the back. The latter (*Noctua c-nigrum*—Fig. 28) has a double row of narrow blackish triangles on the back, diminishing in size from behind forwards and usually disappearing before reaching the head. The army-cutworm (*Chorizagrotis agrestis*) varies from light green to dark brown with stripes along the sides. The fourth American beet-cutworm (*Noctua plecta*) is not known to us in the larval stage.

The Western Army-Cutworm.

Chorizagrotis agrestis Grote.

This species ranges from Nebraska and Texas to Arizona and Montana. It attracted special attention in 1897 by a remarkably destructive outbreak in Montana, where it traveled in hordes, like the army-worm, by night, as its supply of food became exhausted†. It practically swept the country clean of vegetation as it went, devouring all kinds of farm and garden crops (including beets) as well as weeds and grasses and the leaves of fruiting shrubs and trees. Immense numbers were drowned in irrigation ditches. One section of a ditch, for example, two hundred and fifty feet long and two feet wide, was filled with a mass of cutworms

*As this article is going to press we notice a report of serious and peculiar injuries to beets by the so-called dark-sided cutworm (*Carneades messoria*), published in Bulletin 42 of the Washington State Experiment Station, in an article entitled "A New Sugar Beet Pest, and Other Insects Attacking the Beet." The writer, Mr. R. W. Doane, says:

"Among the various species of cutworms that frequently do more or less damage to the beets is the dark-sided cutworm (*Carneades messoria*). These are dark, earth-colored larvæ that feed sometimes upon the leaves of the plant, but more commonly on the upper portion of the root. Sometimes the roots are gnawed entirely in two, at other times large, ugly-looking holes are made in the sides, which, if made while the plant is young, either wholly destroys it or causes it to develop into a deformed, ill-looking root. The worms usually feed only at night, lying concealed in the ground during the day. In very badly infested fields we have often found five or six larvæ around a single beet, usually lying quite close to the root, but sometimes a few inches away. When fully grown these larvæ change to brown pupæ from which, some time later, the adult moth emerges.

"The best and often the cheapest way to get rid of these pests is to search them out and destroy them. Where indications of the insect's work are found, the worm itself is almost sure to be found in the soil not far away. As they are unusually near the surface they are not hard to find, and one person can go over quite a large field in a day and destroy nearly all the worms therein. These larvæ are frequently found hid away under loose boards or stones lying about in the fields. This suggests the feasibility of using such things as traps, and very excellent results have been obtained by scattering loose boards around over the field and collecting and destroying any of the worms that use these for their hiding places during the day."

†Bull. Mont. Agr. Exper. Station, No. 17, pp. 10-18.

six to twelve inches deep, and the smaller ditches were sometimes dammed until the water burst the banks, carrying bushels of the still living caterpillars into adjoining fields.

The mature larva is about two inches long, nearly smooth, light green to dark brown with alternating dark and light stripes along the sides. The moth is brown with gray markings, and a wing expanse of about an inch and a quarter. The larvæ hibernate, like other cutworms, partly grown, doing their principal damage in spring, and the moths appearing late in summer and fall. Ditching and poisoning, as for the common army worm (*Leucania*) will, of course, be effective against this western species. A barrier of poisoned clover proved on one occasion to be an efficient means of destroying it.

The Spotted Cutworm.

Noctua c-nigrum Linn.

This insect, common to Europe and America, is best known as a corn cutworm, but destroys also cabbages, beets, and other garden plants. We have bred the moth, in fact, from cutworms taken on beets. The species is double-brooded, injuries of the first generation being practically over by the first of May, and those of the second brood occurring mainly in July and August. The larva is ashy gray or pale brownish, about an inch and a half long when full grown, and marked as in the accompanying figure (Fig. 28). It pupates under ground or in loose cocoons at the surface. The hibernating larvæ begin feeding in April and May, and most of them produce adults in May or early June. A few, however, are said to continue much longer, even as late as August. Larvæ of the second brood begin to appear in the latter part of June, but are most abundant in the following month. This second brood generally becomes adult from late July to September. We have found a single small cutworm of this species on a beet plant June 24th, which became a pupa July 18th and an adult August 8th. There are occasional traces of a partial third generation during the autumn months.

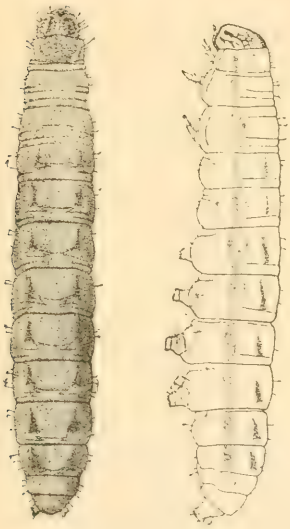

Fig. 28. The Spotted Cutworm, *Noctua c-nigrum*, larva, back and side views.

Fig. 29. The Spotted Cutworm, *Noctua c-nigrum*, adult.

A young specimen taken on violets September 9th was nearly full grown October 1st, when it was accidentally destroyed.

The Greasy Cutworm.

Agrotis ypsilon Rott.

In this larva the cutworm habit is developed to its fullest extent. It is one of our commonest species, and a true cosmopolite, its range extending around the world and including Australia. A partly eaten beet leaf was noticed by us in July, drawn into a crevice in the earth, within which a full grown larva of this species was secreted. It is a general feeder, destructive in gardens, and injurious also to field crops and a variety of fruits, including the strawberry, grape, and apple.

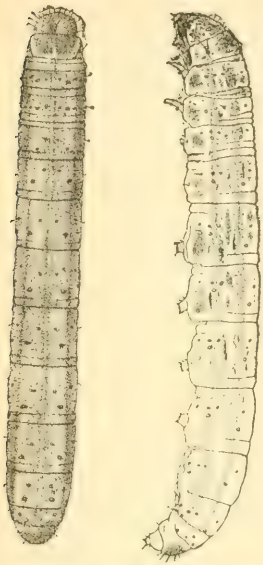

Fig. 30. The Greasy Cutworm, *Agrotis ypsilon*, larva, back and side views.

The pale red, nearly spherical eggs are laid in patches, often two or three layers deep, not always on the food plants of the larvæ. The young are at first semiloopers. When mature they are about an inch and a half long, dirty grayish or blackish, and feebly striped. The dark brown pupa is found in the earth. The life history of this species is not thoroughly known, but there is apparently but one brood each year, with many occasional irregularities in the stage of hibernation and periods of development. The species seems usually to hibernate as a larva, pupating about the first of June, and yielding the moth late in this month and in July, and these moths of summer origin often linger on until October. The hibernating larvæ are seldom found after July 15th. Pupæ have, however, been found in winter, and adults, probably emerging from these, early in spring. It is possible that the discrepancies of this record may be reconciled by the discrimination of one or more additional broods.

Fig. 31. The Greasy Cutworm, *Agrotis ypsilon*, adult.

Noctua plecta Linn.

This European cutworm is widely distributed in the United States from Canada to Texas, and is moderately common in Illinois as shown

by the presence of the moth at electric lights and at "sugar." Its larval habits in this country are entirely unknown, and, indeed, the larva itself has not been recognized by us. It is worthy of mention here, however, because of its injuries to beets in the Old World, where it is reported by Kaltenbach to feed on garden vegetables, including celery, beets, chicory, endive, and lettuce. The moth is a trim little species, slightly more than an inch across the wings, resembling a dwarfed *c-nigrum* except for a well-marked light streak along the anterior border of the fore wings. In this country the insect seems to be two-brooded, like *c-nigrum*, the moths being found in Illinois in the latter part of May and in June, and again in August.

Leaves rolled at edge or folded lengthwise of middle, the rolled or folded portions fastened together by loose webbing.

LEAF-ROLLERS (*Tortricidæ* and *Pyraustidæ*).

The Greenhouse Leaf-Roller.

Phlyctænia ferrugalis Walk (*Botis harveyana* Grote).

No leaf-rollers have hitherto been reported as injurious to the beet, but during the past summer we twice collected from beet leaves a very common greenhouse pest belonging to one of the leaf-roller families (*Pyraustidæ*) and bred these larvæ to the imago of the above species. These insects were obtained from beet fields near Pekin, Ill., and at Urbana. The active rusty brown moths, with wings about three-eighths of an inch long, were also occasionally seen in the same fields.

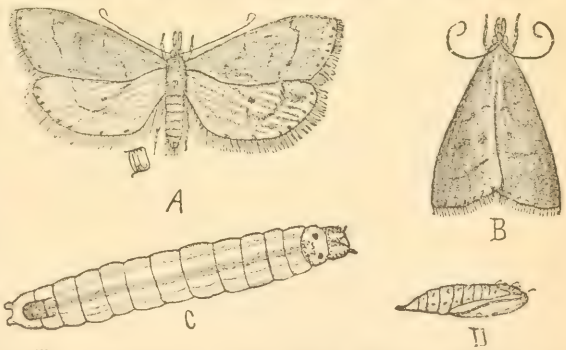

Fig 32. The Greenhouse Leaf-roller, *Phlyctænia ferrugalis: A*, adult, wings expanded; *B*, same, wings at rest; *C*, larva; *D*, pupa. (Davis.)

The caterpillar is translucent green, with white lines on the body and two black dots on the neck shield. It feeds in a loose marginal fold of the leaf, fastened down by a web spun by itself; or sometimes it draws two leaves together, forming a loosely webbed retreat between them. It is said to live, when full grown, in a webbed concavity on the under side of the leaf, but according to our observation this is certainly not always true.

This well-known species is common to Europe and America, and is at times very destructive in greenhouses, where it eats irregular holes in the leaves of various plants. It is also reported by Davis as a celery insect, and by Johnson as injuring young tobacco plants in hot-houses. The strawberry has been mentioned among its food plants in England.

Larvæ found September 2d in Illinois yielded us the adult October 15th, and the moth has been collected by us late in April—facts which indicate the hibernation of this species in the imago stage. The published breeding records of English entomologists indicate a similar hibernation, moths emerging late in October from pupæ formed early in that month. The summer history of the species is not well established, but our own breeding-cage records and greenhouse observations taken in connection with a few scattered published notes indicate the possibility of at least four generations annually.

During the past summer we have several times seen small beet leaves folded along the midrib, and on separating the folds have found a dense silken web forming a somewhat tubular retreat, in which lay a small slender, green, active larva. At least two species of these were recognized, both apparently belonging to the *Tortricidæ*. They were placed in breeding-cages, but failed to mature.

Plant more or less completely covered or inclosed within a loose open web; the leaves eaten by spotted or striped caterpillars.

THE GARDEN WEB-WORMS.

Loxostege and *Hellula*.

Already notorious in the history of beet culture in America are two species of insects belonging to the genus *Loxostege*, both commonly known as web-worms in the Western States, where they are most abundant. They are rather small, smooth, active larvæ, which spin a conspicuous web about the foliage infested by them. They feed largely on garden weeds, such as purslane, lamb's-quarters, and pigweed, but when excessively abundant, as they often are in the West, they may completely destroy beets and other garden vegetables, and a great variety of weeds and cultivated plants.

A third species, the so-called imported garden web-worm (*Hellula undalis*) is especially destructive to cabbages and other *Cruciferæ*. It has lately made its appearance in the eastern United States, and is likely to extend its range.

The eggs of the parent moths of the web-worms are apparently laid upon the plants, above ground. The larvæ make separate webs about

the foliage upon which they are feeding, each with a closely webbed inner retreat for concealment. A single leaf or an entire plant may thus be inclosed. The brown pupa of the native web-worms is formed in an elongate cocoon within a silken tube among the surface debris or in the loose earth beneath the plant. The paler pupa of the imported web-worm is inclosed in a compact white silken cocoon. The moths of these species are small, brownish, buff, or gray, with broad subtriangular wings, and present a triangular outline when at rest. The species seem to hibernate in the cocoon, either as larvæ or pupæ. There are three or more broods in a year, usually becoming more destructive as the season progresses. The numerous dipterous and hymenopterous parasites of these species, together with their other enemies, insect and vertebrate, seem under ordinary conditions to keep them well in check.

The protective web spun by these caterpillars is not sufficiently dense to repel an arsenical spray, and they are consequently easily destroyed and their injuries checked if action is prompt and vigorous. Their attack in the beet field often develops very rapidly, and must receive immediate attention if serious mischief is to be prevented. If beets are to be planted on land previously covered with pigweed, purslane, or lamb's-quarters, it has been found useful to harrow the land thoroughly in fall to uncover the hibernating larvæ and pupæ in their cocoons, and thus to expose them to destruction by the weather and their natural enemies.

Four species of native web-worms have been observed in Nebraska, where these insects have been most extensively studied, three of them feeding upon beets and one on lamb's-quarters and hence likely to feed also upon the beet. Two of these have been well studied; the common web-worm (*Loxostege similalis*) and the beet web-worm (*L. sticticalis*). The first is common in Illinois, although it has never proven very destructive here, and the second probably occurs in the state, although it has not yet been noticed here to our knowledge. Another common species of the genus, *L. chortalis*, occurs also in Illinois, and may quite possibly attack the beet. The larvæ of *similalis* and *sticticalis* are easily distinguished. That of *similalis* (Fig. 33, *a*) varies from pale yellowish to dusky, with symmetrically placed black dots on each segment, and with a pair of narrow pale lines down the middle of the back and one such on each side of the body. The larva of *sticticalis* (Fig. 35, *a*) is darker, the dots are black with white centers, and there are three broad dark stripes above. The larva of the imported web-worm (*Hellula undalis*—Fig. 38, *b*, *c*) is yellowish or grayish, with five well-marked brownish purple stripes above, but no conspicuous dots.

The Common Garden Web-worm.

Loxostege similalis Guen.

(*Eurycreon rantalis* Guen., *Botis posticata* G. & R.)

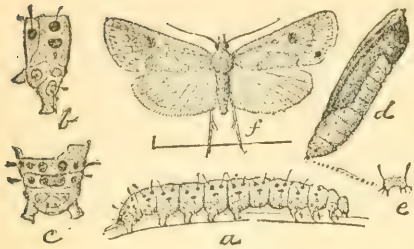

Fig. 33. The Common Garden Web-worm, *Loxostege similalis*: *a*, larva; *b*, middle segment of same, side view; *c*, last segment of same, top view; *d*, pupa; *e*, last segment of same. (Riley, U. S. Dept. of Agriculture.)

This common and widely distributed web-worm breeds largely on pigweed (*Amarantus*) and purslane, but has not attracted especial attention in Illinois by its injuries to cultivated crops. Considerable numbers were present in beet fields last season in this state, however, and a noticeable amount of damage was done.* A full list of its food plants appears in the U. S. Entomological Report for 1885, page 267. Although this species has been most abundant in the region west of the Mississippi, it is distributed throughout the United States and occurs also in South America. It is a common insect in Illinois, and has been reported by Webster as one of the most abundant moths on buckwheat in Indiana. It has been recorded as common and injurious in Mississippi and the Western States, particularly in Nebraska, where it has been a very destructive species, a serious outbreak occurring in 1885 and another in 1892. At both these times this insect destroyed almost all the vegetation which came in its way. The corn crop of the region was seriously injured, and many fields of beets were completely stripped.

The larvæ spin loose but evident individual webs, with usually a single web-worm to each, inclosing more or less of the foliage of the infested plant. On beets a single leaf is often lightly webbed over, with a closer retreat along the midrib where the leaf narrows into the stem. Most commonly, however, especially if the plant be small, the entire base is inclosed in a thin web, with a tubular retreat extending into the loose earth close by. The greatest damage is done within these webs by the eating of the growing bud, thus, according to one beet grower, causing the root to rot in the center above. When very young the larvæ gnaw the surface of the leaves, but later they rag them with large irregular holes, or even devour them almost wholly, leaving a blackened web-covered skeleton.

The eggs of this insect have not been seen by us, and have not been described. They are apparently laid upon the leaves. The larvæ are whitish or dusky, with black dots. They are very active, feigning death

*An attack on soy-beans at Brighton, Macoupin county, Ill., was reported to us by a correspondent, and specimens of the larvæ sent, which we bred to the adult of this species.

when disturbed, or spinning a thread, dropping to the ground, and slipping out of sight in crevices or in the loose earth. Most of the feeding is done at night, the larvæ usually resting in the web by day. The full grown web-worm spins a delicate brownish cocoon within its silken retreat in the earth, and changes there to a brown chrysalis with a pair of terminal prominences each bearing three short spines at the posterior tip of the body. The moth is buffy or grayish, with darker markings as in the figure. Like the other moths of its family it is strongly attracted to lights.

This species seems to hibernate as a moth, and the published data, together with those in our possession, indicate more or less definitely the occurrence of about four generations in a year. The first moths of the season noticed in the West in the latitude of central Illinois appeared late in May and early in June. These probably developed from an unobserved generation of larvæ, the descendants of the hibernating imagos. A brood of larvæ followed in June, becoming adult early in July; and another came about the middle of that month, examples occurring on sugar beets in Illinois July 13th. Larvæ of this brood taken from sugar beets July 26th had pupated July 31st, and a moth emerged August 15th. Adults of this brood have been taken by us abundantly in late July and in August. Larvæ found in Kansas August 11th were thought by Dr. Riley to indicate a fourth larval brood. We have had pupæ and adult larvæ from soy-beans, collected August 27th. These had nearly all pupated by September 4th, and the adults emerged September 10th to 13th. September 1st and 2d, full grown larvæ and moths were very common in our beet fields and also on purslane and pigweed (*Amarantus*). Larvæ put in breeding-cages entered the earth for pupation September 6th to 11th, emerging October 15th to 18th. Some very young larvæ, perhaps representing a fifth brood, were also noticed September 2d. The young web-worm grows rapidly, apparently requiring not more than ten days to mature.

Three hymenopterous parasites have been reared from this species: *Limneria eurycreontis* Ashm., *Agathis exoratus* Cr., and a species of *Pachymerus*. A Tachina fly has been bred from it which appears to be an important parasite. Ladybirds, ground-beetles, etc., also prey upon it.

The Beet Web-worm.

Loxostege sticticalis Linn.

This species suddenly appeared in great numbers in Nebraska in sugar-beet plantations in 1892, causing great destruction to the beet, but not to other cultivated plants. The injury was mainly done within a few days, one plat, for example, losing half its foliage within thirty-six hours after the first signs of injury were noticed. The destruction

was greatest on old beet land and in the middle of large fields where weeds had been most abundant the year before, and especially on sandy soil and comparatively high ground. Another injurious brood appeared

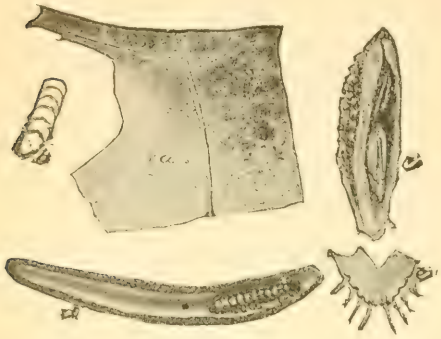

Fig. 34. The Beet Web-worm, *Lexostege sticticalis: a*, eggs; *b*, same, enlarged; *c*, cocoon of pupa; *d*, larval case; *e*, posterior tip of pupa. (Riley, U. S. Dept. of Agriculture.)

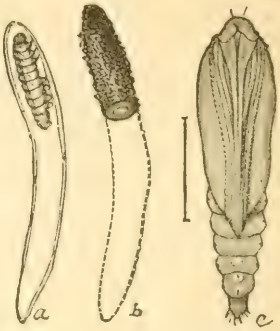

Fig. 36. The Beet Web-worm, *Loxostege sticticalis: a*, larval case; *b*, same, occupied by cocoon of a parasite; *c*, pupa. (Riley, U. S. Dept. of Agriculture.)

later in the same season. The usual food plant of this web-worm is believed to be lamb's-quarters (*Chenopodium album*), and so serious an injury to beets as that described above is altogether exceptional.

This species inhabits Nebraska and adjoining states, and has also been taken in Michigan, but it is not yet known to occur in Illinois. It has been found on *Amarantus* in Kansas and Nebraska, and on tansy in Michigan.

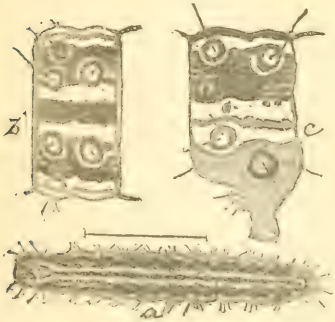

Fig. 35. The Beet Web-worm, *Loxostege sticticalis: a*, larva; *b*, an abdominal segment of same, top view; *c*, same, side view. (Riley, U. S. Dept. of Agriculture.)

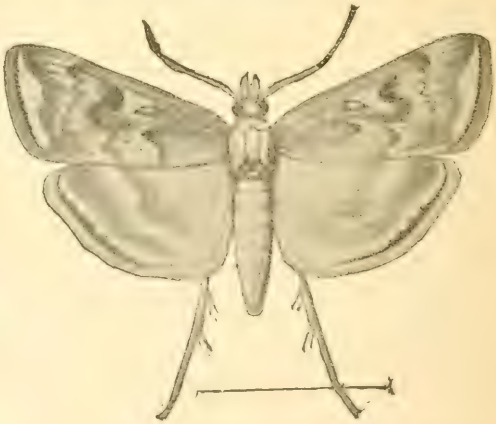

Fig. 37. The Beet Web-worm, *Loxostege sticticalis*, adult. (Riley, U. S. Dept. of Agriculture.)

The pale yellow, very flat, circular eggs are attached to the leaf surface singly or in an overlapping row of two to five or more. The caterpillar, we are informed by Prof. Bruner, does not web the vegetation together so freely as does that of the garden web-worm. Besides the loose cover to the leaf or plant it makes a tubular silken burrow in

the earth or in the surface debris at the base of the plant, and when full grown constructs within this a thin cocoon about twice its own length, —or, in the case of hibernating larvæ, about thrice its length,—in which it changes to a dark brown pupa, this stage lasting about two weeks. The larvæ of the last brood winter in their tubular retreats, changing to pupæ the following May, and soon after emerging as moths. A June brood of larvæ, not yet observed and probably not abundant, must come from these moths, in turn becoming adult, this brood of moths producing the destructive Nebraska brood of 1892, which was at its worst during the third week of July. A presumptive third brood of larvæ reached its maximum that year about the end of August, and entered the ground for hibernation. A few of these larvæ gave origin to the moth in September and October, and these may exceptionally produce a fourth larval brood. In Michigan tansy patches a brood of larvæ appeared in August, probably corresponding to the second or late July brood in Nebraska, the third brood following in the latter part of September. These changed to moths the following May in breeding-cages.

The species is unusually subject to parasitism by several species of *Hymenoptera* and at least one of *Diptera*.

The Imported Garden Web-worm.

Hellula undalis Fabr.

This garden pest is especially destructive to cabbages, turnips, and other *Cruciferæ*, but is also reported as feeding on purslane and as attacking beets. It was first known to occur in this country in 1895, when it was found very destructive to cabbage in the vicinity of Charleston, S.C. In 1898 it appeared near Augusta, Ga., causing a loss variously estimated at from $15,000 to $50,000.* It inhabits Asia, southern Europe, and Australia, and is obviously of European importation, doubtless of comparatively recent date. The moth is also said to have been collected in southern California, and perhaps in Texas. It is seriously injurious in South Carolina, Georgia, and Alabama, and has also ap-

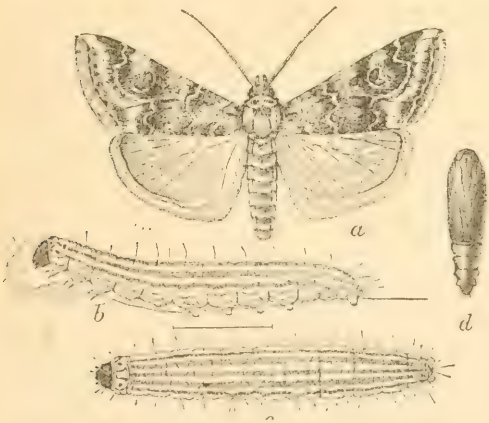

Fig. 38. The Imported Garden Web-worm, *Hellula undalis: a*, adult; *b*, larva, side view; *c*, same, top view; *d*, pupa (Chittenden, U. S. Dept. of Agriculture.)

*Bull. No. 19, N. S., U. S. Dept. Agr., Div. Ent., p. 52.

peared at Los Angeles, California. As it is of tropical and subtropical distribution mainly, it does not at present threaten serious injury in the great beet-growing districts of the country. Its injuries to cabbages in Georgia were apparently increased by the slow growth of vegetation due to a rainy and backward season. The egg being laid in the heart of the growing plant the hatching larvæ are generally carried out upon the unfolding leaf, but on the occasion referred to the growth was comparatively slow, and the larvæ consequently frequently attacked the heart of the plant with destructive effect.

The eggs hatch in from ten to fourteen days. The narrowly striped full grown larva is half to two-thirds of an inch long. It spins a web about itself, extending this with its own growth. In breeding-cages the pupa was formed in a rather compact white silken cocoon about three-eighths of an inch long. It is three-tenths of an inch in length, light yellowish brown, with a pruinose surface bloom and a median dorsal stripe. The adult is about five-eighths of an inch across the expanded wings, grayish, with whitish and blackish lines in patches. The principal injuries seem to be done during the latter part of the year, in August, September, and the fore part of October. In breeding-cages moths have begun to emerge November 21st—a fact which would seem to indicate hibernation as an adult. The number of generations annually is unknown. The larva is parasitized by a Tachina fly (*Exorista piste* Walk.) and probably by an ichneumon (*Limneria tibiator* Cr.).

It is evident that this species can be easily transported, especially on cabbage, either in egg, larval, or pupal stage, and it is practically certain, consequently, to extend its range according to its capacity to endure our climate. As it is a southern species in the Old World, it will perhaps not become general in the United States.

Leaves riddled by small holes usually more or less definitely circular. Many small hard-shelled leaf-beetles present.

THE LEAF-BEETLES.

Chrysomelidæ.

(Pl. IV., Fig. 2; Pls. V. VIII.; Pl. IX., Fig. 1.)

The adults of several of the species of the great family of leaf-beetles feed upon beet leaves and are commonly present in beet fields in sufficient number to make them a prominent feature of the insect life of the crop. Most of these species pass the larval stage on the roots or leaves of other plants, infesting the beet, with various other kinds of vegetation, when they become adult. There are a few species, however, which live upon the beet as larvæ also, and one of these at least is a beet pest of the first importance.

The beet leaf-beetles vary in size from small to minute. The wing-covers are often longitudinally striped, or in a very few cases spotted, and still other species, especially the smaller forms, have a uniform metallic luster—bronze, green, or black. The leaf-beetles should be carefully distinguished from the beneficial ladybugs (*Coccinellidæ*), of similar form and size and also often abundant upon the beet leaves. The latter have wing-covers either plain yellowish or spotted with black, or, in the smaller forms, plain black, often with red or white spots.

The leaf-beetles commonly riddle the leaf with small holes, and if abundant may seriously injure the plant or even destroy the crop when it is still young. Often the injury does not extend at first entirely through the leaf, the epidermis of the opposite side being left unbroken, but this soon shrivels and breaks away and a perforation results. This is usually the case with young larvæ or with the smaller flea-beetles. The holes made by the cucumber beetles and their allies (*Diabrotica*) are more irregular than those made by flea-beetles, the latter being small and approximately circular. If the injured leaf be young the holes increase with its growth, and also change form, becoming longer in the direction of its length. They are sometimes so numerous as to pepper the leaf thickly as if it had been riddled by fine shot, and as they increase in size the substance often breaks away between them, making large irregular openings.

The numerous species of this family which breed on cultivated plants other than beets are not likely to injure beets seriously except in the immediate vicinity of such plants. Those which breed on weeds are more likely to be injurious, especially in weedy fields. Those which breed on the beet leaf itself have rarely been destructively abundant on that plant, but are liable to become so at any time.

Since all these insects, in both the adult and larval stages, feed exposed upon the surface of the leaf, biting and devouring the substance of it, they may be destroyed by the ordinary insecticides, especially the arsenical sprays. The main difficulty in the application of these is their liability to run off the smooth surface of the leaf, but this may be prevented in great measure and the efficiency of the insecticide increased by a combination with the Bordeaux mixture, as described on another page.* Professor Garman, of Kentucky, has found, indeed, that Bordeaux mixture alone is an efficient insecticide for certain of the flea-beetles.

The most serious damage by insects of this class is done when the beet is very young. Here spraying is obviously futile, since the leaves would be eaten before the insects were thoroughly poisoned. This crisis may often be avoided, however, by early planting and active cultivation, pushing the plant rapidly forward before the attack is fully developed.

*See p. 401.

The eggs of insects of this family are laid either upon the leaves of the plant infested by the larvæ or on its roots or in the ground close by. The root-feeding larvæ are usually whitish and slender, but the leaf-eating species are darker, shorter, and thicker, and often with the segments strongly marked. The larvæ change to whitish pupæ in the earth, about the base of the plant infested by them. As a general rule the species pass the winter as adults, are found feeding on the leaves in May, and produce larvæ in June, adults from which are present in July and August. Two and even three broods may occur before the end of the season, but in many root-feeding forms there is but one each year. The important genus *Systena* forms a notable exception to the foregoing account, hibernating either as larva or egg, and producing a single brood of adults in summer. *Colaspis* seems to have a similar history to *Systena*, and *Chætocnema* departs from that given above by the fact that its single brood of larvæ appears about a month later.

The greater part of the beet leaf-beetles belong to the group commonly known as flea-beetles because of the expert quickness and energy with which they leap when disturbed. This group can be distinguished from other beetles of the family by the very thick hind thighs, shaped somewhat like those of a grasshopper. Other members of this family fly rather than leap when alarmed, their hind thighs being of ordinary size. The species of flea-beetles infesting the beet are so numerous, the individuals so small, and the characters distinguishing them so technical and obscure, that a discrimination of the species—useless as it is for economic purposes—will not be attempted in this paper. The entomologist interested in specific characters is referred to Dr. Horn's "Synopsis of the Halticini of Boreal America."* Certain of these jumping beetles are, however, so common and occasionally destructive in the beet field that they are deserving of special mention.

The yellow-black flea-beetle (*Disonycha xanthomelæna*—Pl. V., VI.) is one of the commoner beet insects, both larva and adult feeding upon the leaves. It may be distinguished among the flea-beetles by its comparatively large size (its length about a quarter of an inch), by its metallic greenish-blue or black head and wing-covers, with the thorax uniform pale yellowish above and black beneath and the abdomen entirely yellow beneath. A much smaller, also very abundant, species whose injuries in spring frequently attract attention, is the pale-striped flea-beetle (*Systena taeniata*—Fig. 39). This is about an eighth of an inch in length, light yellowish brown in general color, with a broad pale stripe down each wing-cover.†

*Trans. Am. Ent. Soc., Vol. XVI. (1889), pp. 163–320.

†Other species which have been found on beets, many of them more or less injurious, are *Disonchya crenicollis*, *D. triangularis*, and *D. cervicalis*, *Systena hudsonias* and *S. frontalis*, *Phyllotreta vittata*, *P. albionica*, and *P. decipiens*, *Epitrix brevis*, *Crepidodera atriventris*, *Glyptina brunnea*, *Longitarsus melanurus*, *Chætocnema denticulata*, *C. pulicaria*, and *C. confinis*, and *Psylliodes punctulata* and *P. convexior*.

The leaf-beetles which do not have the leaping habit are fewer in number and much more readily discriminated. The two "French bugs" (*Monoxia*), not found in Illinois, are either pale yellowish with indefinite spots (*M. consputa*) or uniform in color but varying from yellow to black, rarely with a more or less distinct pair of dark stripes on the wing-covers (*M. puncticollis*). The beetle of the northern corn root worm (*Diabrotica longicornis*—Fig. 49) is uniform green; that of the southern corn root worm (*D. 12-punctata*—Fig. 45), generally yellow with three cross rows of black dots on the wing-covers, four in each row. The common cucumber beetle (*D. vittata*—Fig. 46 *a*) is striped with black and yellow; and the grape-vine Colaspis (*C. brunnea*—Pl. IX., Fig. 1) is a thick clay-yellowish beetle about an eighth of an inch long, with cylindrical thorax only about half as wide as the body across the prominent shoulders.

The Larger Striped-Flea-beetle.

Disonycha crenicollis Say.

This rather large flea-beetle, about a quarter of an inch in length, striped with pale yellow and black and with a pair of black dots near the middle of the yellow thorax, has been occasionally found by us in the beet fields of Illinois in summer and fall, and has also been seen on beets in Nebraska. It ranges from New York and Iowa to Texas and Mexico. Its larval habits are not known, but those of related species feed exposed upon the leaves of beets and other plants. This beetle also injures strawberry leaves, and it is one of the common melon beetles of southern Illinois. It hibernates as an adult, but the number of its successive broods has never been determined.

The Three-Spotted Flea-beetle.

Disonycha triangularis Say.

(Pl. IV., Fig. 2.)

This beetle is black except the thorax, which is pale yellowish above and bears three small dots arranged as a triangle, the middle one of the three usually very small. It feeds commonly on leaves of the sugar beet in Illinois, on lamb's-quarters, apparently its favorite food, and also on the spiny pigweed (*Amarantus*). It is found throughout the United States and Canada. It hibernates as an adult, occurring not uncommonly in our January collections. We have taken it frequently in July, and occasionally also in late August and early fall. Its life history is not known except by analogy with that of the following species. It occurs throughout the United States east of the Rocky Mountains and in Canada.

The Yellow-Back Flea-beetle.

Disonycha xanthomelæna Dalm.

(*Disonycha collaris* Fabr.)

(Pl. V., VI.)

At any time throughout the season from early spring to fall the beet leaves may become riddled with small round holes usually from an eighth to a fourth of an inch in diameter. This very common injury is most frequently done, according to our observation, by the larvæ and adults of this common flea-beetle of the beet. The adult insect is about a quarter of an inch long, steel-blue to blackish above, with pale yellow thorax without spots; the larva is grayish white, cylindrical in general form, and also about a quarter of an inch long. The segments are strongly marked, each bearing a row of raised tubercles, with a stiff black hair from the tip of each tubercle. The larvæ commonly feed from the under side of the leaf, and drop to the ground when disturbed. When young they merely gnaw the surface, causing discolored spots to appear on the upper side, but when older they eat entirely through the leaf. They are somewhat gregarious, especially when young, keeping together and moving in company from one leaf to another.

The species ranges from the Rocky Mountains to the Atlantic and Gulf coast, and is also reported from Montana and British America. It has been treated as a spinach insect, attacking this plant as it does the beet, and the beetles have been found feeding on lamb's-quarters, pigweed, and a species of chickweed (*Stellaria media*).

There seem to be two broods in a season. The female beetles emerge from their winter quarters in April and May, and lay their eggs in those months and in early June at the bases of the plants infested, on bits of leaf or earth, or even within the earth. The eggs are orange-colored, and placed on end like those of the potato beetle. They begin to hatch in April or May, according to locality, and continue to hatch into June and even into early July. Most of the larvæ of this generation have attained their growth and entered the earth for pupation late in June and early in July, and beetles begin to emerge in about a month from the time of the first deposit of the eggs. Eggs deposited June 20th at Urbana gave origin to the adult July 25th, and others obtained June 27th and 28th yielded larvæ which began to pupate July 15th and to yield adults July 25th. The beetles of the second generation lay their eggs in late July, August, and early September, and the beetles of this second brood mature before winter sets in. Miss Murtfeldt has found the larvæ feeding upon spinach leaves near St. Louis in April and May, the first beetles from these larvæ appearing late in the latter month. In the northern half of Illinois the development is some-

what later. A dipterous parasite (*Hypostena barbata*) was bred by us in June from the beetle.

Disonycha cervicalis Lec.

This species is yellow and black like *D. xanthomelæna*, but differs in the fact that the body is entirely yellow beneath, while in *xanthomelæna* the under side of the thorax is black. It is recorded by Bruner as a beet insect in Nebraska. Although it occurs in Georgia we have not yet seen it in Illinois.

Crepidodera atriventris Melsh.

A tiny clay-colored species, of whose habits little is known. It was found by us on sugar beets in early October, and is recorded by Webster from buckwheat September 7th. It is common in Illinois, where it hibernates as an adult, occurring in our collections in December and March. Our specimens have been taken, however, mainly late in April, in May, and in July.

THE POTATO FLEA-BEETLE.

Epitrix cucumeris Harr.

This very small, blackish, faintly shining, minutely punctured species lives as a larva, so far as known, only on the roots of solanaceous plants (potato, tomato, egg-plant, tobacco, etc.). The beetles are also practically confined to plants of this order for food when these are available, but, nevertheless, infest other plants occasionally. They have been found abundant in Nebraska on the potato, horse-nettle, and on beets, riddling the leaves of all these plants with minute holes. We have taken them several times in small numbers on sugar beets in Illinois. They are also recorded as injurious to celery, sweet-potatoes, raspberry, turnip, cabbage, and petunia, and have been found by us doing much injury to young potatoes by gnawing the sprouts. The larvæ are not leaf-miners, as they are often said to be, but feed upon the roots, being especially injurious to those of the potato, tomato, and egg-plant. They bore into potatoes, often making them "pimply."

There is probably but one brood in a year, the eggs being laid in June, the larvæ feeding in June and July, and pupating in the earth. The adults, issuing in July and August, hibernate, and feed again in spring, disappearing after the eggs are laid in June. They are sometimes parasitized by a hymenopterous insect, probably one of the *Braconidæ*. The proximity of beets to any of the cultivated food plants mentioned above or to Jamestown weed and other wild members of its favorite family would of course expose the beet field to injury by this insect.

Epitrix brevis Schwarz.

(Pl. VII., Fig. 1.)

This very minute, black, strongly punctured flea-beetle is doubtless frequently overlooked on account of its small size. Outside of Illinois it is known to us from Florida, Louisiana, and Texas. It is somewhat common in this state, and many examples have been taken at Urbana in October on sugar beets. It was originally described from specimens taken on the black nightshade (*Solanum nigrum*). The larva probably feeds on roots of *Solanaceæ*.

Chætocnema denticulata Ill.

This flea-beetle is about an eighth of an inch in length and of a uniform metallic bronze color. It feeds principally upon grass and grain, but has been found injuring beets to some noticeable extent in Nebraska and in Illinois. In the Eastern States it has been reported as injurious to broom-corn, millet, and various grasses. On corn, when abundant, it does conspicuous injury, making minute holes, elongate slits, and white streaks on the leaf. We have seen it very abundant on coarse grasses on the banks of the Ohio River opposite Elizabethtown, Ill. It hibernates as an adult and eggs have been obtained from it by us early in July. Its life history is otherwise unknown, the larvæ never having been recognized.

The beetles were found most abundant on broom-corn near Washington, D. C., during the last week in June, the numbers diminishing after the first week in July. About the middle of August adults, probably of the new brood, have been taken by us abundantly in Kentucky, and also at Metropolis, in southern Illinois. It apparently occurs throughout the United States east of the Rocky Mountains, and it is also known from California, Utah, and Montana.

The Corn Flea-beetle.

Chætocnema pulicaria Melsh.

A number of specimens of this minute bronzed species were taken by us on sugar beets in October in Urbana. The species has been known mainly as a corn insect in Illinois, where for several seasons it did considerable injury to the leaves, riddling them with minute holes, causing them to wither, and noticeably dwarfing the plants. It has also been taken on sorghum, blue-grass, wheat, strawberry, ragweed, and horse-nettle, and was found with the species preceding injuring broom-corn at Washington, D. C. It occurs from Pennsylvania and North Carolina to Texas and Colorado, and seems to be especially common in southern Illinois. It hibernates as an adult, and has been found de-

structive to corn in southern Illinois during the latter half of May, the middle of July, and on various dates thereafter up to the close of the season. Nothing is known of its immature stages, but we have found the adult in winter quarters in November.

The Sweet-Potato Flea-beetle.

Chætocnema confinis Cr.

This minute species has been found by us on sugar beets in October, but makes its principal attack on the sweet-potato, morning-glory, and other plants of the order *Convolvulaceæ*. It burrows small channels along the leaf veins, causing the leaves to turn brown and die if the weather is unfavorable, or, if the plants are young, often killing them before they have fairly started to grow. It has been found by Webster very abundant and injurious on corn and wheat. We have seen it riddling the leaves of raspberries with small holes, thus destroying as much as twenty per cent. of the foliage. It is most injurious on low lands and near the winter shelters of the beetles. Nothing is known of its life history except that it hibernates as an adult and appears abundantly in May,—at which time the sexes copulate,—and that it disappears by the first of July but comes in again during the latter part of the month, becoming abundant by August and continuing until the close of the season. It occurs throughout the greater part or all of the United States.

The Smartweed Flea-beetle.

Systena hudsonias Forst.

(Pl. VIII., Fig. 1.)

This beetle is bluish-black throughout, about an eighth of an inch in length, and more elongate than most of the small flea-beetles, approximating in form the cucumber beetles (*Diabrotica*). It occurs everywhere east of the Rocky Mountains. It has been found abundant on sugar beets in New York, and has occasionally been noticed by us on the same plant at Urbana. No serious damage has been noticed, however, the species feeding primarily on smartweed and dock, and also infesting the daisy, fleabane, plantain, ragweed, goldenrod, catnip, *Brunella vulgaris*, and the wild verbenas. The adults of this species are commonest in midsummer, gradually diminishing in number, and wholly disappearing before winter. Although the life history is not definitely known and the immature stages have not been identified, the species is probably single-brooded, the eggs being laid in the fall.

The Red-headed Flea-beetle.

Systena frontalis Fabr.

(Pl. VIII., Fig. 2.)

A somewhat elongate insect, about an eighth of an inch long, with a narrow thorax, resembling the preceding species in form and general appearance, and bluish black like that, except that the head is pale reddish. It has been reported from New York as riddling the leaves of garden beets to an extent to give the field a brownish look. It has also been seen in moderate numbers on beets in Illinois and Nebraska. Other cultivated plants are occasionally infested, unusual injury having been reported to the leaves of the gooseberry, grape, and pear. It is especially a smartweed beetle, but feeds also on lamb's-quarters and on one of the mallows (*Hibiscus militaris*). It seems to be most abundant in August and September, but its life history is unknown. In the single instance of reported injury the attack was arrested by spraying with Paris green.

The Pale-striped Flea-beetle.

Systena tæniata Melsh.

(*Systena blanda* Say.)

This is one of the most abundant and generally injurious of the flea-beetles and infests an unusual variety of plants, most of them abundant weeds. It is very destructive in beet fields especially when unseasonable weather prevents an early and rapid growth of the plant. In 1899, for example, sugar-beet planting was largely delayed in Illinois until the middle or latter part of May. Towards the middle of June, when these later plantings were very small, the adults of this species were emerging in great numbers and, concentrating on the young beets, completely destroyed many fields of this plant, necessitating a second and sometimes a third planting. The beetles commonly do not eat quite through the leaf of the beet, but gnaw pit-like excavations on both surfaces until young plants if severely infested blacken, shrivel up, and disappear, whole fields being thus laid completely bare. If the plant survives, the epidermis of the leaf opposite to the injury dries up and breaks away, a small hole thus resulting. This injury was much greatest, according to our observation, on beets following or adjoining clover sod. The principal damage to beets by this insect was done the third

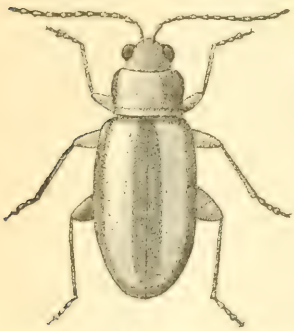

Fig. 39. The Pale-striped Flea-beetle, *Systena tæniata*, adult.

week in June, but some of the fields replanted June 25th were also destroyed.

This species occurs throughout the northern part of the United States east of the Rocky Mountains, from southern New England to Georgia, and is also abundant in the extreme southwest. It has destroyed beets in New York, New Jersey, Michigan, Indiana, Illinois, Nebraska, and Colorado, and has done serious local injury to various other crops including carrots, corn, fruit-grafts, tomatoes, clover, potatoes, melons, beans, strawberries, blackberries, alfalfa, lettuce, parsnip, egg-plant, summer savory, sweet-potatoes, clover, and the cotton plant. Lintner records it as an oak insect, and it is destructive to a great variety of weeds including ragweed, nightshade, pigweed, cocklebur, plantain, purslane, etc.

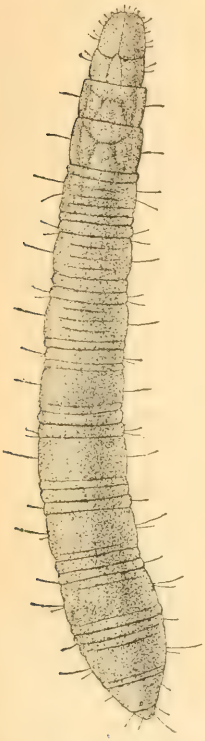

Fig. 40. The Pale-striped Flea-beetle, *Systena tæniata*: larva, top view, greatly enlarged.

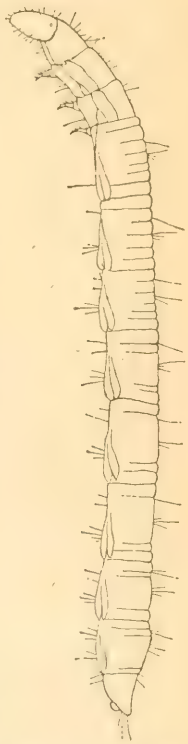

Fig. 41. The Pale-striped Flea-beetle, *Systena tæniata*: larva, side view, greatly enlarged.

Its life history is imperfectly known. All stages of the insect have been found and described, but the number of generations annually has not been ascertained with certainty, and the stage of hibernation is somewhat in doubt. In our own extensive collections the imago of this insect has been very abundant in June and July, especially in the former month, and has gradually diminished in number until September, none appearing later than September nor earlier than June. In many winter collections made for the purpose of accumulating lists of hibernating insects *S. tæniata* has not once occurred. Furthermore, larvæ collected by us from roots of corn in Champaign county, Ill., May 17th had partly, but not altogether, transformed to the adult on the 17th of June, the pupa stage being likewise present at that time. Eggs have been laid, according to Chittenden, from June 10th to July 8th. We find, consequently, at present no satisfactory evidence of more than one brood or of the hibernation of the adult. From the facts now on record it would seem most likely that larval hibernation is the rule; that the June and July appearance of the beetles is due to the development of the adult at that

season; and that the midsummer eggs give origin to the larvæ which pass the winter in the earth. The food plants of the larvæ are doubtless very imperfectly known. Thus far the larva has been found feeding only upon sprouting kernels of corn in the earth and the roots of lamb's-quarters (*Chenopodium*) and *Stramonium* (Jamestown weed). The facts stated above with regard to the relation of this beetle in the beet field to the growth of clover makes it seem likely that the larva may also infest that plant.

The larva is a slender, stiff, sluggish insect, about an eighth of an inch in length, yellowish white, and narrowing gradually from behind forward. The sutures of the thorax form a peculiar X-mark, and the anal segment tapers to a prolonged process with a crown of short spines and four long spinose hairs at its apex.

"The egg is elliptical but somewhat inconstant in outline, about two and a half times as long as wide, and opaque, light buff yellow in color. The sculpture of the surface, as observed under a moderately high power of microscope, appears to be granulated, but under a higher lens it seems to be divided into very minute and rather ill-defined shallow concave hexagonal areas arranged in sevens inclosed in hexagons. Length, 0.60 to 0.68 mm.; width, 0.25 to 0.27 mm." *

Longitarsus melanurus Melsh.

Fig. 42. *Longitarsus melanurus.* (Davis)

These minute brownish elongate flea-beetles, only about a twelfth of an inch in length, were found in small number on sugar beets in Urbana in October. Davis reports it as the commonest of the celery flea-beetles. It occurs from the Dakotas and Canada south to Kansas, Missouri, and North Carolina. It hibernates as an adult, and has been taken by us in that stage from winter quarters November 15th and March 2d. It has been most abundant with us, however, in May, June, and July. The immature stages and life history are unknown.

Glyptina brunnea Horn.

(Pl. VII., Fig. 2.)

This minute brown species, slightly shorter than the preceding, was found on sugar beets in Illinois in July and October, quite abundantly in the latter month. Its known range includes Georgia, Louisiana, and Texas, Illinois, and Wisconsin. Its life history is unknown.

*Chittenden, in Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., p. 24.

The Cabbage Flea-beetle.

Phyllotreta vittata Fabr.

This minute insect, from a tenth to a twelfth of an inch in length, black with two longitudinal yellowish stripes—narrower in the middle and sometimes broken into four yellow spots, is a destructive enemy to cruciferous plants, especially to cabbage, turnips, and radishes. The worst injury is done by the larvæ, which live upon the roots, but the leaves are often very badly pitted or riddled by the beetles. Beets are not injured, so far as known, by this beetle to any serious extent, although the adults occur upon them occasionally in considerable numbers. The species hibernates as an imago, occurring in our collections in November, December, and March. Plants are likely to be injured by them in the latter part of May; larvæ are produced late in May and June; and beetles are developed from these in the latter part of August. The species is doubtless single-brooded, at least in central Illinois.

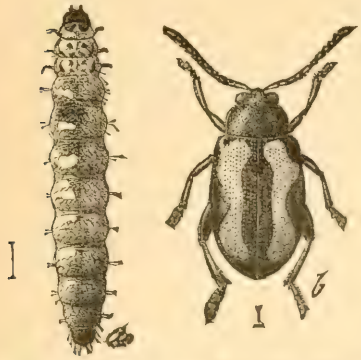

Fig. 43. The Cabbage Flea-beetle, *Phyllotreta vittata*: *a*, larva; *b*, adult. (Riley, U. S. Dept. of Agriculture).

Phyllotreta decipiens Horn.

This is an insect of the far West, inhabiting Washington and Oregon, and reported injurious to beets, radishes, turnips, potatoes, etc., in the latter state. It has the general appearance of *P. vittata*, except that its black color is varied only by a short indistinct yellowish line on each wing-cover, this, indeed, being sometimes wanting.

The Western Cabbage Flea-beetle.

Phyllotreta albionica Lec.

This species is common in Colorado, occupying there the place of *P. vittata* in the Eastern States. The adults are very small,—only about a fifteenth of an inch in length,—black above, with a brassy luster, and without longitudinal stripes. They are reported by Bruner as injuring sugar beets in Nebraska; and by Gillette as infesting cauliflower and other cruciferous plants and the bee-plant (*Cleome integrifolia*). The immature stages and life history are unknown.

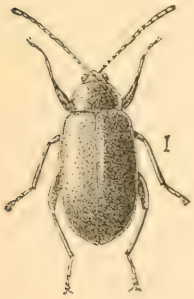

Fig. 44. The Western Cabbage Flea-beetle, *Phyllotreta albionica*. (Riley, U. S. Dept. of Agriculture.)

The Rhubarb Flea-beetle.

Psylliodes punctulata Melsh.

This and the following species are about a twelfth of an inch in length, of a bronzy luster, elongate-oval in form, and readily recognized by the curious mode of attachment of the hind tarsi. *P. punctulata* attacks beet, cucumber, and radish leaves. We have noticed it several times on sugar beets in Illinois, but never in numbers to be seriously injurious. Its favorite food is apparently the rhubarb leaf, in which it burrows small superficial pits about a tenth of an inch in diameter. It is apparently single-brooded, the hibernating beetles appearing in May and disappearing in June. The larvæ are said to bore the stems of succulent plants, but their depredations have attracted no special attention. This species ranges from Canada to New Jersey, and westward to the Pacific coast.

Psylliodes convexior Lec.

The range of this species is more southerly than that of the preceding, extending from the Pacific coast to Florida and the District of Columbia. Like *P. punctulata* it is somewhat elongate-oval, about a twelfth of an inch in length, with a bronzy luster, but broader and more convex than the preceding species. The beetles are said to be very abundant and injurious to beets in parts of Nebraska. They are recorded as injuring corn in Indiana, eating pits in the leaves and not perforating them, and also as feeding on panic-grass.

The European Beet-tortoise-beetle.

Cassida nebulosa Linn.

This is a European beet insect of considerable importance which has lately made its appearance in California as an entomological rarity. If it should maintain itself in this country it is likely to require the attention of beet growers, who should consequently be forewarned against it. Its principal European food is lamb's-quarters (*Chenopodium album*) and other plants of the *Chenopodium* family, but in the absence of these it turns its attentions to beets, sometimes devastating large areas by eating out the parenchyma of the leaf, leaving only the principal veins. In this country it is said to feed on morning-glories, sweet-potatoes, and Irish potatoes.

This species hibernates as an imago, and lays its eggs, in groups of several, in large numbers on the under side of the leaves. The larvæ,—which feed in groups of three or four on the under side of the leaves, riddling them with small holes,—are oval, flat, and spinose, light green with white markings, and with two long tails turned over the back and

supporting a protecting shield composed of cast skins and excrement. The pupa is similar in appearance, but lacks the elongate tails, and is attached to the under side of the leaf. The beetles are turtle-shape, pale rusty brown with dark mottlings. They feed on the upper side of the leaves, gnawing the surface but not eating through the leaf. There are two broods of beetles in a year, one appearing in August and the other in the fall. This beetle is little likely to injure beets if its usual food plants are suppressed in the field.

The Grape-vine Colaspis.

Colaspis brunnea Fabr.

(Pl. IX., Fig. 1.)

This common beetle, ranging from Nebraska to the Atlantic States and Canada, has frequently been taken on the sugar beet in Nebraska and Illinois. It is a very general feeder in the beetle stage, injuring grape, strawberry, beans, buckwheat, corn-silk, clover, willow blossoms, and the leaves and blossoms of many other plants. It is said to begin its injury by making a small round hole, which it enlarges until, perhaps, the entire leaf is eaten. The larva—a whitish cylindrical grub an eighth of an inch in length and with a yellowish brown head—has been found feeding upon the roots of timothy and Indian corn in central Illinois, and is also widely known as a strawberry root-worm. It appears to be primarily a grass-root insect in the larval stage, attacking other crops when these are substituted for grass on infested land. It lives as a beetle during the summer months, ranging in our collections from June 22d to September 14th, but being most abundant in July and August. We have not found it at all in winter even in strawberry beds where it had been previously abundant. The eggs are doubtless laid in summer and fall, and the time at which injury to corn begins indicates the presence of the larvæ in the ground quite early in May. The species is evidently single-brooded, and probably hibernates as a larva partly grown.

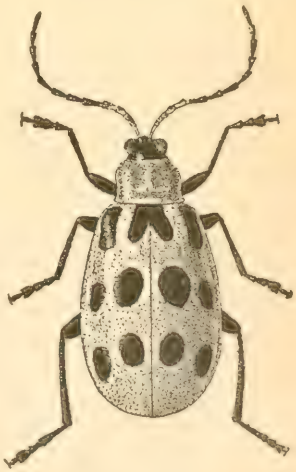

Fig. 45. The Southern Corn Root Worm, *Diabrotica 12-punctata*, adult.

The Southern Corn Root Worm.

Diabrotica 12-punctata Oliv.

This notorious pest includes the sugar beet in its large dietary, which contains also leaves, silk and pollen, and unripe kernels of corn; unripe grains of wheat; petals of various

garden flowers; the leaves of small grain, fruit-trees, garden vegetables, and of some weeds; and, lastly, certain molds. The beetles are common on sugar beets throughout the season, and have frequently been found gnawing away the surface or making irregular holes in beet leaves in Illinois, Nebraska, and Oregon. The larvæ are subterranean, living on the roots of corn, but especially also on those of coarse sedges of the genera *Scirpus* and *Cyperus*.

The life history of this insect is in confusion. The beetle appears in early spring, increases in apparent numbers with the advancing season, becoming most abundant in August, and continues in gradually diminishing numbers until October or November. The data, published and unpublished, in our possession, are insufficient to separate the succession into distinct broods.

The Striped Cucumber Beetle.

Diabrotica vittata Fabr.

This well-known melon and cucumber pest feeds when in the beetle stage on a large variety of plants, among which, according to observations made in the beet fields of Nebraska and Oregon, the sugar beet is

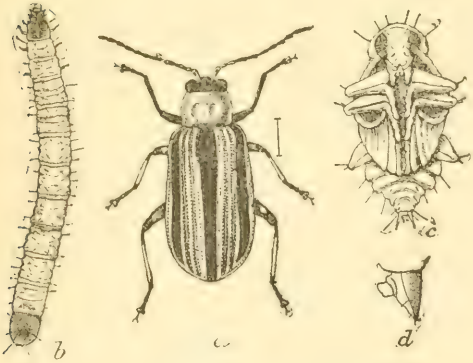

Fig. 46. The Striped Cucumber Beetle, *Diabrotica vittata: a*, adult; *b*, larva; *c*, pupa; *d*, last segment of larva. (Chittenden, U. S. Dept. of Agriculture.)

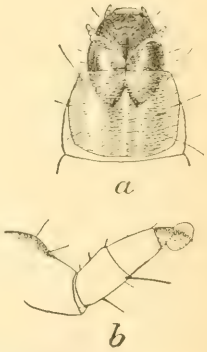

Fig. 47. The Striped Cucumber Beetle, *Diabrotica vittata; a*, top view of head and prothorax of larva; *b*, leg of same. (Chittenden, U. S. Dept. of Agriculture.)

to be included. It is, like the preceding species, subterranean as a larva, feeding in that stage upon the roots of cucumbers, squashes, melons, and other plants of the cucumber family. The adults feed not only on these plants but also on beans, peas, and ripe apples; on the leaves, silk, pollen, and unripe kernels of corn; on the blossoms of fruit-, and other, trees; and on the sunflower, the goldenrod, and other *Compositæ*. We have found them eating the blossoms and riddling the

leaves of the horse-chestnut in early spring. The species winters in the beetle stage, coming out from its hibernation quarters in April or May, and attacking its favorite food plants even before they appear above ground. The beetles of the following brood begin to appear about the second week of July and continue abundant until October. The details of the life history are not clearly known and the number of generations annually has not been definitely determined.

a *b*

Fig. 48. The Striped Cucumber Beetle, *Diabrotica vittata*: *a*, egg; *b*, portion of its surface greatly enlarged. (Chittenden, U. S. Dept. of Agriculture.)

The Northern Corn Root Worm.

Diabrotica longicornis Say.

The grass-green adult beetle of this species is more or less abundant according to the kind of agriculture prevalent, as it breeds, so far as known, only in fields of Indian corn, and becomes numerous there only where the same land is planted to corn for several successive years. It is abroad as a beetle during the late summer and fall, and dies before winter, leaving eggs in the corn field to hatch the following spring. It lives upon a considerable variety of the softer and more succulent vegetable tissues of the latter part of the season. Although it has never been known to eat beet leaves it is frequently seen upon them, especially in the vicinity of corn fields, and the fact that in Nebraska it has sometimes riddled the leaves of radishes and turnips makes it seem likely that a closer observation of it in the beet field would show an occasional similar injury there.

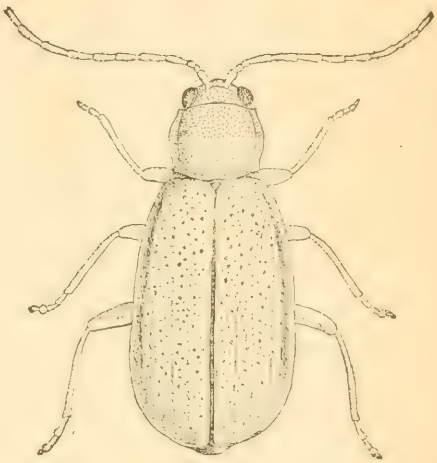

Fig. 49. The Northern Corn Root Worm, *Diabrotica longicornis*, adult.

The French Bugs.

Monoxia puncticollis Say.

Monoxia consputa Lec. (*M. guttulata* Lec.).

Monoxia puncticollis has seriously injured the beet crop in New Mexico. It inhabits seacoasts and inland salty places, occurring along the Atlantic coast, in Texas, and in California, and inland in the southwestern United States as far as Colorado. The larva feeds on the sea-

blite (*Suæda linearis*). A New Mexico correspondent of the U. S. Department of Agriculture, Division of Entomology, * says the beetles lay their eggs on the under side of the sugar beet, these hatching in about six days. The larvæ feed on the beet leaf. Hundreds occurred on a single plant, causing it to shrivel and die. After about nine or ten days, they enter the earth, change to pupæ, and a few days later the beetles appear.

Monoxia consputa injures sugar beets to a serious extent in the West. It ranges from Arizona and California northward to the Dakotas and the northwestern United States. It is quite common on the Pacific coast, and seems to be the most troublesome beet pest in Oregon. These beetles eat small holes in the leaf, sometimes leaving only a network of veins, checking the growth of the beet plants, or killing them entirely. An application that was successful in killing these and other leaf-feeding insects was composed of half a pound of Paris green and three pounds of whale-oil soap in fifty gallons of water. The whale-oil soap was probably necessary to make the spray adhere to the plants.

GRASSHOPPERS.

Acrididæ and *Locustidæ.*

Notwithstanding the abundance of grasshoppers everywhere in beet fields, and the considerable list of species occurring there, their injuries to beets are not usually serious but are mainly confined to fields adjacent to grass lands in which grasshoppers have bred in extraordinary numbers. An instance of injury under these conditions came to our notice in July, 1899. One of the fields of the Illinois Sugar Refining Company, near Pekin, Ill., was considerably injured at this time by the common red-legged grasshopper (*Pezotettix femur-rubrum*—Fig. 55), which ate large irregular holes in the leaves, or cut broad deep notches out of their edges, leaving only the larger veins to hold the leaves together.

The two families commonly confused under the general name of "grasshopper" may be easily distinguished by their antennæ. Those of the meadow grasshopper (*Locustidæ*) are many-jointed, slender, and much longer than the body (Fig. 57, 59) and those of the *Acrididæ* (often called locusts by entomologists) are much shorter than the body and comparatively thick (Fig. 50—56). The female of the *Locustidæ* (Fig. 57) has projecting backward from the tip of the abdomen a compressed sword-shaped organ which is used for placing the egg in or about plants, while the female of the *Acrididæ* has at the end of the abdomen four stout blunt structures with curved tips which, brought together on the middle line, form a thick conical tip to the body, used in forcing the abdomen into the earth for the deposit of the egg mass.

*Bull. No. 18, N. S., p. 95.

The young of both families differ from adults principally in the absence of developed wings.

A few of our grasshoppers hatch in fall and become full grown in spring. Most of them, including all those really injurious to beets, pass the winter in the egg, and, hatching in the spring, undergo their successive molts during the summer, and reach the winged stage in the latter part of the summer and early fall. Most of these summer species continue to feed until cold weather closes their career.

As a general rule, whenever grasshoppers are destructively abundant one year they are present for some years following in insignificant numbers only, a fact explained by the numbers and powers of reproduction of their parasites and other enemies. Late in the season adults are often seen with small, bright red, egg-like bodies attached at the bases of the wings, and sometimes elsewhere on the body. These are parasitic mites, which, like ticks, suck the blood of their insect host in the fall, and, in the following spring, after undergoing a striking metamorphosis, devour the egg masses of the grasshoppers in the ground. Long thread-like, milk-white hairworms (*Mermis*) are often found in the abdomens of grasshoppers, living there as internal parasites, and escaping after maturity to enter the earth, where they pass the winter, pair, and produce myriads of eggs the following spring. The young from these infest the grasshoppers of the year and assist greatly in the reduction of any excess of numbers. Larvæ of a Tachina fly often occur within the body when grasshoppers are very numerous, and every specimen so infested perishes before reproducing. Deadly fungus parasites also infest and kill them, and larvæ of the common blister-beetles devour their eggs in the earth.

If injuries by grasshoppers reach a stage or threaten a result which calls for treatment in the beet field their numbers may best be reduced by poisons mixed with bran mash. For this purpose stir thoroughly five pounds of arsenic into half a barrel of bran (or in this ratio for smaller quantities), dissolve in a pail of water an amount of sugar equal in weight to the arsenic, and stir the sweetened water into the bran, adding more water, as necessary, until a good mash is made. This should then be distributed in handfuls to the part of the field infested by grasshoppers, which will prefer it to the beet itself, for which, indeed, they have no very eager appetite. Injuries by invasion from without should, however, be prevented when practicable by watching adjacent grass lands, and, if grasshoppers appear on them in unusual numbers, by using the so-called "hopperdozer" for their destruction, according to methods frequently published and generally well known. Spring plowing of grass-lands and their subsequent treatment with the disc harrow will effectually destroy the eggs in the earth.

The common short-horned grasshoppers (*Acrididæ*) are thicker

and heavier, and are armed with a thicker crust than the *Locustidæ*, or slender-horned group. The former are usually neutral blackish brown or gray in general color. Some of them have pointed foreheads, the face slanting downwards and backwards. The yellow grasshopper (*Stenobothrus curtipennis*) is an example of this form (Fig. 50). The others have rounded foreheads, with the faces nearly vertical. Among these are two well-marked groups. In one there is a distinct slender conical spine midway between the fore-legs on the under side; in the other there is little or no trace of this spine. The black-winged grasshopper (*Dissosteira carolina*, Fig. 51), known by its black under wings broadly bordered with yellowish, is the only one of the group without the spine which we have noticed frequently in Illinois beet fields. There are other common Illinois species of this group, however, which may yet be found to feed on beets.

Of the remaining genera, those possessing the prothoracic spine, only *Schistocerca*, *Campylacantha*, and *Melanoplus* have been reported from beet fields. *Schistocerca* contains very large species, some of which are common in central and southern Illinois, but the species (*S. alutacea*—Fig 52) known to be injurious to the beet is not often seen in Illinois. It is a brownish yellow species with a pale stripe down the middle of the back, usually much blotched with red on the fore wings and abdomen, and with a closely placed row of red or blackish points along the hinder edge of each abdominal segment, above. *Campylacantha olivacea*, a species with rudimentary wings, is found from Nebraska to Texas. The genus *Melanoplus* contains our commonest grasshoppers. There are five well known species on our list of those infesting the beet, two larger ones (*bivittatus* and *differentialis*), about a quarter of an inch through at the base of the fore wings,—which latter are not evidently dotted with small spots,—and three smaller ones, about an eighth of an inch thick, with the fore wings sprinkled with reddish or blackish dots, at least along the middle. The two-striped grasshopper (*Melanoplus bivittatus*—Fig. 54) has a yellowish line on each side of the back along the angle between the upper and lateral surfaces when the wings are closed. The olive grasshopper (*M. differentialis*—Fig. 53), a very common Illinois species, is a heavy species of a nearly uniform dark olive color. *Melanoplus femur-rubrum* (Fig. 55), the abundant "red-legged grasshopper" of the beet fields, and everywhere else in Illinois, has the shortest wings of the three smaller species, these reaching when closed little beyond the tip of the body; and if the tip of the male abdomen be carefully viewed from behind, it will show a nearly straight upper edge. In the other two small species, the closed wings reach considerably beyond the tip of the body, and the tip of the male abdomen is distinctly notched above. One of these is *M. spretus* (Fig. 56), the Rocky Mountain grasshopper, which has never invaded

Illinois; the other is a moderately common Illinois species, *M. atlanis.*

The meadow grasshoppers are distinguished from the other long-horned green grasshoppers comprising the family *Locustidæ* by the point of the forehead ending in a narrow but very blunt and somewhat wart-like protuberance between the bases of the antennæ. They belong to two genera, *Orchelimum* and *Xiphidium*, corresponding somewhat in size and variety to the two groups of larger and smaller species of the genus *Melanoplus.* These also have a spine between the bases of the fore legs. In *Orchelimum*, this is quite short and the sword-shaped ovipositor of the female is rather broad and noticeably curved (Fig. 57). In the smaller species, those belonging to *Xiphidium*, the spine is long and slender, and the ovipositor is straight or very little curved. The two species of *Xiphidium* on our list are short winged. They may be separated as follows: In *X. femorale* the wings cover about half the length of the abdomen in the female, and two-thirds of it in the male; the ovipositor is much shorter than the body and a little curved throughout; and the terminal points of the male abdomen are straight and usually parallel. *X. strictum* has very short wings, less than half the length of the abdomen, while the ovipositor is very long, exceeding the length of the body. The terminal points of the male curve slightly inwards.

The Yellow Grasshopper.

Stenobothrus curtipennis Harr.

This trim little species, yellowish olive above and yellow beneath, has short narrow wings and yellowish hind legs with black knees. It is quite common throughout Illinois and has been reported among the more numerous species on sugar beets in Iowa. Although wintering as an egg, it matures at an unusually early date the following year, adults having been taken as early as June 23d. It becomes common in July, and continues until October.

Fig. 50. The Yellow Grasshopper, *Stenobothrus curtipennis.* (Lugger.)

The Black-winged Grasshopper.

Dissosteira carolina Linn.

This is a rather large species, very common throughout Illinois, found by Bruner eating leaves of the sugar beet in July. Its mottled brown color, varying to yellowish or gray, often with obscure cross bands on the wings, makes it inconspicuous when at rest, but it is distinguishable at once in flight by its black hind wings strongly bordered with yellow. The median dorsal ridge extending

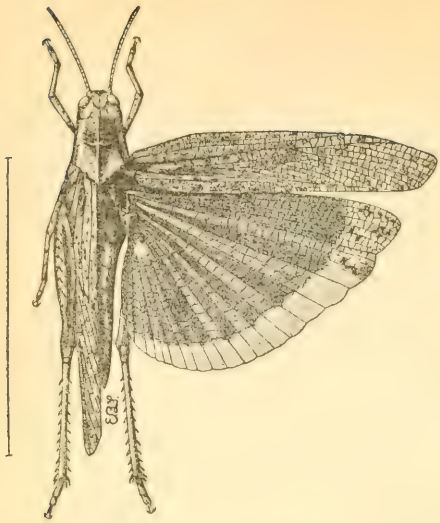

Fig. 51. The Black-winged Grasshopper, *Dissosteira carolina*. (Lugger.)

backward from the head is distinct and sharp, while in our other common species from the beet there is little trace of such a ridge.

This grasshopper matures early, having been taken from June 25th until fall. It pairs early in August and deposits eggs in August and September.

Trimerotropis latifasciata Scudd.

This species has been several times reported as injurious to the sugar beet in western Nebraska, but is not found in Illinois.

Spharagemon æquale Scudd.

This is a widespread insect in Nebraska, where it is reported as feeding upon the sugar beet, but not in numbers to make it especially injurious. It is not known to occur in Illinois.

Schistocerca alutacea Harr.

(*Acridium alutaceum* Harr., and A. *emarginatum* Uhl.)

This species is generally rare in Illinois, becoming more common westward. It is mentioned by Osborn among the grasshoppers most numerous on sugar beets in Iowa. It is found from July to October.

THE LUBBER GRASSHOPPER.

Melanoplus differentialis Thos.

This is a very common and widely distributed grasshopper, its normal range extending from the Pacific to Indiana, and south to Mexico. Its uniform dark olive color and large size, taken in connection with its distinctive features mentioned above, will readily serve to identify it. Next to the red-legged species it is our most injuri-

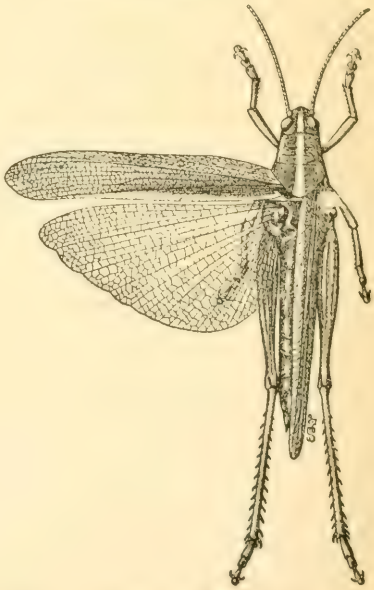

Fig. 52. *Schistocerca alutacea*. (Lugger.)

ous grasshopper. It lays its eggs in damp shady ground during the latter part of the afternoon. As many as one hundred and seventy-one eggs have been counted in a single mass. Sometimes only one such cluster is laid by a single female, but two or even three may be deposited at intervals. The adult stage is reached about the first of August, and the eggs are laid from the middle of August to October.

Fig. 53. The Lubber Grasshopper, *Melanoplus differentialis.*

The Two-striped Grasshopper.

Melanoplus bivittatus Say.

This species, common in Illinois, is confined mainly to the Mississippi Valley, not occurring on the Atlantic or Pacific slopes or in the extreme northwest. It may be recognized at once by the yellowish dorsal stripes on each side of the middle, along the angle between the back and side. It has attacked beets in low grounds or beside rank growths of grass or clover, but has never been seriously injurious to that crop.

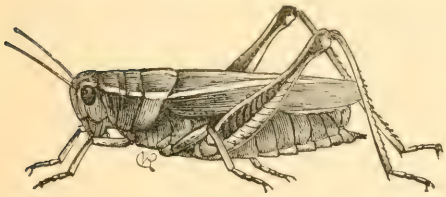

Fig. 54. The Two-striped Grasshopper, *Melanoplus bivittatus.* (Riley, U. S. Dept. of Agriculture.)

The eggs are placed in any compact soil, such as old roads, closely-cropped pastures, and prairie sod. Adults usually begin to appear about July 1st. Eggs are apparently laid in September, and have been observed to hatch in March.

The Common Red-legged Grasshopper.

Melanoplus femur-rubrum DeG.

This is the commonest Illinois grasshopper, and the most abundant of its kind in fields of beets. It closely resembles the western destructive grasshopper (*Melanoplus spretus*), and also another species of the genus (*atlanis*) which occurs in Illinois but which is much less generally known than the other two. The native home of the destructive western grasshopper, or Rocky Mountain locust, is the mountain country of the Rocky Mountain system; *atlanis* breeds mainly

Fig. 55. The Common Red-legged Grasshopper, *Melanoplus femur-rubrum.*

in the lesser mountains and hills of the eastern part of the country; while the present species prefers relatively low and level territory, being also most at home in the eastern part of the United States. The destructive *spretus* never reaches Illinois; the long-winged *atlanis* is common in the hilly region of the southern end of this state; while the shorter-winged, red-legged species is abundant everywhere. It does not tend to migrate in large swarms like both the others, although when very abundant locally, flights to short distances are sometimes made in numbers to suggest the flying swarms of the western locust. A single female red-legged grasshopper may lay approximately one hundred eggs in three or four separate masses, deposited in the ground usually in grass-lands and in the firmer parts of fields, such as paths and roadways and trampled spots in pastures.

This species is single-brooded. Most of the eggs hatch in May, and the young feed and grow through June and July, getting wings about seventy days after hatching. Occasional adults may appear as early as the latter part of June, but the great part of the generation matures in August, and from this time on the perfect insects are most abundant. They continue their depredations until arrested by the approach of winter.

Melanoplus atlanis Riley.

This species inhabits especially the Eastern States, and seems to prefer hilly and wooded country. It is much like the western destructive grasshopper in structure and habits, and in its tendency to migrate when very numerous. It is at times very destructive, especially in New England. It is common in the hilly region of southern Illinois, and is taken at times in other parts of the state. It lays from two to four egg masses and its period of development is about eighty days. The adults are nearly a month earlier in their appearance than those of the red-legged species, being commonest in July and August.

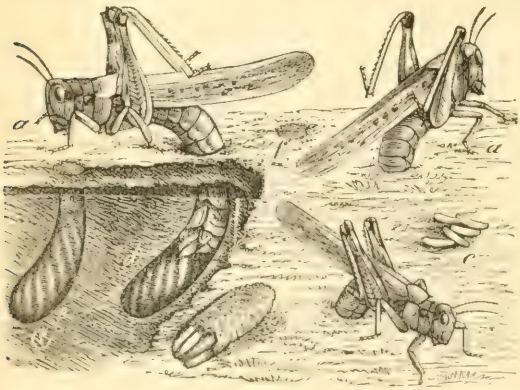

Fig. 56. The Rocky Mountain Grasshopper, *Melanoplus spretus: a, a, a,* females ovipositing; *b,* egg pod removed from ground, with end broken open, showing eggs; *c,* eggs; *d, e,* egg masses in the ground; *f,* egg mass completed and covered up.

The Rocky Mountain Grasshopper.

Melanoplus spretus Thos.

This, the most destructive American species, is so thoroughly well known throughout the region infested by it that its special treatment here is uncalled for, particularly as it does not occur in Illinois..

Campylacantha olivacea Scudd.

(*Pezotettix olivaceus* Bruner.)

This species ranges from Nebraska to Texas, but does not occur in Illinois. It is reported as rare in eastern and middle Nebraska, but it is occasionally found there in beet fields, and also feeding on sunflower (*Helianthus*) and lamb's-quarters.

The Larger Meadow Grasshopper.

Orchelimum vulgare Harr.

This is one of the long-horned species (*Locustidæ*), the commonest of its genus in Illinois. By means of its sword-like overpositor it lays

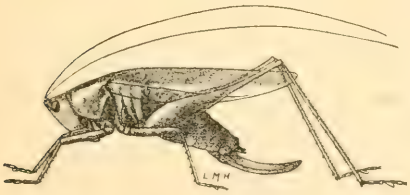

Fig. 57. The Larger Meadow Grasshopper, *Orchelimum vulgare*, female. (Lugger.)

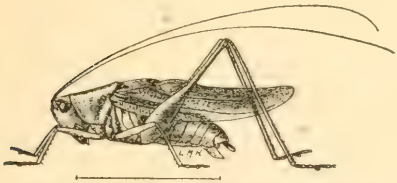

Fig. 59. The Larger Meadow Grasshopper, *Orchelimum vulgare*, male. (Lugger.)

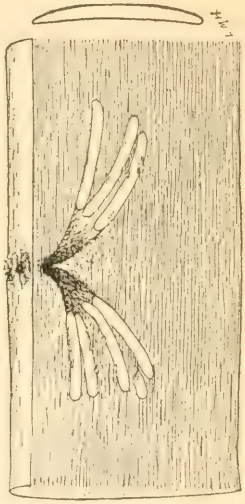

Fig. 58. The Larger Meadow Grasshopper, *Orchelimum vulgare;* eggs in stem of corn tassel, with single egg in outline.

its eggs in the pith of a great variety of soft plants, from one to several in a place according to the size of the stem. The clusters are placed at intervals of about an inch in a single row which usually takes a slightly spiral direction along the stem. The cuticle is torn up with the jaws before the eggs are inserted, a row of roughened fibrous spots thus marking the location of the eggs. These are especially common in corn stalks just below the tassel, or in stalks of weeds, elder twigs, and the like. They are usually laid in the first half of September, but hatch somewhat late in the following season. The young are most abundant in July and August, and adults begin to appear by the end of July. This species seems to prefer upland localities, especially fields of clover and timothy. It has been often seen by us on beets.

The Smaller Meadow Grasshoppers.

Xiphidium.

Specimens of *Xiphidium nemorale* Scudd. were taken on sugar beets in Urbana in October, 1898, and those of *X. strictum* Scudd. were found feeding on beets July 26th and August 19th, young at the former dates and adults at the latter.

*OTHER LEAF-EATING BEETLES.**

Clivina impressifrons Lec.

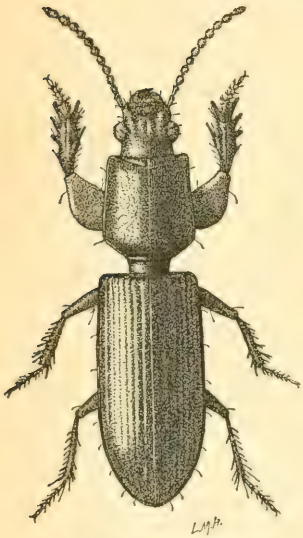

Fig. 60. *Clivina impressifrons.*

This little ground-beetle about a quarter of an inch long, recognizable by the accompanying figure, (Fig. 60), may receive mere mention as a beet insect, having been once seen by us in small numbers enlarging a small excavation on the petiole of a beet leaf. The same species had previously been seen burrowing freely into seed corn in the ground.

The Beet Carrion-beetle.

Silpha opaca Linn.

This insect, a member of a genus, and indeed of a family, nearly all of which feed upon decayed animal matter, is itself a vegetarian, and has become noted in Europe as perhaps the worst insect pest of the beet field. It was brought into America at least twenty years ago, but is still quite uncommon in the United States. It was reported by Dr. Horn from California in 1880, and in 1891 Prof. Bruner found it several times in the beet fields of Nebraska. In 1893 he reported again that it had been several times taken in Nebraska feeding upon beet leaves. In England, France, and Austria large numbers of the larvæ of this species appear in the early part of the season in the beet field eating away the parenchyma of the leaf, usually

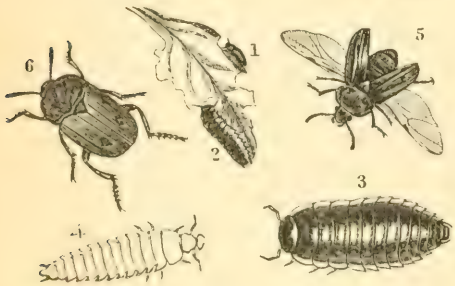

Fig. 61. The Beet Carrion-beetle, *Silpha opaca:* 1, 2, young larvæ feeding on beet leaf; 3, 4, larvæ; 5, adult beetle in flight; 6, adult at rest. (From publishers of Curtis's "Farm Insects.")

*The flea-beetles and a few other beetles doing a similar injury to the beet have already been treated on pp. 112-128.

at night, and leaving only the skeleton of the veins or wholly destroying the young leaves as fast as they appear. The adult insect is black, with nearly parallel sides, the body flat and thin, about three-fourths of an inch in length, with more or less marked parallel ridges on the wing-covers. The scaly looking larvæ taper from before backwards and have something the appearance of the well known sow-bugs or cellar bugs (*Oniscidæ*). The beetles hibernate, and lay their eggs in June, and these hatch in about five days thereafter—in England and France about July 1st. The young mature within a fortnight. In about a month from the time the eggs were deposited the adult beetles emerge.

Silpha bituberosa Lec.

This American species, our nearest ally to the beet carrion-beetle of Europe, is a western and northern species, ranging from the British Northwest Territory as far south as Kansas. In British America the larvæ were seen by Mr. Fletcher in 1893 feeding on a variety of weeds, particularly upon those belonging to the *Chenopodium* family, and also on squash and pumpkin vines. In breeding-cages they ate freely of the leaves of beet and lamb's-quarters, feeding by night and hiding by day.

The larvæ are black and shining, half to three-quarters of an inch long and a fifth of an inch wide, convex above, flattened below, and tapering towards each end. The beetle is dull black, with dusky hairs on the thorax, of oval outline, broader than *S. opaca*, which is a comparatively elongate species. Fletcher found the larvæ living in his breeding-cages from June 5th to July 12th, and adults emerging from July 6th to 24th. Although this species has not yet been known to injure beet plants in the field, the foregoing facts make it an object of interest to economic entomologists engaged in the study of insect injuries to the beet.

BLISTER-BEETLES.

Meloidæ.

This family of insects, readily distinguishable by their elongate-cylindrical bodies, comparatively soft wing-covers, small thorax, and rounded head attached to the thorax by a comparatively slender neck, receive their common name from the fact that when crushed or roughly handled they cause a blister on the skin due to an irritant oil secreted by the beetle. They are best known to ordinary agriculture by their injuries to the tomato and potato, especially to the latter. Previous to the advent of the hard-shelled, thick-bodied Colorado potato-beetle these blister-beetles were the principal insect enemy of the potato, and are frequently referred to now as the "old-fashioned potato-beetle." There are several American species of this family, some striped with black

and yellow, others black or gray, and still others uniformly colored with metallic blue, green, or coppery. They move commonly in companies, devouring their food plants as they go. Their injuries to vegetation are confined to the beetle stage, the food habits of the larvæ being very different from those of the beetle. The young of some species are parasites on bees and eat their eggs and honey, but most of them are beneficial as larvæ, feeding on the egg masses of the grasshoppers buried in the ground. They hatch from eggs laid by the female blister-beetle in small cavities burrowed in the loose ground among grasshopper eggs. Most of them pass the winter in the larval stage, coming out as adult beetles the following summer.

In the beet field these insects may either be poisoned with arsenical applications, killed by knocking them off into water covered with a film of kerosene, or driven out of the field by threshing the infested plants with brush or wisps of straw. Curiously, if the commonest species are subjected to this last treatment they are not likely to return. On account of the beneficial habits of their larvæ it is best, as a rule, not to destroy the beetles unless really necessary to preserve the crop. Indeed they are commonly abundant only when grasshoppers have themselves become abundant enough to do considerable harm, the blister-beetle then largely contributing to the suppression of the grasshopper outbreak.

A pound of Paris green or London purple stirred up with an equal weight of lime in two hundred gallons of water has been found sufficient to destroy the beetles without injury to the leaf, at an expense for the insecticide of only two cents per acre. With an ordinary hand force-pump working in a barrel on a cart, the cost of treatment was about a dollar an acre, but with a specially constructed sprayer carrying a number of nozzles, one for each row, Osborn thought that the expense could be reduced one half.

Megetra vittata is a black western species with very large exposed abdomen and a short pair of strongly diverging wing-covers bearing fine reddish markings. *Macrobasis unicolor* (Fig. 62) is uniform ashy gray, sometimes darker. The gray specimens are almost indistinguishable by the naked eye from the less common *Epicauta cinerea*, and the dark ones might be confused with *E. pennsylvanica*, but they differ clearly from both of these in the larger relative size of the second joint of the antennæ. *Epicauta maculata* (Fig. 63) is a western species, gray, finely dotted with black. *E. vittata* (Fig. 64) is the common yellow and black striped species, with either four or six black stripes above. *E. cinerea* is uniform gray, distinguished from our common *M. unicolor* as already stated; *E. marginata* (Fig. 65), common in Illinois, is black above with a narrow gray edge all around each wing-cover, except at base. *E. pennsylvanica* (Fig. 66), very common in Illinois, is solid black

throughout. *Cantharis nuttalli* (Fig. 67) has brilliant metallic colors—coppery, green, or blue. Like *E. maculata* it is a western species.

Megetra vittata Lec.

This insect is reported by Cockerell to injure sugar beets in New Mexico and also in Arizona, and is probably in the larval stage a bee parasite and honey eater.

The Common Gray Blister-beetle.

Macrobasis unicolor Kirby.

This beetle, although common in Illinois, has not yet been found by us in the beet field, but in Nebraska it is reported as injurious to the sugar beet. It inhabits the entire western United States and is especially destructive to plants of the bean family, including beans, peas, clover, black locust, honey-locust, wild indigo, lupines, and *Astragalus*. It also seriously damages the potato and is known to injure tomatoes and sweet-potatoes and to eat the leaves of the cherry, anemone, and chrysanthemum. In the latitude of central Illinois the beetles have been found from May 19th to October. They are most abundant about the middle of June, and are actively injurious for a month or more. Specimens collected June 13th soon laid their eggs abundantly, the female burrowing into the earth for this purpose, sometimes as much as two inches, and depositing a batch of sixty to one hundred and twenty eggs irregularly stuck together.

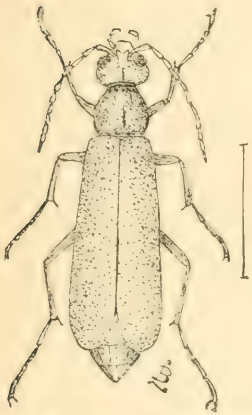

Fig. 62. The Common Gray Blister-beetle, *Macrobasis unicolor*, adult. (Bruner.)

The Spotted Blister-beetle.

Epicauta maculata Say.

This abundant western species, ranging from New Mexico to Dakota and west to California and Oregon, is reported as decidedly injurious to beets in Kansas, Nebraska, and South Dakota. It is especially fond of lamb's-quarters and other weeds of the *Chenopodium* family, and also feeds upon the potato, clover, and greasewood.

Fig. 63. The Spotted Blister-beetle, *Epicauta maculata*. (Bruner.)

The Striped Blister-beetle.

Epicauta vittata Fabr., and var. *lemniscata* Fabr.*

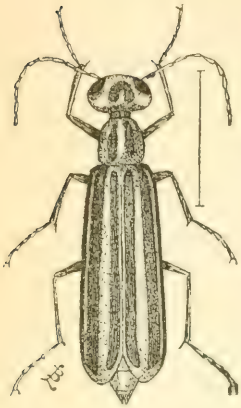

Fig. 64. The Striped Blister beetle, *Epicauta vittata*. (Bruner.)

This is the common striped blister-beetle of Illinois, the one most generally known as a potato beetle. The variety may be distinguished by the fact that it has six black stripes on the back instead of four. It is distributed throughout the United States from Florida to Canada, and west to the Rocky Mountains. It is a well-known destroyer of the potato and tomato, and feeds frequently with injurious effect on leaves of the sugar beet. It scatters more widely in feeding than the black species does, and is consequently less injurious to individual plants attacked. It devours also buckwheat, carrots, corn, some of the leguminous plants, cabbage, the arrowleaf (*Sagittaria*), clematis, and the common pigweed (*Amarantus*). The adults occur from June 1st to the first part of September, most abundantly in the latter half of July and in August. Dr. Riley found them at St. Louis in October, and a second brood more or less complete may occur in the South. With us, however, the species is apparently single-brooded, the female laying four or five hundred eggs, about one hundred and thirty at a time.

The Ash-colored Blister-beetle.

Epicauta cinerea Forst.

This species, extremely like the gray blister-beetle, with which it has evidently often been confused, appears to be most abundant westward, principally in Nebraska and adjacent states. It occurs, however, in small numbers in Illinois and probably farther east. It is quite destructive to plants of the bean family in Nebraska, and almost destroyed a small beet field near Lincoln in that state. It often completely defoliates the hornbeam, honey-locust, and black locust trees. It has been taken sparingly in July and August in both northern and southern Illinois, most commonly on the Virginia creeper.

*This form is so generally found pairing with typical *vittata*, that there can be no doubt of their specific identity.

The Margined Blister-beetle.

Epicauta marginata Fabr. (*E. cinerea marginata* Horn).

Fig. 65. The Margined Blister-beetle, *Epicauta marginata*, adult.

This blister-beetle, very common in Illinois, is easily distinguished by its general black color, except that the wing-covers are edged with gray. It is quite injurious to beets in Illinois and Indiana, but not especially so in Nebraska. It has done serious injury to beans, tomatoes, potatoes and other vegetables, and to asters and other flowers. Among wild plants it feeds upon pigweed, ground-cherry (*Physalis*) and wild sunflower (*Helianthus*). We have taken the beetles from the latter part of June till October, most abundantly from about the middle of July until after the middle of August. Two broods of the beetles are said to have been observed in Indiana.

The Black Blister-beetle.

Epicauta pennsylvanica DeG.

This is probably our most destructive blister-beetle both to beets and to other crops, owing especially to its great numbers and its gregarious feeding habits. It seems to be very common throughout the country from Massachusetts to Utah. It is found in Texas, and in Kentucky is said to have destroyed an acre of beets in two days. It is one of the most destructive of beet insects in Nebraska, and has been reported to us from Minnesota beet fields, and is known to have destroyed a beet crop in some part of New York. It feeds upon a variety of plants including potatoes, beans, carrots, cabbages, the leaves and silks of corn, honey-locust, passion-flowers, garden pinks, and pigweed, and, especially in fall, upon flowers of the goldenrod, rosin-weed (*Silphium*), mustard, etc. The adults appear from June to October. The period of its greatest abundance is during August and

Fig. 66. The Black Blister-beetle, *Epicauta pennsylvanica*. (Bruner.)

September—about a month later than that of the other species. The Kentucky outbreak referred to above occurred late in July.

Nuttall's Blister-beetle.

Cantharis nuttalli Say.

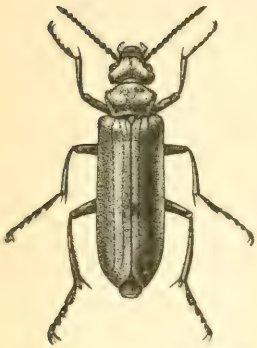

Fig. 67. Nuttall's Blister-beetle, *Cantharis nuttalli*. (Chittenden, U. S. Dept. of Agriculture.)

This beautiful western species, shining green and red or purple, is distributed from the Mississippi to the Rocky Mountains, being especially abundant northwestward into British America. The larvæ probably feed on the eggs of the Rocky Mountain grasshopper, as the beetles seem to increase in numbers after "grasshopper years." When abundant they ravenously devour the tender parts of garden vegetables, including beets, beans being perhaps injured worst. The adults appear about July 1st and in some localities continue in destructive numbers into the fall. For this species destruction by mechanical means is evidently to be preferred to insecticide measures.

SNOUT-BEETLES.

Rhynchophora.

The beetles of this family are distinguished by the character of the head, which is drawn out in front into a more or less evident beak or snout, sometimes short and broad, sometimes very long and slender, but always attached to the head without a joint, and bearing the mouth and the jaws at its tip. The larvæ of this family are white, thick grubs, without legs and usually with brown heads, which live in the roots, stems, and fruits of plants, within which the eggs are deposited by the female beetle.

The adults often injure plants by feeding on the leaves, stems, flowers, and fruit. Those with short snouts simply devour the leaves or stems from without, and those with longer snouts puncture the stem or some other thick and succulent part of the plant and devour the soft substance within. In this manner beets are injured, the leaves being eaten by some species, and the leaf stems punctured and gouged by others. So far as known to us, the larvæ of the snout-beetles do not appear in the beet root, although Lintner makes a statement to that effect.

In eastern Europe serious injury is often done to beets by beetles of this family, but in America they have rarely been abundant enough in the beet field to do any considerable harm. The beetles are sluggish and most of them feign death when disturbed, falling to the ground and

lying motionless there. They are thus easily captured by hand, or they may be reached by the usual arsenical insecticide applications to the beet plant.

Seven species of American snout-beetles are known to feed upon the beet leaf, four of them black or gray with broad short snouts, and three minute black or gray beetles with long slender snouts. *Tanymecus confertus* is about as large as the cucumber beetle and one fourth of an inch long. It is gray, mottled and speckled with brown, and washed with yellowish, especially on the subcylindrical head and thorax. *Epicærus imbricatus* (Fig. 68) is also blackish gray with oblique pale-gray bands upon the back. It is three-eighths of an inch long, plump and rounded, and much heaviest behind. Two species of *Otiorhynchus* common to this country and Europe infest the sugar beet in America, *O. sulcatus* and *O. singularis*. *Sulcatus*, three eighths of an inch long, with heavy abdomen and small distinct thorax, is black, without transverse or oblique bands, dotted sparsely with minute tufts of yellow hairs; *singularis* is similar but smaller, five sixteenths of an inch long, with relatively larger thorax, the color dull dark brown sprinkled with yellowish.

Two American species of *Centrinus* injure the leaf-stem of the beet; *C. penicellus*, which is about an eighth of an inch long, brownish gray, usually with denuded black spots near the tip of the wing-cover, and *C. perscitus* about half as long as the foregoing and a much darker grayish-brown. A minute black seed-weevil (*Apion*) also occurs on sugar beets.

The Imbricated Snout-beetle.

Epicærus imbricatus Say.

This beetle feeds upon a very large list of plants, comprising the sugar beet, the leaves and bark of the twigs of the pear, peach, plum, apple, cherry, raspberry, blackberry, and gooseberry, the leaves and fruit of the strawberry, and the leaves of the cabbage, bean, watermelon, musk-melon, cucumber, squash, beet, potato, tomato, sweet-potato, onion, corn, pigeon-grass, and locust, besides the blossoms of the red clover. In the beet field the largest of the leaves are eaten away until, in some cases, only the stems and a few fragments of veins and leaves are left.

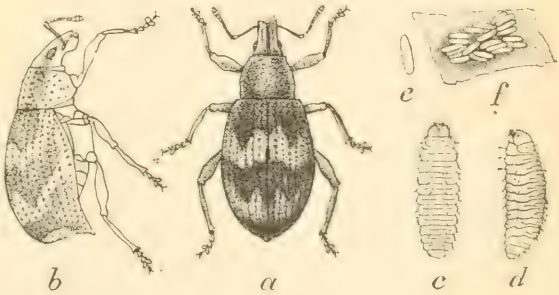

Fig. 68. The Imbricated Snout-beetle, *Epicærus imbricatus*: *a*, adult, top view; *b*, side view; *c*, larva, top view; *d*, side view; *e*, egg; *f*, eggs on leaf. (Chittenden, U. S. Dept. of Agriculture.)

This species is widely distributed from the Atlantic to Utah and Arizona, except in the most northern states. It is especially common on sandy soil and east of the Mississippi. Eggs have been found on the pear and strawberry and on the wild sensitive-pea (*Cassia marilandica*). They are elongate-cylindrical, pale yellowish, smooth, and shining. They are placed side by side in irregular rows within a concealment made by gluing together two adjacent leaves, or by turning over the edge of the leaf and gluing it securely to the surface. A female of this species kept under observation in Washington laid five hundred and forty eggs, which hatched in from ten to fifteen days. The larvæ have not as yet been raised to maturity, but they seem to thrive in confinement on strawberry leaves. There is apparently but one generation in a year, the species hibernating as an adult. The beetles have been found abundant in early spring along the Potomac, and we have collected them throughout the season up to August 1st. They are most injurious, however, in May. The eggs have been noticed April 24th to July 6th. The first adults of the season seem to appear about September 1st, and specimens of this generation have been taken by us in October.

When disturbed the beetles drop to the ground, apparently feigning death, and they can consequently easily be destroyed by knocking them off the plants into pans of water covered with kerosene.

The Black Vine-Weevil.

Otiorhynchus sulcatus Fabr.

This European species seems not to thrive in the United States. Although it is found from New York northwest into Canada and has long been known on this continent, it is still comparatively rare here, and its injuries have been confined mainly to greenhouse plants, especially the fern and cyclamen. In Europe it is a troublesome pest, eating the leaves and shoots of grape, strawberry, raspberry, mangel-wurzel, primrose, etc. The eggs are laid in the earth at the roots of the plant infested by the adult. There is but one brood a year, and the species passes the winter in the larva stage. The pupa is formed in April, and the beetles appear in April and May. They are nocturnal in their habits, feeding only in the night and hiding usually by day. They are consequently readily collected under chips, pieces of board, etc., like the plum-curculio.

The Clay-colored Weevil.

Otiorhynchus singularis Mann. (*O. picipes* Fabr.).

This European species, but little known in this country, is a noxious pest in England, swarming out at night from their day-time retreats,

and devouring the leaves of vines, fruit-trees, raspberries, currants, and a considerable list of garden crops. Not only leaves, but buds, green shoots, and tender bark are eaten. The larvæ infest the roots of many of the plants attacked by the adults. The species has been reported from Essex, Massachusetts, by Prof. A. S. Packard. Its life history is substantially the same as that of the preceding species.

Tanymecus confertus Gyll.

This species has been but once reported as notably injurious to the sugar beet. In Nebraska it devoured early in the season the cocklebur, lamb's-quarters, and smartweed in a twelve-acre beet-field, and when these were gone completely destroyed the beets. This was a very weedy field which had been allowed to fill up with cockleburs, and the beetles probably bred on the roots of this plant.

The species is found throughout the United States as far west as the Rocky Mountains. It is apparently single-brooded and hibernates as an adult. We have collected it in November and December, and at various dates in spring and summer up to the first part of July. A few beetles taken by us in September were probably from the new brood.

Apion sp.

A single black species of this genus of minute seed-weevils, has been found by Bruner in Nebraska on sugar beets.

Centrinus penicellus Hbst.

This little beetle, reported by Bruner as attacking beets in the West, is moderately common from the Atlantic States to the Rocky Mountains. It gnaws small holes in the leaf-stems, and when numerous does considerable harm to plants attacked. Its immature stages and life history are unknown. We have taken the beetle in the latter part of July and in August.

Centrinus perscitus Hbst.

Bruner reports this species also as injurious to beets, gnawing small holes in the leaf-stems. It is commoner in Nebraska than the preceding species, and is reported also from Georgia, Texas, and Iowa.

THE EXPOSED LEAF-EATING CATERPILLARS.

Besides the web-worms, cutworms, leaf-rollers, etc., already discussed, fifteen species of caterpillars have thus far been seen by us or

reported by others feeding upon the beet leaf with a frequency to make them worthy of mention in this article. The cigar-case-bearer is a minute caterpillar, instantly recognized by the whitish cigar-shaped case with which it surrounds its body in summer, only the head and legs projecting as it crawls about. The common army-worm (Fig. 69), the cotton cutworm, the grass-worm (Fig. 73), and the beet army-worm are striped with gray, blackish, or brown. The army-worm has three dark stripes on each side; the cotton cutworm may be recognized by two conspicuous rows of velvety black oval-triangular spots on the back, and by a black spot on each side of the first segment of the abdomen just behind the legs; and the grass-worm and the beet army-worm have on each side a broad blackish stripe. The slight differences between the last two will be given in describing the beet army-worm. Next follow two green larvæ, each with a white or roseate lateral stripe. One of these, *Mamestra trifolii* (Fig. 75 *a*, *b*), is distinguished by a row of darker streaks down each side of the back which are wanting in the green beet leaf-worm (*Peridroma incivis*). The zebra-caterpillar (*Mamestra picta*—Fig. 77) may be readily known by its brilliant black and yellow stripes and bands, and the pale green *Plusias* (Fig. 76) by their resemblance to measuring-worms as they move along. Having but three pairs of legs on the abdomen they loop the body more or less in locomotion. The purslane-caterpillar (*Copidryas gloveri*—Fig. 78) is banded with black on a light background; and the purslane-sphinx (*Deilephila*) is either yellow-green,—with eye-like spots on each segment, often accompanied by dark stripes (Fig. 81),—or blackish, with series of pale yellow spots (Fig. 82).

All the foregoing are smooth or naked caterpillars. Three additional species are densely covered with a fur of long slender hairs, on account of which they have received the general name of the woolly bears. These are the yellow bear (*Spilosoma virginica*—Fig. 84 *d*, Fig. 85), the hedge-hog caterpillar (*Pyrrharctia isabella*—Fig. 84 *c*, Fig. 86), and the salt-marsh caterpillar (*Leucarctia acræa*—Fig. 84 *a*, *b*).

The Cigar-Case-bearer.

(*Coleophora fletcherella* Fernald.)

This little caterpillar in its curious cigar-shaped case has been several times noticed by us on sugar beets, eating small circular holes through the leaves. It ranges from New York and Canada eastward, and sometimes seriously injures the buds of apple, pear, and plum in spring, and later bores the fruit. It spends the winter partly grown, forming its characteristic case about the middle of May. It pupates within this case, attached to the leaf, in June and July. Its injury to beets has thus far been altogether insignificant.

The Army-worm.

Leucania unipuncta Haw.

The common army-worm is a striped caterpillar with sixteen legs, of similar size and general appearance to ordinary cutworms, to which, indeed, it is closely related in the entomological classification and by all its habits except the occasional one of traveling in hordes or armies, to which its common name is due. When full grown it is greenish black, lighter beneath, with three dark stripes, similar in width, on each side of the body, the middle one nearly black. The adult moth is fawn-colored, with dusky hind wings, and with a small white dot near the middle of each fore wing. Although it is normally a grass insect, breeding ordinarily in meadows, or occasionally in fields of young grain, a large variety of garden vegetables, including beets, are accepted by it as food if they happen to be in its line of march. It will not be seen in the beet field, however, except where its ordinary food supplies of grass and grain have begun to fail, compelling it to abandon its usual feeding grounds. It is a common insect at all times and in all parts of Illinois, but it is not noticeably destructive except in occasional years when circumstances favor its multiplication to an extraordinary extent.

Fig. 69. The Army-worm, *Leucania unipuncta*, larva.

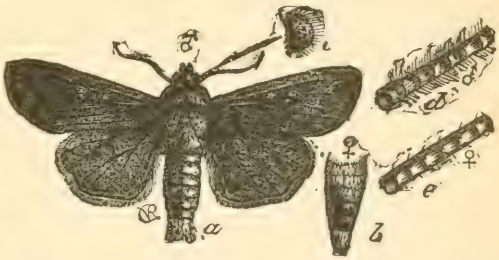

Fig. 71. The Army-worm, *Leucania unipuncta*: *a*, male adult; *b*, abdomen of female adult; *c*, eye; *d*, base of male antenna; *e*, base of female antenna.

The eggs are deposited in the rolled-up bases of grain or grass leaves on ground where the rankest growth of plants occurs. From ten to fifty may be laid on a single leaf. The moths are of nocturnal habit, and the eggs are deposited after dark.

Fig. 70. The Army-worm, *Leucania unipuncta*, pupa.

The caterpillars feed at night, usually remaining hidden by day except during cloudy weather. When full grown they bury themselves in the ground an inch or two, forming there, by turning about, a smooth cavity within which the transformations occur. There are three generations in a year, and the winter is passed mainly in the moth or the pupa stage.

The adults, which come abroad in early spring either from hibernating pupæ or from the winter quarters of the moths, lay eggs late in

April or early in May for the first brood of the caterpillars. The second brood, appearing in Illinois late in June or early in July, is more likely than either of the others to be injurious, and more than one of the three broods is never destructive in the same locality.

This species is especially subject to destruction by parasites, which speedily suppress any destructive outbreak, with the effect that the army-worm is rarely especially abundant for two successive years in the same locality. Commonly, indeed, an interval of several years occurs between noticeable army-worm outbreaks.

Wherever these insects appear in numbers, their movement may be checked and themselves destroyed by the time-honored farmer's resource of ditching across their line of movement, or by plowing a series of furrows, with the smooth vertical edge facing the advancing host. In these barriers, which they will not easily surmount, they can readily be destroyed by methods generally well known. Sometimes a similar purpose may be effected by spraying thoroughly with Paris green and water a strip of vegetation which the army-worms are about to cross. If they are abroad in the vicinity of a beet field their progress must be promptly arrested, as a day's delay will often result in the destruction of several acres of the crop exposed to their invasion.

The Cotton Cutworm.

Prodenia ornithogalli Guen. (*P. lineatella* Harv.).

This caterpillar, an inch and a third to an inch and two-thirds long, is conspicuously marked with a row of velvety black oval-triangular spots along the back, at some distance on each side of the middle. It is darker than the average cutworm and is distinguished by a conspicuous black spot on each side just behind the jointed legs. It has a varied list of food plants, including beets, corn, wheat, cabbage, potato, asparagus, salsify, peach, raspberry, and, especially, cotton. Dr. Riley says that he found it on practically all kinds of succulent plants both wild and cultivated. It is one of the common caterpillars in Illinois beet fields. It has attracted principal attention as a cotton insect, destroying sometimes acres of young plants shortly after they appeared above ground, and later boring into cotton bolls much as does the boll-worm (*Heliothis*). The species is found from Massachusetts to Minne-

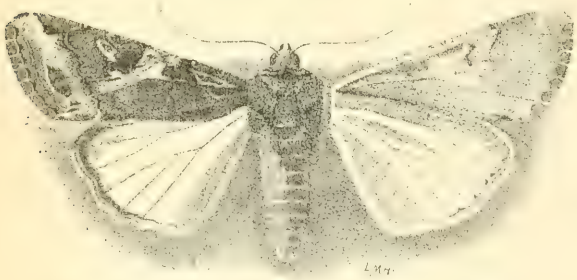

Fig. 72. The Cotton Cutworm, *Prodenia ornithogalli*, adult.

sota and California, and south to the Gulf of Mexico. It passes the winter, according to Riley, most generally in the larval stage, but sometimes also as pupa or imago. The caterpillars are commonest in Illinois in July and August, where there is perhaps but a single brood. In the South, however, there seems to be at least two generations annually, one occurring in April and the other late in June.

The Common Grass-worm.

Laphygma frugiperda S. & A.

This insect, called also the fall army-worm, and often confused on that account with the true army-worm, was extraordinarily abundant throughout Illinois and many other states during the summer of 1899. According to Chittenden's article* it was reported from New York and New Jersey southward to Florida, and westward to Texas, Kansas, and Nebraska. It attracted most attention, perhaps, last season in lawns, the turf of which it completely deadened in many towns; but it was also injurious to small grain, corn, broom-corn, etc., giving rise to much apprehension among those not acquainted with its history and habits. In Illinois it was definitely reported to the office from Chicago and its suburbs, from Quincy, Meredosia, Arcola, and Urbana, and from Villa Ridge in extreme southern Illinois, as well as from many intermediate places.

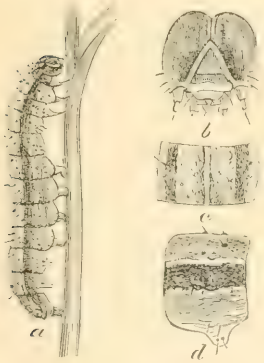

Fig. 73. The Common Grass-worm, *Laphygma frugiperda*: *a*, larva; *b*, head of larva, front view; *c*, abdominal segment of larva, top view; *d*, side view.

It is especially fond of grass and other graminaceous plants, corn, broom-corn, wheat, oats, etc. In a watermelon field it cleared out the grass-like weeds, but did not injure the melon vines. Notwithstanding its abundance about Champaign none were seen by us on beets until October, when young larvæ were found gnawing the leaves of that plant. Most of them were freshly hatched, but none of the lot was large enough for unmistakable identification. Its list of food plants is so long and varied as to be almost exhaustive of our ordinary crops and weeds. Indeed, in extreme cases it leaves scarcely any green vegetation uninjured, and has even been known to enter greenhouses, and to eat corn fodder in the stack.

Fig. 74. The Common Grass-worm, *Laphygma frugiperda*: *a*, adult; *b*, *c*, two-color varieties.

*Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., p. 79.

It differs from the army-worm in its method of avoiding the consequences of a too prolific multiplication, not moving off in definite hordes and in fixed directions, like the latter insect, but spreading indefinitely in all directions from the most densely populated area.

It ranges over the whole United States east of the Rocky Mountains, and it is also found in Jamaica and Brazil. There are at least two, and probably three, generations of the species in each year in the latitude of central Illinois, one becoming destructive in the larval state late in July and continuing abundant in August, and another appearing in October. The fall brood is usually the destructive one, any other rarely being numerous enough to attract attention. This species is believed to hibernate mainly in the pupa stage, but partly also, in all probability, as an adult. Thus, larvæ collected by us October 11, 1884, were mostly alive in the earth as pupæ in December, a few only having emerged in the preceding month.

It is held in check mainly, if not wholly, by its parasites, of which a tachinid fly is one of the most important.

The Beet Army-worm.

Laphygma flavimaculata Harv.

This caterpillar, which replaces the foregoing in the Western States, differs from it by its more decidedly mottled ground-color, by a row of white dots at the lower margin of the lateral dark band, and by the yellower color of the light stripes. It is an interesting fact that while the preceding species was doing serious, unusual, and very wide-extended injuries in the Eastern and Southern States, the present one was similarly abundant in Colorado, where besides destroying many kinds of weeds and grasses it completely defoliated thousands of acres of sugar beets. In some cases where the foliage of the beet did not furnish it sufficient food, the root was attacked and the upper surface often completely gnawed away. Late plantings of course suffered most severely, especially when surrounded by newly broken ground. The weeds most generally eaten were pigweed, saltweed, wild sunflower, and *Cleome*. Potato, pea, and apple leaves were also devoured. These injuries occurred about the middle of August, at which time larvæ and pupæ were abundant, and a few moths laden with eggs were also noticed. These facts are derived from the statements of Prof. C. P. Gillette, of the Colorado Experiment Station, who furnished the material for this account together with specimens of the insect.

This species evidently hibernates as a moth, and at least two broods of larvæ may be looked for each year, the first about June and the second in August. The species has been reported thus far from Colorado and California, but it doubtless has a more extended range in the moun-

tain region of the far West. Prof. Gillette's field experiments showed that it could be destroyed by dusting or spraying arsenical poisons on the beet leaf.

The Garden Mamestra.

Mamestra trifolii Rott.

(*M. chenopodii* Albin.)

This green larva, striped with rose or pinkish white, with a row of darker lines on each side of the back, is found all over Europe and North America. It infests a variety of garden plants and weeds, and sometimes does considerable injury to beets by eating the leaves or even the entire tops of small plants, as reported by Bruner in Nebraska. We have found it also on beets in late September and early October on the Experiment Station farm in Illinois. In America it has been noted feeding on cabbage, turnips, and numerous other garden vegetables, and upon lamb's-quarters and purslane among the common weeds. It is evidently two-brooded, hibernating as a pupa, and the moths appearing in the early spring. We have found them abundant at electric lights in May. Larvæ of the first brood have been taken in June and early July, and of the second brood in September and early October. Larvæ taken from the sugar beet September 26th and October 9th entered the ground for pupation between October 8th and 13th.

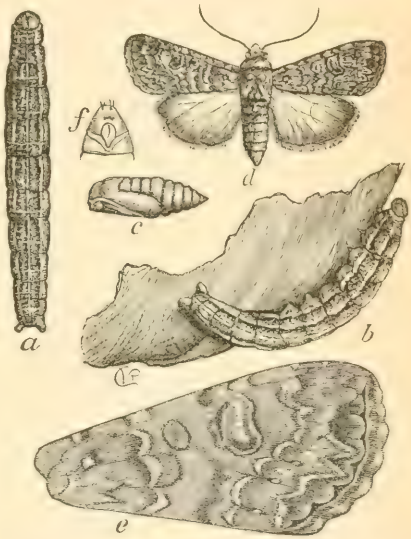

Fig. 75. The Garden Mamestra, *Mamestra trifolii*: *a*, *b*, larva; *c*, pupa; *d*, adult; *e*, wing of adult enlarged; *f*, last segment of pupa, ventral view. (Riley, U. S. Dept. of Agriculture.)

Mamestra sp.

Bruner mentions a larva found abundant in beets at Norfolk, Neb., which was about the size and general appearance of the darker form of *M. trifolii* but differed in habits and markings. It was not bred to the imago, and its species is consequently unknown.

The Green Beet Leaf-worm.

Peridroma incivis Guen.

During 1899 and 1900 this green larva, with a white or roseate stripe on each side, was the commonest caterpillar on beet leaves in Illinois.

It fed freely exposed on either the under or upper side of the leaf, eating irregular holes, but not becoming seriously injurious. Garman reports it as a common Kentucky insect. It ranges from Florida and Texas to Massachusetts and Illinois, and occurs also in California. French and Garman speak of it as feeding in gardens, and we have found it eating purslane as well as sugar beets. The larva enters the ground and pupates there. In southern Illinois and Kentucky the species is apparently two-brooded. Larvæ are common in spring, yielding the imago in June and July; and another brood of larvæ occurring in August and September gives the imago in October. In central Illinois we have found larvæ of all sizes common in July and again in September, the last of them disappearing about October 15th. Examples taken July 14th and 26th and September 2d all went into the winter in the pupa stage. Further study of the life history is evidently necessary to determine the usual facts for this species.

The Cabbage Plusia.

Plusia brassicæ Riley.

This pale green looping caterpillar is striped with longitudinal whitish lines of varying distinctness, which narrow noticeably towards the head. It is by preference a cabbage insect, but occasionally eats the leaves of beets. When young it eats small holes in leaves, but as it grows larger it devours the leaf completely, and even gnaws away the stalk. It is seriously injurious to the cabbage in the South, and in Minnesota was reported in 1884 to be almost as injurious to cabbage as the common cabbage worm (*Pieris rapæ*). It feeds also on celery, kale, turnip, tomato, lettuce, mignonette, dandelion, dock, clover, lamb's-quarters, and some less common cultivated plants. It ranges throughout the United States, and occurs also in Canada. The eggs are laid upon the food plant singly or in small clusters, loosely attached to the leaf.

Fig. 76. The Cabbage Plusia, *Plusia brassicæ*: *a*, larva; *b*, pupa in its thin cocoon; *c*, adult.

The full grown larva spins a gauzy cocoon wrapped in the leaf or attached to the stem, and within this the green or light yellowish pupa is presently found. The blackish or dark gray moths are distinguished

by a silvery U-shaped spot on the middle of the fore wing and an oval silvery dot adjoining it on the outside.

The number of generations annually has not been satisfactorily determined. Riley believed that there were probably four in the latitude of Washington, D. C. This caterpillar has an enormously destructive parasitic enemy, a minute hymenopterous insect, which pupates within the skin of its dead host and emerges in almost incredible numbers, over twenty-five hundred having been counted which must have come from a single infested larva. In a large lot of larvæ collected by us at Urbana, only one example escaped parasitism, and Dr. Riley reports a similar observation upon fifty larvæ collected by him.

The Celery Plusia.

Plusia simplex Guen.

This is our commonest Illinois Plusia. It occurs generally in the United States east of the Rocky Mountains, as well as in New Mexico and the Hudson Bay Territory. It is a very destructive celery insect, and we have bred it from a larva found feeding on the sugar beet. It differs from the cabbage species in the fact that its spiracles are distinctly ringed with black, according to Coquillett, while in the cabbage Plusia these rings are indistinct, partial, or wanting. There are believed to be three broods of this species in a year. The caterpillars of the first generation of the year hatch late in May and get their growth late in June or early in July. The life of the second generation extends from the first part of July to the middle of September, and the third begins to issue from the egg early in October. This brood hibernates about half-grown, attaining full size during the latter half of April. This account, compiled from Coquillett's statement in the Eleventh Illinois Report, is confirmed by our collections, in which the moths of this species occur twice in April, ten times early in May, ten times between July 15th and August 15th, and six times in the latter half of September.

The Zebra-caterpillar.

Mamestra picta Harr.

Although evidently preferring cabbage and other cruciferous plants, this abundant and conspicuous caterpillar occasionally attacks beets. It seems to be somewhat whimsical in its food habits. It has been reported by Felt, of New York, as excessively abundant in timothy and as the probable agent in the destruction of twenty acres of oats. Other food plants recorded are cauliflower, turnip, rutabaga, bean, pea, carrot, celery, potato, spinach, asparagus, buckwheat, corn, clover, currant, cranberry, apple, orange, willow, spruce, mignonette, aster, sweet pea, snowberry, honeysuckle, smartweed, burdock, and lamb's-quarters. It

is distributed from Canada to Florida, and west to Nebraska. The eggs are deposited in large clusters of as many as a hundred and fifty each, usually on the under surfaces of the leaves. The young caterpillars are at first white, hairy, and speckled, each with a black head and a black crescent upon the thorax. They feed for a time in a dense group, but after a few days they molt and assume the zebra-markings of the full grown larva. This is black with two yellow stripes on each side, the broad interval between which is crossed by numerous fine white lines. The under surface is tawny. When disturbed the caterpillar coils up and falls to the ground. It pupates under ground within a rude cocoon. There are two generations a year, hibernation being either in the pupal or larval stage. The first and most destructive brood of larvæ occurs in June and July, and the second in September and October.

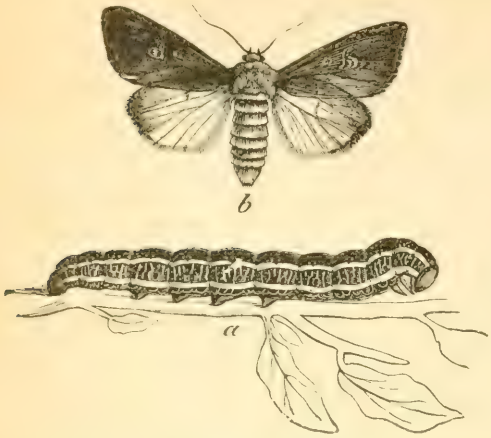

Fig. 77. The Zebra-caterpillar, *Mamestra picta: a*, larva; *b*, adult. (Riley, U. S. Dept. of Agriculture.)

The Purslane-caterpillar.

Copidryas gloveri G. & R.

Fig. 78. The Purslane-caterpillar, *Copidryas gloveri: a*, adult; *b*, larva. (Riley & Howard, U. S. Dept. of Agriculture.)

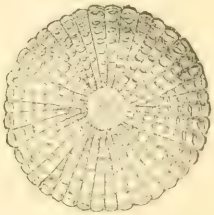

Fig. 79. The Purslane-caterpillar, *Copidryas gloveri*, egg, greatly enlarged. (Riley & Howard, U. S. Dept. of Agriculture.)

Fig. 80. The Purslane-caterpillar, *Copidryas gloveri*, with head and last segments enlarged. (Riley and Howard, U. S. Dept. of Agriculture.)

This insect, the usual food of which is purslane, is not an Illinois species, but as it seems to have spread from its original home in Texas

and New Mexico into Kansas and Nebraska it may yet reach Illinois, where there is certainly no lack of its favorite food. In Nebraska it has been seen to feed on the leaves of the sugar beet. Its size is about that of a common cutworm. It is whitish or light gray, conspicuously banded with black on each segment, and shaded with salmon-pink. The eggs are laid in clusters of two to five on the under side of the leaf of the infested plant. The young larvæ, which hatch in two or three days, are light or yellowish green at first, with darker shadings. They become full grown in eight or nine days, and make then a tubular burrow in the earth for pupation, closing the opening with a thin layer of dirt. After about twelve days as a pupa, the moth appears. This is brownish gray, with a creamy curved streak along the fore wings, the hind wings buff with a blackish border. Four broods of this caterpillar have been recorded.

The Purslane-sphinx.

Deilephila lineata Fabr.

This fairly well-known caterpillar varies in markings to an unusual degree. Two distinct forms may be separated, one yellow-green, with eye-like spots on each segment, often accompanied by dark stripes, the

Fig. 81. The Purslane-sphinx, *Deilephila lineata*, larva.

other blackish with series of pale yellow spots. Its favorite food-plants are purslane and chickweed, and on these it may often be found in considerable numbers. Its preferences are not very strict, however, and it may devour almost any low plant. It is reported by Bruner to injure

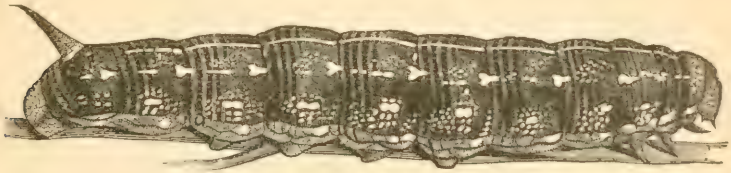

Fig. 82. The Purslane-sphinx, *Deilephila lineata*, larva, dark variety. (Lippincott Co.)

the sugar beet in Nebraska, and has been seen eating beet leaves at Pekin, Ill. Thus far it has caused no serious injury to vegetables in cultivation, and if it should become locally abundant it could easily be destroyed by hand. When full grown it forms a smooth cavity in the

earth within which it changes to a light-brown pupa with a tongue-sheath like the handle of a pitcher. The handsome well-known moth from this pupa is commonly called the white-lined morning-sphinx. It is one of the twilight species which when flitting about flowers in the dusk is most likely to be mistaken for a hummingbird by those ignorant of the

Fig. 83. The Purslane-sphinx, *Deilephila lineata*, adult. (Lippincott Co.)

habits of that species. It is also not uncommon at the electric light. This sphinx-moth is two-brooded, the larvæ of the first brood being most abundant in July and August, and those of the second from the middle of September through October. It hibernates in the pupa stage.

The Woolly Bears (*Arctiidæ*).

The Yellow Bear (*Spilosoma virginica* Fabr.).

The Hedge-hog Caterpillar (*Pyrrharctia isabella* Abb.).

The Salt-Marsh Caterpillar (*Leucarctia acræa* Dru.).

The larvæ of these three related species are one and a half to one and three fourths inches long, and thickly coated with erect hairs—from which fact their general name is derived. They are common and widely distributed, and very general feeders, devouring leaves of garden vegetables (including beets), small fruits, vines, and young trees. The yellow bear is probably the commonest and the salt-marsh caterpillar the least common of the three in Illinois. The hedge-hog caterpillar, tawny red on the middle half or two-thirds of the body and black at each end, is a familiar object in late fall and early spring, often noticed as it hurries over the ground in search of hibernating quarters, for it passes the winter in the larval stage. It derives its popular name from the fact that it rolls itself up into a bristly ball when frightened or disturbed. In the other two species the coat is nearly uniform in color throughout, but differs in shade from very light to very dark. The head of the yellow

bear is pale and unmarked, the hair is commonly dark brown, the body beneath it often with dusky stripes. In the salt-marsh caterpillar the

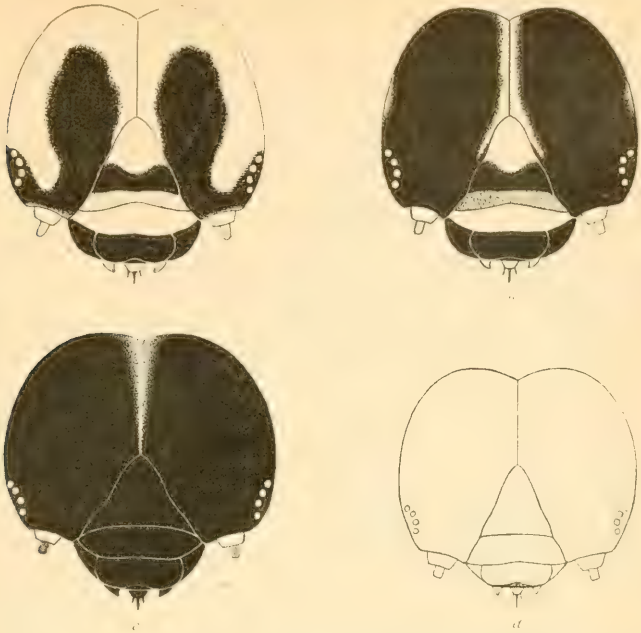

Fig. 84. Faces of woolly bear larvæ: *a*, *b*, The Salt-Marsh Caterpillar, *Leucarctia acræa*, showing variation in extent of black coloring; *c*, The Hedge-hog Caterpillar, *Pyrrharctia isabella*; *d*, The Yellow Bear, *Spilosoma virginica*.

head is more or less black, the hair is commonly dark brown, and the body is blackish, with pale lateral and mediodorsal stripes. Both these species hibernate in the pupa stage. When quite young the larvæ merely eat the surface of the leaves, but when older they make large holes. When one of the woolly bears is full grown it seeks a convenient shelter, makes rather a thick cocoon of the hairs of its coat interwoven with coarse silk, and transforms within this to a dark brown chrysalis. The pupa of the hedge-hog caterpillar bears some tufts of golden bristles, and its tawny cocoon is often found on old boards.

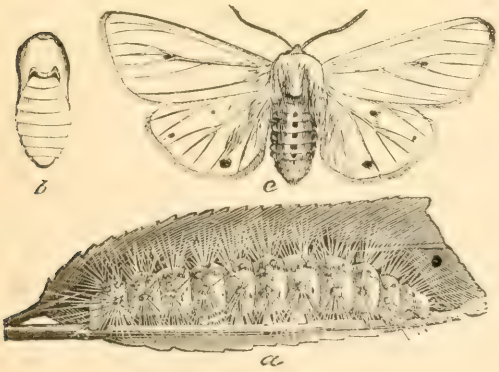

Fig. 85. The Yellow Bear, *Spilosoma virginica*: *a*, larva; *b*, pupa; *c*, adult.

The perfect insects of these species are very well-known thick-bodied moths, that of the yellow bear being the one to which the common name of "miller" is most likely to be attached. Its heavily-coated wings are snowy white with a few black dots, and the abdomen orange, with three rows of black spots above. The adult of the hedge-hog caterpillar is the Isabella moth, orange-buff on wings and body, with the hind wings tinted more or less with rose. The wings are also speckled with black, and black dots are arranged on the upper surface of the abdomen in three longitudinal rows. The moth of the salt-marsh caterpillar has the abdomen orange, and all the wings white in the female, the male differing by the orange hinder wings. In both sexes the wings are thickly speckled with black, and the abdomen with black in three longitudinal rows. All three of the species seem to be normally two-brooded. The larvæ of the first brood are commonest in June and July, and those of the second brood in September. The woolly bears are frequently beset by hymenopterous parasites, and the hedge-hog caterpillar seems especially subject to death by muscardine—due to the attacks of a parasitic fungus which converts the body soon after death into a rigid mummy, scarcely shrunken from the proportions of the living insect.

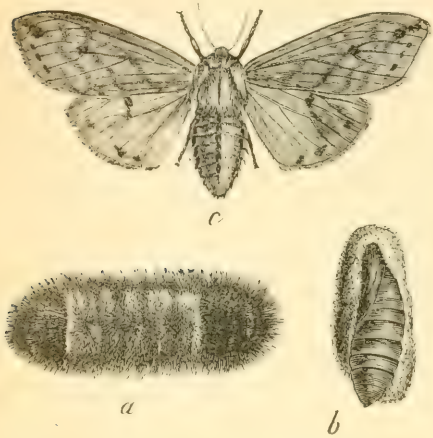

Fig. 86. The Hedge-hog Caterpillar, *Pyrrharctia isabella*: *a*, larva; *b*, pupa in cocoon; *c*, adult.

Injuries to the roots.

In case an unthrifty condition of the beet plant is not fully explained by injuries to the foliage, an examination of the roots will often betray the presence there of insects doing an injury sufficient to diminish the general vigor of the plant, or which may result in its destruction. There are two classes of injury to the roots of beets by insects: those resulting from a sucking of the sap from the tissue of the root by true bugs (*Hemiptera*); and those due to beetles and their larvæ, which gnaw the surface of the root or eat into its substance. Injuries by the suctorial *Hemiptera* are distinctly recognizable only when the insects themselves are found on the root, since the local effect of the abstraction of the sap is not usually very marked. The insects of this description thus

far noticed on the beet root are few in number, and have rarely been of great importance. Our present list of those infesting the root of the beet is limited to two species of plant-lice (*Pemphigus betæ*, and *Aphis middletonii*) and a single mealy bug (*Dactylopius*), the species of which is uncertain.

ROOT-LICE (*Aphididæ* and *Coccidæ*).

The Beet Aphis.

Pemphigus betæ Doane.

This insect, but very lately brought to the attention of beet-growers, offers an extraordinary example of the injury to vegetation which may be done by root-lice. Our information concerning it is due to Mr. R. W. Doane, Assistant Zoölogist of the Washington State Agricultural Experiment Station, at Pullman, Wash., whose latest publication on this species is contained in Bulletin 42 of that Station.

Attention was first called to this pest, he says, in 1896, when it was found that a field of two or three acres of beets was generally infested, a strip of twenty-five to a hundred yards being so badly injured that the beets were nearly all soft and spongy, and the plants much smaller than the average. Other beet fields in the vicinity of this were also generally infested. During subsequent years this aphis has been found in considerable numbers in almost every beet field in that locality, and in 1899 it was unusually destructive.

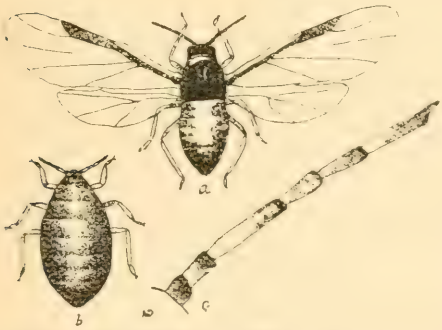

Fig. 87. The Beet Aphis, *Pemphigus betæ*: *a*, winged female; *b*, wingless female; *c*, antenna of winged female. (Doane.)

It was first described as a new species by Mr. Doane in 1900, and seems thus far to have been found only in Washington and Oregon. In the latter state it has been even more destructive than in Washington, at least a thousand tons of beets having been destroyed by it in one year in a single valley devoted largely to beet culture. Like very many other beet insects, this species infests also several wild or useless plants; a wild yarrow (*Achillea lanulosa* Nutt.) and a knot-weed (*Polygonum aviculare*), together with various other weeds and grasses, both native and introduced. It has also been reported as occurring on potatoes, cultivated roses, and the wild service-berry, but its identity in these cases is as yet in doubt.

This root aphis occurs in two forms, wingless and winged, the

wingless form being much the more abundant. These are small, pale yellow or whitish, with a mass of flocculent matter covering the posterior part of the body, evidently much as in the case of the woolly aphis of the apple. Indeed, the first thing to attract attention when an infested beet is examined is this white fungus-like substance covering the infested surface. The insects are mostly pear-shaped, an eighth of an inch in length when full grown.

"Upon examination with the lens the whole body, including the legs and antennæ, is seen to be dusted over with a white powder, and the flocculent mass is seen to be made up of thousands of very fine white threads arising from the last three or four segments of the body and often half as long as the body itself. The legs and antennæ and a rather large spot on the dorsal side of the head are brown. The eyes appear as small black dots on the sides of the head. The antennæ are six jointed, the third joint being the longest; the sixth joint, which is the next in length, has the distal portion contracted so it is only about half as large as the basal portion.

"Winged forms are also often found late in the season. These are somewhat larger, more elongated, and very much darker in color. The whole head and thorax, together with the legs and antennæ, are bluish black, lightly dusted with the white powder. The abdomen is dark green with only a little of the flocculent matter on the posterior segments. The thin membranous wings are usually held folded roof-like over the body, beyond the tip of which they extend for some distance. The eyes are much larger than in the wingless forms and are brown. With the winged forms a number of pupæ usually also occur. These look just like the winged forms, but instead of the wings they have little blunt pad-like organs, the undeveloped wings, on either side of the thorax."

The smaller rootlets of the beet are first attacked by this aphis, and if it occurs in considerable numbers these are soon all destroyed, and the leaves thereupon soon wither, and the whole beet shrivels and becomes spongy. This wilting of the leaves will frequently, in fact, be the first thing to attract the attention of the beet grower. The actual injury to the crop will, of course, depend largely upon the time when the attack of the aphis is made. If the plants are small they may readily be destroyed, while if they are practically full grown the loss of the small rootlets will not materially affect them.

No sexual generation of this aphis has as yet been discovered and no eggs have been seen, viviparous reproduction continuing throughout the year except when the cold of the winter temporarily suspends the physiological activities of the species. The winged females, appearing from time to time during the summer and fall, serve to distribute the species generally, new colonies being started wherever these females find lodgment and food. In districts liable to injury by this insect it

seems inadvisable that beets should be the first crop on new land, or that ground should be continued in beets or in any other root crop after the pest has made its appearance in the field.

Aphis middletonii Thos.

Occasionally colonies of this root aphis, which had previously been found only on roots of certain weeds, were detected by us in 1899 and 1900 in Illinois on the sugar beet, established among the smaller roots on each side of the main mass of the beet. Only a small percentage of the beets examined were infested. Two species of ants, *Lasius niger alienus* and *Formica schaufussi*, were running about among them in a way to indicate an association of the usual form.

The wingless insects of this species are greenish gray, with dark spots above, near the sides, and some dark cross-bars in front of the middle. The winged individuals have the head and thorax black. Thomas found the winged form among the wingless ones during the latter part of September, and the eggs occurred at the same time among the roots.

The species is recorded as abundant on the roots of various weeds of the order *Compositæ*—the fleabanes (*Erigeron*), horse-weed (*Ambrosia trifida*), goldenrod (*Solidago serotina*), iron-weed (*Vernonia*), and aster. It has been recorded from Illinois, Minnesota, and Nebraska.

The Root Mealy Bug.

Dactylopius sp.

A minute whitish insect, resembling a wingless plant-louse, but with an oblong or oval body and very short legs and antennæ, may sometimes be found on sugar beets. Like the beet root-aphis, described above, it is usually well covered with a white waxy excretion. Such insects infest the roots of a considerable variety of plants. Little is known of their life history, and very few have been taken on beets. A single immature specimen was seen on a sugar beet root in July in Illinois along with examples of *Aphis middletonii*, and specimens doubtfully referred by Cockerell to *Dactylopius solani* Ckll. were found in Colorado on the crown of the sugar beet. This species occurs on the roots of a common western weed, *Solanum rostratum*, and a variety of it infests the roots of a plant of the beet family, *Atriplex canescens*.

WIREWORMS.

Elateridæ.

Among the subterranean insect enemies of the beet one may occasionally find, buried in its substance or eating into it from without, long, cylindrical, hard, smooth, reddish brown, worm-like larvæ, about an

inch long when full grown, and with three pairs of short legs immediately back of the head. This last is flattened, wedge-shaped, with the mouth in front and the jaws extending forward. These wireworms are ordinarily most abundant in grass-lands, which are their normal breed-

Fig. 88. The Corn Wireworm, *Melanotus cribulosus*, larva.

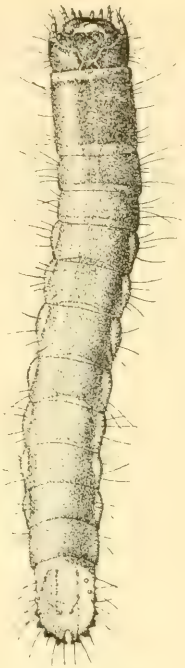

Fig. 89. *Drasterius elegans*, larva.

Fig. 90. The Corn Wireworm, *Melanotus cribulosus*, last segment of larva, top view.

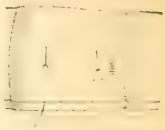

Fig. 92. The Corn Wireworm, *Melanotus cribulosus*, right-side view of one of the middle segments.

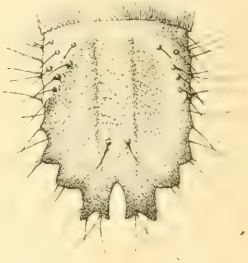

Fig. 91. *Drasterius elegans*, last segment of larva, top view.

ing grounds, but as they live in the earth about two years before transforming to the adult beetle stage, they continue their injuries to succeeding crops when the infested pastures or meadows are broken up, often doing much greater injury to this cultivated vegetation than to the grass the roots of which furnish their usual food.

These wireworms have been found to eat the smaller roots of beets, and, burrowing into the tap-roots and crowns, often cause the plants to shrivel and die. The species have not ordinarily been discriminated by observers, but we have seen larvæ of *Melanotus cribulosus* and of *Drasterius elegans* about beet roots which had been more or less injured and eaten away. An elaborate account of them and of their injuries to corn will be found in the Eighteenth Report of the State Entomologist of Illinois, with keys and figures for the discrimination of the various species thus far separated.

The injurious species agree fairly well in the main features of their life history. They change, when full grown, to dormant pupæ in the earth in July, or sometimes in August, and again some three or four

weeks later to the brown or reddish beetles commonly known as click-beetles or "jumping-jacks"—hard, somewhat hairy insects, of slender oval form, distinguished at once by their peculiar habit of springing into the air with a sudden click when placed upon their backs. A large part of these fully developed beetles remain under ground until spring, enjoying there the protection of the oval earthen cavity or cell formed by the

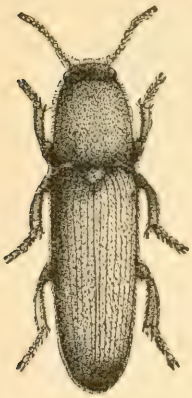

Fig. 93. The Corn Wireworm, *Melanotus cribulosus*, adult.

Fig. 94. *Drasterius elegans*, adult.

larva as a preparation for pupation. A part, however, come forth from the ground in fall, passing the winter in sheltered places, and the remainder emerge in spring, laying their eggs most commonly in grass-lands in the earth. Of their subsequent life history little is yet definitely known. It seems certain that all live more than one year as wireworms in the earth, and observation of the various sizes of larvæ of the same species to be found in the field at once, usually supports the common impression that the period of life in the larval stage does not extend much beyond two years. Obviously, infested ground, and especially infested grass-land, should not be put into sugar beets for a year or two after it is broken up from sod.

WHITE GRUBS.

Lachnosterna and *Ligyrus*.

The white grubs or grub-worms are the larvæ or young of the very common insects usually known as May-beetles or June-bugs, and of another group, known as manure beetles. These grubs are so common and generally recognized that the accompanying figures will serve to identify them without further description. They are most abundant in grass-lands or in lands recently in grass, although they are occasionally bred in large numbers in fields of corn. They do serious injury to the

underground parts of a great variety of crops, including sugar beets, being, like the wireworms, most destructive the second year after grass. They eat the smaller roots, destroy the tap-root of the plant, or gnaw

Fig. 95. A June-bug larva or White Grub, *Lachnosterna rugosa.*

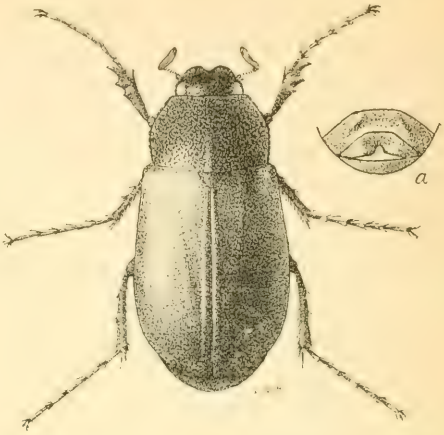

Fig. 97. A June-bug, *Lachnosterna rugosa*, adult; *a*, last segments of male, from beneath.

large cavities in the substance of the beet—injuries frequently indicated by the sudden wilting of the leaves. In a Nebraska field of beets, planted on ground which had lain idle for a few years, about fifteen per cent. of the plants were thus destroyed. Grubs of *Lachnosterna rugosa* have been found by us this year injuring the roots of beets in central Illinois, and causing the plants to wilt.

The white grubs common in this state are elaborately treated in the Eighteenth Report of the State Entomologist of Illinois, to which reference may be made for a more detailed account. The following summary of the life history will, however, be useful in this place.

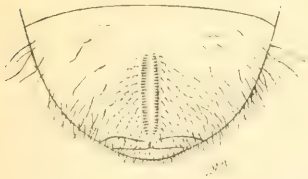

Fig. 96. A June-bug larva or White Grub, *Lachnosterna rugosa*, last segment, from beneath.

The eggs are transparent white, at first oblong-oval, soon becoming nearly spherical. They are deposited in the earth, one to three inches below the surface, usually some time in June, and they hatch in about ten to eighteen days. The young larvæ feed on roots during the remainder of the season, winter over deeper in the ground, and come up and resume feeding when the next season opens. A second winter is passed in the same way, and in June and July of the third season they form oval cells in the earth, and in late summer change to the June beetles. These beetles do not usually leave their cells until the following spring, when they emerge, pair and lay their eggs, and soon die. They feed during their short life on the

leaves of trees, especially oak, hickory, and ash, as well as on a few other plants. The damage to foliage is sometimes considerable.

There are no measures which can be depended upon for the destruction of white grubs in the beet field, and the beet grower must consequently rely upon preventive measures. The most obvious of these is suggested by the fact that the white grub is bred mainly in grass-lands, and that there are few pastures or meadows of long standing which are not more or less infested by them. Consequently, whenever an old sod is broken up it should be planted to some other crop for at least two years before it is set in beets; or, if necessity requires that beets should be raised on such ground at once, this should not be done until it has been cleared of the grubs by thorough pasturing of the sod with pigs. These search out and root out the grubs in the ground, greedily devouring them, and may in the course of a few weeks completely clear a badly infested turf. The fact of the winter retreat of the grubs to a considerable depth below the surface must, however, be borne in mind in this connection. From November to March inclusive they will commonly be beyond the reach of pigs.

The Muck Beetle.

Ligyrus gibbosus DeG.

(Pl. IX., Fig. 2.)

The larva of this muck beetle need not ordinarily be distinguished from the white grubs above discussed, its size, habits, and appearance being substantially similar; but its life history is less definitely known, and the period of its continuance in the earth is in doubt. The principal economic difference is due to the different habit of the adult beetle, which does not feed, so far as known, upon the leaves of plants like *Lachnosterna* and *Cyclocephala*, but burrows in the earth, eating the roots or the lower part of the stalk of the infested plant much as does the larva itself. In early spring, says Mr. H. E. Weed, the beetles are often dug up by persons working in grass-land. They are said by Bruner to have been quite destructive to sugar beets over limited areas in western Nebraska, gnawing great holes into the roots and sometimes thus entirely imbedding themselves. They work at different depths from the surface, sometimes as much as six or seven inches, but mostly about three or four inches under ground. They were most abundant on old ground and on ground that had been irrigated. They are reported as feeding also on carrots, roots of sunflowers, and tubers of the dahlia. In Mississippi, according to Mr. Weed, a serious injury to corn following upon grass was done by these beetles, which gnawed the base of the stalk, causing the plant to wilt or killing it outright. The species is widely distributed in the United States, and is abundant in Illinois.

TECHNICAL LIST OF SPECIES OF BEET INSECTS.

ORDER ACARINA.

Red Spiders.

ORDER ORTHOPTERA.

Grasshoppers (*Acrididæ, Locustidæ*).

ORDER HEMIPTERA.

SUBORDER HETEROPTERA.

The Pigweed Bug.

The Common Flower-bug.

Leaf-bugs (*Capsidæ*).

Smaller Plant-bugs (*Lygæidæ*).

Larger Plant-bugs (*Coreidæ, Pentatomidæ, Corimelænidæ*).

SUBORDER HOMOPTERA.

THE FLATAS (*Ormenis*, *Chlorochroa*).

LEAF-HOPPERS (*Jassoidea*, *Delphacinæ*).

TREE-HOPPERS (*Membracidæ*).

PLANT-LICE (*Aphididæ*).

ROOT COCCID.

ORDER COLEOPTERA.

GROUND-BEETLES (*Carabidæ*).

CARRION-BEETLES.

WIREWORMS (*Elateridæ*).

WHITE GRUBS.

Leaf-beetles (*Chrysomelidæ*).

NON-JUMPING LEAF-BEETLES.

Breeding on Leaves of Plants.

Breeding on Roots of Plants.

FLEA-BEETLES.

Breeding on Leaves of Plants.

Breeding on Roots of Plants.

Leaf-mining Flea-beetles.

Blister-beetles (*Meloidæ*).

Snout-beetles (*Rhynchophora*).

Leaf-eating Snout-beetles.

Stem-eating Snout-beetles.

ORDER LEPIDOPTERA.

The Cigar-case-bearer.

Leaf-rollers (*Tortricidæ, Pyraustidæ*).

Garden Web-worms (*Loxostege, Hellula*).

Cutworms.

Exposed Smooth Caterpillars.

Woolly Bears (*Arctiidæ*).

ORDER DIPTERA.

The Beet Leaf-miners.

ECONOMIC BIBLIOGRAPHY.

1882.

LINTNER, J. A.—Notice of some Anthomyians mining Beet Leaves. (Ninth Ann. Rep. on the Injurious and other Insects of the State of New York, pp. 203–211.)

Account of injury in vegetable garden at Middleburg, N. Y., in summer of 1881. Method of feeding, notes on life history, and description of immature stages given. Three species of adults bred from the larvæ: *Phorbia* (=*Chortophila*) *floccosa*, *C. betarum* n. sp., and *Pegomyia vicina* n. sp. Similar depredations by these insects observed at Morrisville, N. Y., and at Bennington, Vt., during this same season.

1884.

LINTNER, J. A.—Insects mining Beet Leaves. (Cultivator and Country Gentleman, Vol. XLIX., Aug. 18, 1884, p. 677.)

Answer to a correspondent who sends from Erie, Pa., beet leaves mined by larvæ of *Anthomyidæ*. Species not determined. Refers to earlier observations of this injury to beets. Advises picking off infested leaves.

1888.

BRUNER, L.—Report of the Entomologist. (Rep. Neb. State Bd Agr., pp. 84 130.)

Epicærus imbricatus briefly treated (p. 117), and list of food plants given, including the beet.

1889

CASSIDY, JAMES.—Notes on Insects and Insecticides. (Bull. 6, Col. Agr. Exper. Station, p. 18.)

Systena mitis (=*tæniata*) reported to injure beets, etc.

1890.

LINTNER, J. A.—Notices of Various Insects. (Sixth Rep State Ent N.Y., pp 109–155.)

Epicauta vittata extensively treated (p 132), and beets mentioned among food plants.

WEBSTER, F. M.—Notes on Garden Insects. (Insect Life, Vol. III., pp. 148–151. Subjoined statement also in Trans Ind. Hort Soc, 1890, p. 26.)

Reports beets on grounds of the Indiana Experiment Station seriously injured by *Systena blanda* (=*tæniata*).

1891.

BRUNER, LAWRENCE.—Report on Nebraska Insects. Beet Insects. (Bull. No. 23, U. S. Dept. Agr., Div. Ent. pp. 11–18.)

General description of insect injury to beets in Nebraska during summer of 1890. Notes use of growing beets for shelter against the sun by many insects not feeding upon them Insect enemies of sugar beets mostly general weed-feeders, especially

those infesting tumble-weeds, pigweed, purslane, and other juicy weeds. None found exclusively injurious to beet. Only very few considered destructive. Those recognized either leaf-feeders or root-borers. Publishes list of sixty-four species with brief notes upon injuries by each. Advises clean culture, and use of arsenical sprays except for suctorial insects, and for these the kerosene emulsion.

BRUNER, LAWRENCE.—Notes on Beet Insects. (Insect Life, Vol. III., No. 5, pp. 229, 230)

Author's abstract of article read at the second annual meeting of the Association of Economic Entomologists, held at Champaign, Ill., Nov. 11–13, 1890. Consists mainly of list of sixty-four species found upon either leaves or root of the sugar beet. Notes fact that most of the common species are usually known as weed-feeding forms.

BRUNER, LAWRENCE.—Experiments in the Culture of the Sugar Beet in Nebraska. Insect Enemies. (Bull. No. 16, Neb. Agr. Exper. Station, Vol. IV., Art. I., Sugar Beet Series No. II., pp. 55–72; and Fifth Ann. Rep. Neb. Agr. Exper. Station, pp. 55–72.)

General article, discussing the garden web-worm, several flea-beetles, blister-beetles, true bugs, leaf-hoppers, cutworms, and wireworms, giving descriptions, illustrations, habits, and life histories of several of them, with description of injuries to beets and other food plants, and recommendation of remedies.

OSBORN, HERBERT, and GOSSARD, H. A.—Some Insect Enemies of the Sugar Beet. (Bull. No. 15, Iowa Agr. Exper. Station, Nov. 1891, pp. 265–272.)

General article, including observations made at Ames, Ia., with matter compiled mainly from Bruner. Discusses cutworms, grasshoppers, blister-beetles, flea-beetles wireworms, true bugs, the clover leaf-hopper, beet lice, and "Insects associated with rotting in Beets."

WASHBURN, F. L.—A Sugar-Beet Beetle (*Monoxia guttulata*). (Bull. No. 14, Oregon Agr. Exper. Station, p. 11; Noticed in Bull. No. 26, U. S. Dept. Agr., Div. Ent., p. 11, and in Bull. No. 18, N. S., p. 95.)

Reported as quite destructive to sugar beets in Oregon. A solution of Paris green—half a pound to fifty gallons of water—with the addition of three pounds of whale-oil soap killed the beetles, but six weeks later they were again at work. Double the above strength of poison was used without injury to the beet leaf.

1892.

BRUNER, LAWRENCE.—Notes on certain Caterpillars attacking Sugar Beets. (Bull. No. 24, Neb. Agr. Exper. Station, Vol. V., Art. II., Sugar Beet Series, No. IV., pp. 3–7; Sixth Ann. Rep. Neb. Agr. Exper. Station, App., pp. 47–51.)

Description of food plants and natural history of some of the garden web-worms, with illustrations of *Euryoreon similis* (after Riley). Natural and artificial remedies.

BRUNER, LAWRENCE.—Report upon Insect Depredations in Nebraska for 1891. Sugar Beet Insects. (Bull. No. 26, U. S. Dept. Agr., Div. Ent., pp. 10, 11.)

Adds two species to list of Nebraska beet insects, and two others are reported from Oregon. Notes abundance of cutworms, which almost destroyed entire crop on two Experiment Station plats. Observation indicating that fall plowing followed by spring plowing may prevent injury.

NICHOLSON, H. H., and LLOYD, RACHEL.—Experiments in the Culture of the Sugar Beet in Nebraska. (Bull. No. 21, Neb. Agr. Exper. Station, Vol. V., Art. I., Sugar Beet Series No. III., p. 15; Sixth Ann. Rep. Neb. Agr. Exper. Station, App., p. 15.)

Mention of injury to beets by cutworms. Amount of injury as related to previous crop. Destruction by poisoning.

SHAW, G. W.—Sugar Beet. (Oregon Agr. Exper. Station, Bull. No. 17, p. 15; Bull. No. 44, p. 36.)

Under "Enemies," *Monoxia guttulata* (see Washburn, 1891), *Phyllotreta decipiens*, and cutworms are reported as injurious.

1893.

BRUNER, LAWRENCE.—Report upon Insect Injuries in Nebraska during the Summer of 1892. Beet Insects. (Bull. No. 30, U. S. Dept. Agr., Div. Ent., pp. 36–41.)

Describes injuries by *Hadronema militaris*, blister-beetles, white grubs (*Lachnosterna*), the beet web-worm (*Loxostege sticticalis*), the garden web-worm (*Loxostege similalis*), *Silpha opaca*, and species of *Mamestra* and *Anthomyia*. Gives also remedies and preventive measures for blister-beetles and white grubs, and notes on the life histories of *L. sticticalis* and *Anthomyia*.

BRUNER, LAWRENCE.—Something about a few of the Insect Enemies of the Sugar Beet. (Bull. No. 27, Neb. Agr. Exper. Station, Vol. VI., Art. I., Sugar Beet Series, No. V., pp. 30–33.)

General preliminary discussion of insects injuring beets in Nebraska, including *Hadronema militaris* (quite numerous), two or three leaf-hoppers not specified, white grubs (destroying in one case fully fifteen per cent. of the beets), and two or more species of web-worms, the injuries and life history of one of which (*Loxostege sticticalis*) is briefly summarized. Results of experiments with arsenical and kerosene sprays were favorable. Expenses of spraying estimated.

LINTNER, J. A.—Beet Insects. (Cultivator and Country Gentleman, Vol. LVI., July 16, 1891, p. 577; Ninth Ann. Rep. on the Injurious and other Insects of the State of New York, pp. 374–376.)

Describes injuries to beet leaves submitted for examination. Infers attack by tarnished plant-bug, flea beetles, and leaf-miners. Advises use of kerosene emulsion.

RILEY, C. V.—The Sugar Beet Web-worm. *Loxostege sticticalis* Linn. (Rep. of the Entomologist, in Ann. Rep. Dept. Agr. for 1892, pp. 172–175, Pl. VI., Fig. 1–3.)

Account of outbreaks of this insect in Nebraska beet-fields in 1891 and 1892, with details of its successful treatment with Paris green. Life history given so far as known; also brief descriptions of egg and larva. Moth and larva contrasted with corresponding stages of the "so-called garden web-worm."

RILEY, C. V., and HOWARD, L. O.—The Sugar Beet Web-worm. (Insect Life, Vol. V., July, pp. 320–322. Four figures.)

Notes additional to the above, with account of experimental economic measures for the destruction of the larval cases in fall. Conclusion reached that most of larvæ left undisturbed in beet fields will transform to adults and stock the beet plantations with their eggs—probably in June. Three generations believed to occur. Recommends application of Paris green solution on first appearance of larvæ.

1894.

BRUNER, LAWRENCE.—Report on Injurious Insects in Nebraska and Adjoining Districts. Sugar Beet Insects. (Bull. No. 32, U. S. Dept. Agr., Div. Ent., p. 18.)

Account of "*Tanymecus confertus* as a Sugar Beet Enemy."

HOWARD, L. O.—Completed Life-history of the Sugar Beet Web-worm. (Insect Life, Vol. VI., pp. 369–373, Fig. 30, 31.)

HUSTON, H. A.—Sugar Beets. (Bull. No. 49, Purdue Univ. Agr. Exper. Station, Vol. V., March.)

Under "Injury from Insects" (p. 33), damage by *Epicauta marginata* (=*cinerea*) recorded, with note of remedy used.

PIPER, C. V.—Small punctured flea-beetle (*Psylliodes punctulata*). (The Ranch June 23, 1894.)

Damage to Sugar beets. Remedies.

1895.

GILLETTE, C. P., and BAKER, CARL F.—A Preliminary List of the Hemiptera of Colorado. (Bull. No. 31, Tech. Ser., No. 1, Col. Agr. Exper. Station. 137 pp.)

Record from sugar beets the following species: *Nysius minutus* (p. 22), *Geocoris pallens* (p. 24), *Lygus pratensis* (p. 36), *Agallia uhleri* (p. 81), *Platymetopius acutus* (p. 84), *Thamnotettix* (=*Eutettix*) *tenella* (p. 100), *Gnathodus abdominalis* (p. 104), and *Dactylopius solani?* (p. 126); and from "cultivated beet," *Thamnotettix* (=*Eutettix*) *belli* (p. 94).

HOWARD, L. O.—The Beet-Leaf Pegomyia (*Pegomyia vicina* Lintn.). (Insect Life, Vol. VII., p. 379.)

Account of its injuries in sugar-beet fields in California. Figure.

1896.

OSBORN, HERBERT.—Spraying Mangels for Blister Beetle [*Epicauta pennsylvanica*] (Bull. No. 33, Iowa Agr. Coll. Exper. Station, pp. 597, 598.)

A solution of London purple, one pound to two hundred gallons of water, was found to be a very satisfactory spray, costing about one dollar an acre. When sugar beets are attacked by this insect the same treatment, it is said, will be found effective.

QUAINTANCE, A. L.—Insects Affecting the Beet. (Bull. No. 34, Fla. Agr. Exper. Station, March, 1896, pp. 264–266.)

Brief general account of blister-beetles, cutworms, and wireworms, with reference to miscellaneous insects affecting the beet.

SIRRINE, F. A.—The Spinach Leaf Maggot or Miner, *Pegomyia vicina*. (Fourteenth Ann. Rep. Bd. of Control, N. Y. Agr. Exper. Station, pp. 625–633, Pl. IV.)

General article. Known only to feed on *Chenopodium*, beets, and spinach.

1898.

CHITTENDEN, F. H.—A New Sugar-Beet Beetle. (Bull. No. 18, N. S., U. S. Dept. Agr., Div. Ent., p. 95.)

Reports serious local injury to sugar beet by *Monoxia puncticollis* in N. Mex. Gives correspondent's notes on life history. Principal damage by larva.

SAUNDERS, D. A.—Four Injurious Insects. (Bull. No. 57, U. S. Exper. Station, S. Dak., pp. 35–52.)

Lioderma (=*Pentatoma*) *uhleri* and *Epicauta maculata* treated. Said to attack beets; the former new as a beet insect.

SAYLOR, CHAS. F.—Beet-Sugar Industry in the United States. (House Document 396, 55th Congress, 2d Session; Separate Reprint. 72 pp.)

On pp. 224 and 231 are given answers by correspondents in Nebraska, California, and New Mexico to the question, "What are the obstacles you encounter, including diseases, insects, etc.?"

WILCOX, E. V.—An Army Cutworm. (Bull. No. 17, Mont. Agr. Exper. Station, pp. 10–18.)

Description of an excessive outbreak of *Chorizagrotis agrestis*, with an extensive list of plants attacked, including beets.

1899.

COCKERELL, T. D. A.—*Megetra vittata* injuring Sugar Beets. (Ent. News, Vol. X., p. 44.)

Reported by a correspondent in New Mexico. Comment on coloration of the two specimens sent.

FELT, E. P.—Notes of the Year for New York. (Bull. No. 20, N. S., U. S. Dept. Agr., Div. Ent., p. 60.)

Reports injury by *Systena frontalis* to sugar beets in N. Y. Insect killed by spraying with Paris green.

GILLETTE, C. P.—The Sugar-Beet Caterpillar. (Special Press Bulletin, Col. Agr. Exper. Station, Aug. 19, 1899.)

Injuries to sugar beets in Colorado by *Laphygma flavimaculata* reported. Spraying with Paris green recommended.

PETTIT, RUFUS H.—Some Insects of the Year 1898. 13. Leaf-miner in Sugar-Beet. (Bull. 175, Mich. State Agr. Coll. Exper. Station, pp. 356, 357, Fig. 14.)

Pegomyia vicina reported mining sugar-beet leaves in Michigan. Imago figured.

STONE, J. L.—Sugar-Beet Investigations for 1898. Part I. Observations and Conclusions based upon a Study of Field Conditions. (Bull. 166, Cornell Univ. Agr. Exper. Station, March, pp. 419–438.)

"Enemies of the Beet Crop" (p. 425); *Systena tæniata*, *S. hudsonias*, and *Pegomyia vicina* reported as common beet feeders, but no considerable damage done.

1900.

CHITTENDEN, F. H.—The Pale-striped Flea-beetle (*Systena blanda* Mels.). (Bull. No. 23, N. S., U. S. Dept. Agr., Div. Ent., pp. 22–29.)

Detailed account of this species as an enemy of cultivated plants, including sugar beets.

DOANE, R. W.—A New Sugar Beet Insect, and other Insects attacking the Beet. (Bull. No. 42, Wash. State Agr. Exper. Station. 14 pp., 4 figures.)

Detailed account of the beet aphis (*Pemphigus betæ*) and its injuries to sugar beets; also brief treatment of flea-beetles,—especially *Psylliodes punctulata*,—and of cutworms,—in particular *Carneades messoria*,—as beet insects.

DOANE, R. W.—Notes on a New Sugar-Beet Pest, with a Description of the Species. (Ent. News, Vol. XI., No. 3, pp. 390, 391.)

Description of *Pemphigus betæ*, with note of extent and character of its injuries to the sugar beet in Washington State, and a brief account of its life history.

GILLETTE, C. P.—The Beet Army Worm (*Laphygma flavimaculata*). (The Sugar Beet, July, 1900, p. 103*; Twelfth Ann. Rep. Col. Agr. Exper. Station, p. 39—briefer account of same outbreak.)

Account of injuries to beets in Colorado in August, 1899. Many acres completely stripped of foliage; body of the beet also injured. Items of life history given. Arsenical poisons tested successfully. Arsenate of lead preferred. One pound to a hundred gallons of water used without injury to beets. Occurrence of insect reported at various Colorado points and at Lehi, Utah. Figure of injured beets.

*Received after the paragraphs on this species (in preceding article) were in type.

ERRATA.—On page 75, under *Eutettix tenella* Uhl., the synonym *Thamnotettix tenella* Uhl. should have been placed; and on page 113 the foot-note citation should be to page 53. Yellow-*back*, line 1, page 116, should read yellow-*black*.

All the figures of the plates except Fig. 1, Plate III., and Figures 29, 31, 58, 65, 72, 84, and 85 in the text, drawn by the Artist of the State Laboratory of Natural History, Miss L. M. Hart, are published in this paper for the first time. Figures 18–21, 27, 28, 30, 39–41, 45, 49, 53, 55, 56, 60, 69–71, 73, 74, 76, 81, 86, 88, and 89–97 have all been published in the Reports of the State Entomologist of Illinois.

ADDITIONAL ERRATA.

Page 75, line 6 from bottom, for "*the next species*" read *Phlepsius irroratus*.

Page 78, line 15 from bottom, for *Aletra* read *Alebra*

Page 115, last paragraph, dele third sentence.

Page 128, line 15 from bottom, for *Pezotettix* read *Melanoplus*.

Page 131, line 14, for *femorale* read *nemorale*.

Page 149, line 8 from bottom, for *none* read *one*.

PLATE I.

Fig. 1. *Stobera tricarinata.*

Fig. 2. *Liburnia puella.*

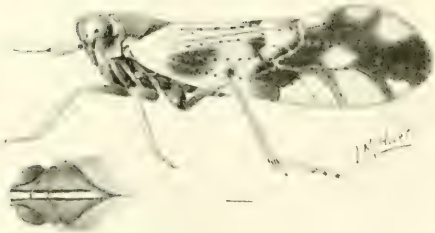

Fig. 3. *Liburnia ornata.*

DELPHACINE LEAF-HOPPERS.

PLATE II.

Fig. 1. *Cicadula sexnotata.*

Fig. 2. *Deltocephalus nigrifrons.*

Fig. 3. *Empoasca mali.*

Fig. 4. *Empoasca flavescens.*

GREEN LEAF-HOPPERS.

PLATE III.

Fig. 1. The Grape Leaf-hoppers, *Typhlocyba*. Leaf showing effect of injury, and, on under side, the cast skins and the young; at left, young of different ages; at right, adults of *T. vulnerata* (upper) and *T. comes* (lower). (Lugger.)

Fig. 2. *Phlepsius irroratus.*

Fig. 3. The False Flea-hopper, *Agalliastes associatus.*

PLATE IV.

Fig. 1. The Green Leaf-bug, *Macrocoleus chlorionis.*

Fig. 2. The Three-spotted Flea-beetle, *Disonycha triangularis.*

PLATE V.

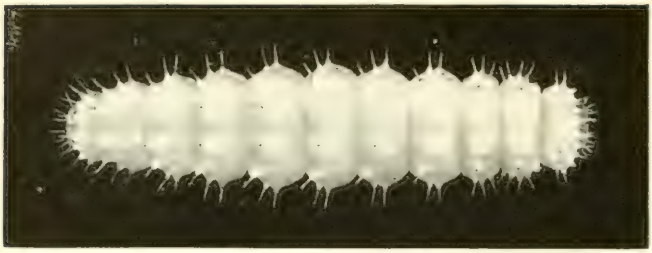

Fig. 1. Larva, dorsal view

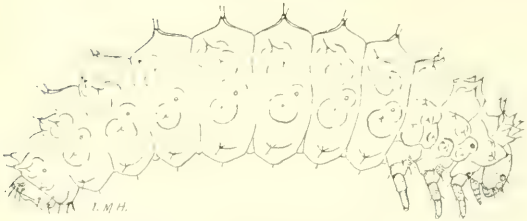

Fig. 2. Larva, side view.

Fig 3. Face of larva.

Fig. 5. Adult

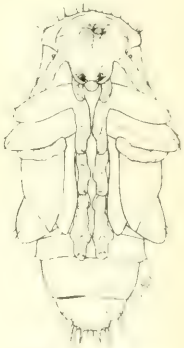

Fig 4. Pupa.

Fig. 6. Eggs on leaf.

THE YELLOW-BLACK FLEA-BEETLE, DISONYCHA XANTHOMELÆNA.

PLATE VI.

Fig. 1. Beet-leaf riddled by the Yellow-Black Flea-beetle, *Disonycha xanthomelæna*.

PLATE VII.

Fig. 1. *Epitrix brevis.*

Fig. 2. *Glyptina brunnea.*

PLATE VIII.

Fig. 1. The Smartweed Flea-beetle, *Systena hudsonias.*

Fig. 2. The Red-headed Flea-beetle, *Systena frontalis.*

FLEA-BEETLES. SYSTENA.

PLATE IX.

Fig. 1. The Grape-vine Colaspis, *Colaspis brunnea.*

Fig. 2. The Muck Beetle, *Ligyrus gibbosus.*

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