Ohio Agricultural Experiment Station.

BULLETIN 106.

WOOSTER, OHIO, APRIL 1899.

THE CHINCH BUG.

EXPERIMENTS WITH INSECTICIDES.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 106. APRIL, 1899.

I. THE CHINCH BUG. II. EXPERIMENTS WITH INSECTICIDES.

BY F. M. WEBSTER.

I. THE CHINCH BUG.

In both bulletins 69 and 77, I called attention to the fact that there are in Ohio two forms of chinch bug. In one form the wings are always of the ordinary length, fitting the possessor for flying, (Fig. 1), and in

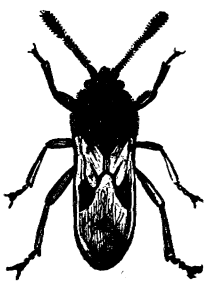


FIG. 1.

the other, in many cases and sometimes in the majority, the wings are so abbreviated as to render them useless as a means of locomotion. In these last the wings are not all of equal length, but vary in different individuals from almost a total absence to nearly or quite full winged, as is illustrated in Figs. 2, 3, 4, 5. All of these figures are enlarged and the natural length is indicated by the line under Fig. 1. This form, including large numbers of the short-winged individuals, seems to occupy only

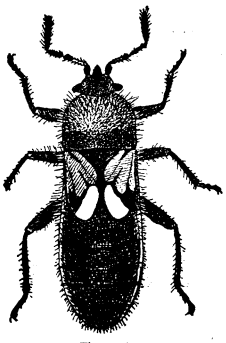


FIG. 2.

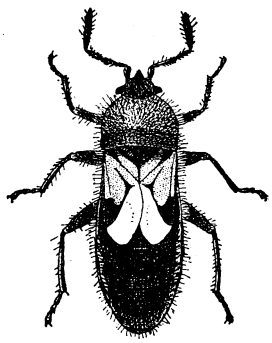


FIG. 3.

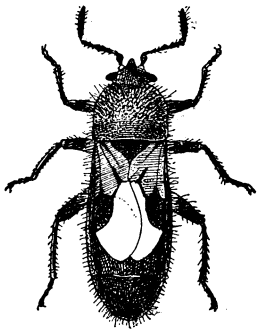


FIG. 4.

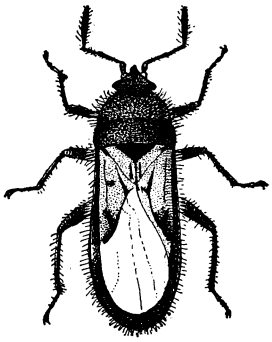


FIG. 5.

certain portions of the state and there depredates exclusively or largely on timothy, while the fully winged form covers the larger portion of the remainder of the state, depredating nearly if not quite exclusively upon the principal grain crops.

OCCURRENCE OF THE LONG AND SHORT WINGED FORMS AND THEIR DISTRIBUTION.

The occurrence of both the long and short-winged forms, intermixed along our seacoasts and in the northeastern section of the country, but not elsewhere, shows very plainly that this dimorphism is not due to the temperature of any particular locality, but must be regarded as having been brought about by disuse of the wings for a considerable period of time, thus indicating a seashore habit on the one side, while the total lack of the short-winged form elsewhere indicates otherwise.

In a paper presented before the Entomological Society of Washington,[1] "On the insects found on *Uniola panicula* in southeastern Florida," by Mr. E. A. Schwarz, the author stated that *Blissus leucopterus* occurred in large numbers on the upper part of the plant, the imagos and larger young among the ears, and the smaller individuals between the upper

[1] Proc. Ent. Soc., Washington, Vol. I, p. 104. Read Nov. 3, 1887.

blades. Mr. Schwarz attributes this habit to the tough, woody nature of the storm-beaten plant near the ground, thereby driving the insects to the more tender, though more exposed portion of the plant. In connection with this statement the writer tells us that the insect occurs in that southern latitude only in the short-winged form, and that in the examination of thousands of specimens from that region he had never found a single long-winged specimen.

In the Annual Report of the Florida Experiment Station for 1898, Assistant Biologist, Mr. A. L. Quaintance, states that during the summer of that year, chinch bugs appeared at several localities in that state, notably, St. Augustine, Belleview, Palatka and Lake City, depredating upon the grass of lawns. At Lake City, the bugs, both old and young, confined their attacks mainly to the lower portions of the grass both the long and short-winged forms being present, the former in much the majority. Dr. L. O. Howard has witnessed a similar attack on the lawns in the city of Brooklyn, N. Y., the injury in this case being due to attacks of the short-winged form.

Under date of May 4, 1896, Mr. W. H. Harrington wrote me of this species as follows: "In September, 1890, I found it at Aulac, almost on the border between New Brunswick and Nova Scotia. It seemed not uncommon and occurred under stones, about the roots of grass, in a pasture adjoining the marsh where I found *Diabrotica longicornis,* the pasture being on the upland skirting the marsh. Both the long and short-winged condition occurred, as in Cape Breton."[2] Dr. A. S. Packard communicated to Dr. J. A. Lintner the following extract from his diary: "June 17, 1871, at Salem, Mass., chinch bugs with wing covers extending over the basal third of the abdomen, seen in copula, end to end."[3] In the serious outbreak of this insect in the timothy meadows of northern New York, in 1882 and 1883, about 20 per cent of the bugs were of this short-winged form.[4]

Although Dr. Asa Fitch, as early as 1855, refers to this form along with nine others, he does not give the source from which he obtained specimens, but just previous to this he says (p. 287) that he had met with but three specimens from his own State, and these were found on willow in the spring of 1847.[5] Had any of these been of the short-winged form he would have been very likely to have mentioned the fact. Mr. E. P. Van Duzee[6] states that he had known of the occurrence of the species in western New York as early as 1874, and had also found it at Ridgeway and Muskoka, Ontario. Ordinarily the short-winged form predominates, but in hot, dry summers they mostly acquire

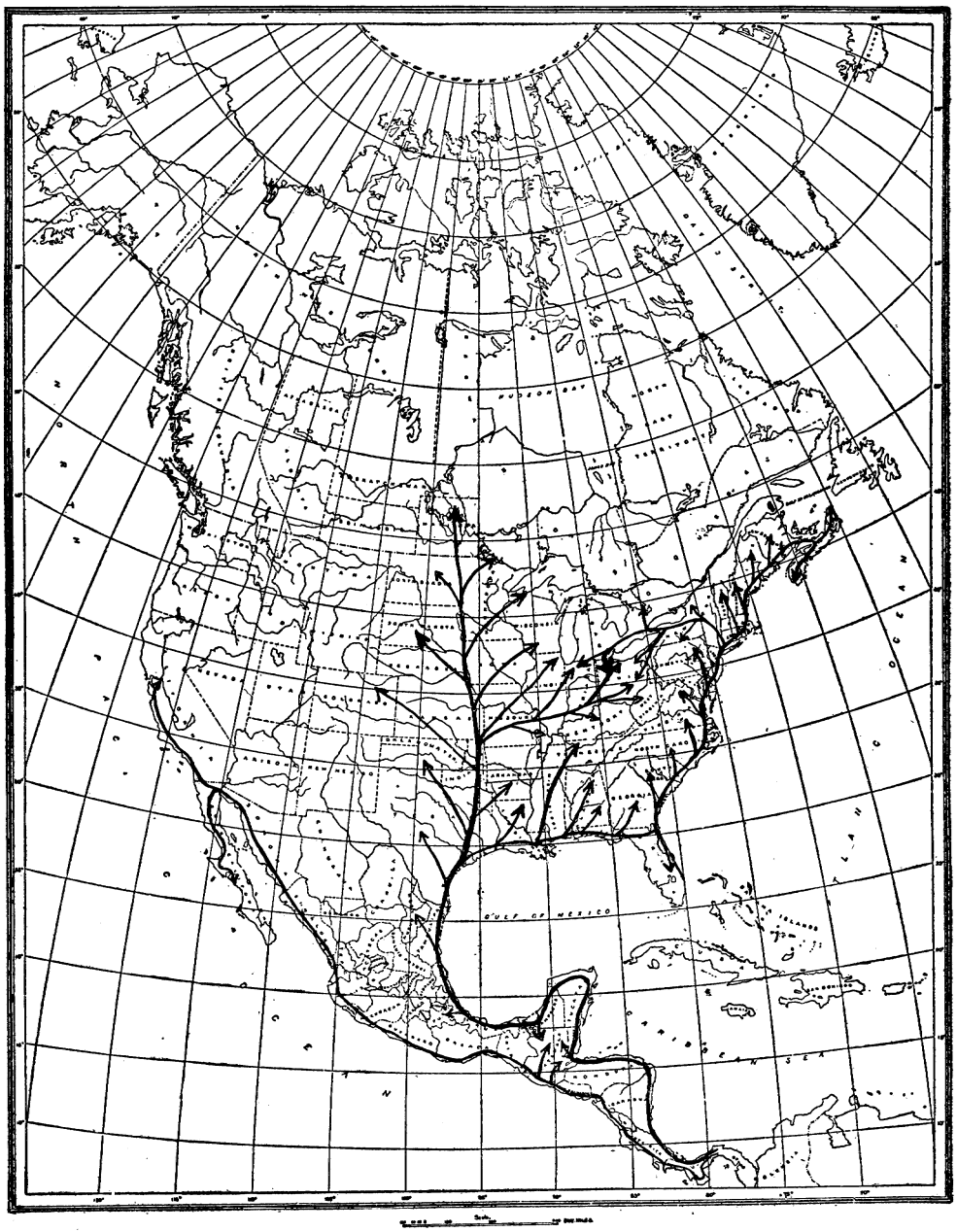
[2] Canadian Entomologist, Vol. XVI, p. 218.
[3] Lintner's Second Report, State Entomologist of New York, p. 164.
[4] Loc. cit., State Entomologist of New York, p. 156.
[5] Second Report on Noxious Insects of New York, p. 291.
[6] Canadian Entomologist, Vol. XVIII, pp. 209–10, 1886.

fully developed wings. He had never found the species in grain fields of any sort, but always on grass lands, generally in timothy or clover, but sometimes in wild grasses. Of eleven specimens collected from under the bark of an old log by Mr. J. Pettit, of Grimsby, Ontario, in 1866, and sent to Mr. B. D. Walsh for determination, all were of the short-winged form.[7] It was these specimens that, doubtless, led Dr. Riley to call attention to the fact[8] that, in Europe, there are many genera of half-winged bugs which occur in two distinct or "dimorphous" forms with no intermediate grades between the two, viz., a short-winged, or sometimes a completely wingless type, and a long-winged type. Frequently the two occur together and copulate promiscuously, while, sometimes, the long-winged type occurs in particular seasons, especially in very hot seasons, while more rarely the short-winged type occurs in a different locality from the long-winged type, and usually in that case in a more northern region. In northeastern Ohio the species occurs during some years in great abundance and very largely at least on timothy. Here the short-winged form is very largely in the majority, and in the spring of 1897, of 1,900 specimens collected indiscriminately, only about 400 were of the long-winged type. In May, 1898, of 66 specimens sent from a field of young corn that had been planted on newly broken timothy meadow that was injured the year previous, all were of the short-winged form. The former lot were from a timothy meadow near Youngstown, while the latter were from near Salem. Of a large number of adults that were hibernating among the dead leaves in vineyards not far from the shores of Lake Erie, northwestern Ohio, not a single individual of the short-winged form was found, although they occurred among the timothy meadows in that immediate vicinity. During the summer of 1898 there was widespread injury to timothy meadows in Huron and adjacent counties. This was supposed by farmers to have been due to the extremely hot weather that followed the hay harvest, but an examination of these meadows near New London, in March of the present year, revealed the fact that they were over-run with the short-winged form. A single short-winged individual was found at Bellville, in the fall of 1898, and two individuals, also of this form, were found near Stonelick, in Clermont county, in corn fodder that had been left over from the wintered-over shocks standing in the field. It seems quite probable that northwestern Ohio, together with northern Indiana, is populated by this form, and it is fair to assume that intermixed among these are many of the western form, and the presence of these, in this section, may perhaps be accounted for by the trend of the migrations of the insect in the United States east of the Rocky Mountains, as indicated by the accompanying map. But, aside from the localities indicated, with an acquaintance with this species running over forty years, chiefly in Indiana, Illinois, and Ohio, I have never met with the

[7] Practical Entomologist, Vol. II, p. 21.

[8] Second Report on the Insects of Missouri, p. 22, 1870.

short-winged type, though I have seen millions of adults. If this short-winged type occurs elsewhere to the westward, except along the Pacific coast, where both forms have been collected by Koebele and others, it has not been found by entomologists, even to the northward as far as



Map showing probable diffusion of chinch bug in North and Central America.

Minnesota, Winnipeg, and Manitoba, while to the eastward of this Mr. Van Duzee collected the short-winged form on Muskoko River, Ontario, near the lake of that name.[9] On comparing specimens from New York with a large series from Kansas, the former were found to be more uniformly robust, with longer hairs on the pronotum.[10]

It seems to me that we here have evidence of two distinct tides of migration, the one sweeping north and eastward, while the other has mainly been to the north and westward, meeting the former in northeastern Ohio and northern Indiana, and possibly somewhere farther to the north in British America. The two, besides differing in the length of the wings, are sufficiently unlike in appearance to attract the attention of students of Hemiptera. (See Map).

RELATIONS BETWEEN THE INLAND AND SEA-COAST SHORT-WINGED FORMS.

There seems but little doubt that the short-winged form of chinch bug, found in Ohio, had its origin along the Atlantic coast. Just why it is that this form occurs along the seacoasts of both the Atlantic and Pacific, is a problem as yet unsolved; but there is now little doubt of their belonging to the same species. It would seem, then, that we might reasonably assume that the species was originally long-winged; but, living along the seashore, the winged individuals have either flown each year inland, or else have been blown into the sea to such an extent that a short-winged form has thus been evolved which was unable to migrate and not easily blown into the water. In pushing inland while the country was still inhabited by the aborigines, another source of destruction would confront these insects in the annual recurrence of fires, whereby vast areas of country were burnt over in autumn, winter, or early spring, and these must have destroyed very many of the hibernating insects, while such individuals as migrated to sections not so burned over would escape destruction.

PROBABLE COURSE OF DIFFUSION.

Let us suppose that the species originally worked its way northward from South America, or even Panama, along the lowlands between the more mountainous interior and the Gulf of Mexico until it reached Texas, with its vast areas of level country extending, not only across the state itself, but northward into British America, and, generally speaking, with the exception of the Ozark mountains in Missouri and Arkansas, eastward to the Appalachian system extending from Cape Gaspe, Quebec, Canada, to northern Alabama. This area is more or less covered with a grass flora that affords ample food for these insects, and it would seem that there was here offered every incentive to migration broadly to the north-

[9] Can. Ent. Vol. XXI, p. 3, 1889.
[10] Loc. cit. Vol. XVIII, p. 209.

ward and eastward, and at the same time there would be the Gulf coast, along which those individuals which either could not or did not migrate inland, could make their way as had their progenitors along the coast in Mexico. (See map).

On the other hand, we might expect the shore-inhabiting individuals to continue in their progress along the coast, the winged individuals continually migrating inland, leaving a mixture of the two forms to push forward to the east coast of Florida and northward along the Atlantic to Cape Breton. As soon as this migration had passed the southern terminus of the Allegheny mountains, the inland spread would, very lagrely at least, be restricted to the area lying between the eastern slope of these mountains and the coast, thus leaving the whole area to the west to be occupied by the northward tide of migration instead of that from the east. East of the Mississippi River and south of the Ohio River, the country is more heavily timbered and the prairies are lacking, so that forest fires would here take the place of prairie fires; but in the Southern States the woods are composed more largely of pine, and Dr. Lugger, in Minnesota, finds that the chinch bug does not invade the region on which only pine and other Coniferæ grow, but that the more southern counties of this state, which are well wooded with deciduous trees, are invaded. He also calls attention to the fact that, before the country was settled by the whites, these timbered lands were burned over frequently, probably annually, but now the wooded areas are confined to small tracts interspersed among the farms, and as these are not annually burned over, they afford suitable shelters for the chinch bug during winter, and the grain fields of the farmer afford ample food during the summer, while on the prairies which are burned over such is not the case.[11]

Along the eastern coast the chinch bug has never been especially destructive to the wheat crop north of North Carolina, where, according to Dr. Fitch, the earliest depredations occurred in 1783,[12] while Webster[13] states that it threatened total destruction to the grain in 1785; but since that time the ravages have not been nearly as severe as farther west in the Mississippi valley. Strangely, too, nowhere along the Atlantic coast do we find the short-winged form far inland until we reach New York and the New England states, and, what is equally perplexing, there it does not attack grain, but grass, whereas to the southward it is the grain fields that are devastated. In other words, throughout New England, New York, northeastern and northwestern Ohio, northern Indiana, and the Dominion of Canada we have both the long and short-winged forms occur-

[11] First Annual Report of the Entomologist of the State Experiment Station of the University of Minnesota, 1895, p. 26.

[12] Second Report on Noxious, Beneficial, and other insects of New York, p. 278.

[13] Webster on Pestilence, Vol. I, 279.

ring together, but depredating almost or quite exclusively upon timothy (*Phleum pratense*).

So far as it is possible to determine, there are a considerable number of winged adults produced in this area every year — perhaps from 30 to 50 per cent some seasons — and these breed in the grain fields; but at wheat harvest, instead of migrating to the corn, as is done elsewhere, they go by preference to the timothy meadows. In western New York, where both the long and short-winged forms occur, Mr. Van Duzee writes me that he has never found an individual of either form in grain fields, but that they both literally swarm in timothy during some years. Dr. Lintner told me that in the serious outbreak of this pest in the meadows of New York in 1882 and 1883 about 20 per cent were of the short-winged form. Dr. Perkins has recorded an attack of chinch bug in a timothy meadow in northern Vermont. Whether or not the short-winged form was the depredator in this last-named locality I am unable to say, but, generally speaking, the short-winged form is unknown at any considerable distance from the coast, except in New York, Ohio, Ontario, and northern Indiana, and but rarely does it occur in either form in the two latter localities.

Just why this short-winged form should occur in such abundance in the two States named is a matter that I am just at present unable fully to explain; but it does seem that this difference in food habits as between the two forms and the limited distribution of the short-winged form inland might open the way to a solution of the mystery. I believe that the insect is primarily a tropical long-winged species, and that it has followed the coast from South America along the Gulf and Atlantic northward to Cape Breton, and along the Pacific coast to San Francisco and possibly beyond; also that it spread from northern Mexico and Texas northward as far as Winnepeg, subsisting upon the native grasses, and in the meantime spreading also to the eastward to northern Indiana and Ohio, and that during this time, by force of circumstances, all trace of its former apterous condition, if such existed, has disappeared.

On the other hand, from the Atlantic coast there has originated a tide of diffusion the trend of which has been westward, the species here partaking more of the nature of their seashore ancestry, and are more or less of the short-winged form, which their less nomadic habit has served to further emphasize. This tide of diffusion has encountered what the western tide did not, at least until much later, namely, the timothy meadows of the Caucasian agriculturist, and, adapting itself to this food plant, has held closely to it, thus avoiding the necessity of seasonal migration; and that in northeastern Ohio and possibly in northern Indiana and northwestern Ohio it has met the east-bound tide of diffusion, and is probably amalgamating with it. (See map, illustrating supposed direction of diffusion of chinch bug.)

Although not at all conclusive evidence, I might add that the single specimen taken at Winnepeg by Dr. Fletcher was of the long-winged form, while the single example taken by Mr. Van Duzee at Muskoka, Canada, was of the short-winged form; and this, with the fact that the specimens from the island of Granada were of the former and the Florida coast specimens of the latter exclusively, shows that latitude and climate have no effect.

For the farmer, engaged in attempts to check the ravages of the insect in his fields the question of origin, or how it came to reach him, will, at the time, have little interest for him. It will suffice that it is present in overwhelming numbers, and what he will most desire will be to learn how to rid his premises of its most unwelcome presence in the most summary manner possible.

If, however, the farmer happens to be a thoughtful and observing man he will sometimes wonder how it is that, except in Virginia and the Carolinas, a person need not be very aged in order to remember a time when the chinch bug was an unknown factor in his profession, with a possible value far too small to merit consideration. If he happens to reside in northeastern Ohio or in some portions of New York, and has spent some time in Illinois, Iowa, Kansas, or Minnesota, he will probably marvel at the striking difference in appearance between many of the chinch bugs of his own locality and those found in any of the last mentioned States, and will probably be able to satisfy himself of their identity only by the similarity of their vile odor. Again, he will probably be equally at a loss to understand why it is that his own timothy meadows are overrun by these pestiferous insects and destroyed, while in other localities, perhaps less than 100 miles away, similar meadows are left untouched, the injury there being confined to the wheat and corn fields.

If wondering leads to questioning, as it often does among the constantly increasing number of educated and up-to-date farmers, it will not satisfy him to receive an evasive or obscure reply to his query as to why such differences exist, for if he can not get a clear explanation he will want ideas, theories, or possibilities. He wants the best explanation possible to give until some one finds out a better one, realizing that had mankind been perfectly satisfied with the knowledge that a stroke of lightning would split a tree or destroy human life, and had stubbornly refused to listen to possibilities or to anything but facts, we would not now be able to understand and utilize electricity in the many ways that we do at the present time. Such men understand, perfectly, that the solution of most problems in natural science must of necessity commence with theories which must be patiently tested and adopted or rejected as the results demand, while the scientific man knows that the solution of one problem often opens up the way for the

soluton of another, the last not infrequently having an entirely different application from the first.

The science of applied entomology is growing rapidly and becoming both broader and deeper, and it is not enough to simply tell the husbandman what an insect is and how to kill it. He must have something along with that information to set his own mind to thinking, to work out problems or improve upon the solutions already given him, otherwise it is much like giving money to a professional beggar. If we can not give facts based upon demonstrations, then give the best explanation possible, even though it be a theory which is only expected to stand until some one does better. It is for the thoughtful, progressive farmer, as well as the student of geographical distribution, that this possible solution of the problem of the chinch bug has been prepared, and while the full practical value of the ideas advanced has yet to be demonstrated, this of itself can not be urged as sufficient grounds for not sending it forth for study and consideration.

NUMBER OF ANNUAL GENERATIONS.

Over the most of its area of habitation, in North America at least, the chinch bug is two brooded, though in northeastern Ohio I have totally failed to detect the presence of a second brood.

My notes on the chinch bug in northeastern Ohio are as follows: Very young larvæ, with what appeared to be their progenitors, were observed at Jefferson, Ashtabula county, within 11 miles of the shores of Lake Erie, on June 16, 1893, no advanced larvæ being observed among them. On August 27, 1896, a few miles south, at West Andover, in the same county, I could find only adults in two days' search, though some of these showed by their color that they had but recently passed the pupal stage. In this latter locality, on May 7, 1897, the sexes were pairing, but no young were present, so far as could be observed, while to the south and west of this locality, on June 8 and 9, precisely the same conditions obtained as to the bugs, no young appearing at this time. Quite copious rains might have destroyed the young, but within 15 miles of these localities, on July 14 of this year also, I found larvæ after first molt and stages intervening between these and the adults. Near Youngstown, on October 3, 1897, I could find only adults and pairing was not in progress, and the insect was not pairing in Ashtabula County on August 27, 1896. June 9, 1898, only two very young larvæ could be found at Salem, about 15 miles southwest of Youngstown. October 17, 1898, no young of a second brood had been observed though careful search had been made from time to time in the fields and meadows of northeastern Ohio, and a large number of adults, which developed in July and August, and were since kept in confinement, had not only not reproduced but had shown no disposition whatever to pair. On the

other hand, in southwestern Ohio, in the vicinity of Cincinnati, on September 24, where the species occurred in abundance, fully seventy-five per cent were pupæ, the remainder being made up of larvæ, some of them quite young, and adults in about equal proportions, some of the latter showing by their immature colors that they had but just passed the pupal stage.

In the timothy meadows of northeastern Ohio and in Huron County, however, the principal injury is done during August and September, and in favorable weather on into October. Now if we allow sixty days for development from the egg, it would be September before the appearance of the adults of the brood to which these various young belonged. If all eggs were deposited immediately, it would be November before the adults of the second brood would begin to occur, a condition of affairs that has never been observed. On January 17, 1899, Mr. Mally found several pupæ at Gypsum, Ottawa County, but to which form these belonged it is impossible to say, and later examinations of meadows in Huron County revealed adults only.

In the light of the information that has been gained by these observations I am led to doubt the occurrence of a second brood of young in northeastern Ohio. Hatching is not fully in progress here before the 25th of June, only an occasional individual having passed the first molt before the 10th of July. The first brood is not fully developed before the first of September, and there certainly is no indication that a second brood of young is developed during September and October. It would seem then that from eastern Ohio through New York, New England, and probably to Nova Scotia, the adults from the first brood of larvæ winter over, and that there is here but one annual brood.

DIFFICULTY OF REACHING CHINCH BUGS IN MEADOWS.

There is some doubt in regard to the practicability of applying the ordinary remedial measures in meadows. Meadow lands can be burned over with perfect safety to either the grass or clover, if done while the ground is frozen, but there is danger of injury if burned over in spring, and it is somewhat doubtful if the hibernating chinch bugs would be killed unless the surface of the ground was heated to a degree that the grass and clover plants would hardly be able to withstand.

Infested areas of meadow land could be plowed, it is true; but the work would have to be done very carefully, else the grass and stubble would be left to protrude above ground along each furrow and constitute so many ladders by which the chinch bugs could easily crawl out and make their escape. Where the ground will admit of subsoiling, or a "jointer" plow can be used, this latter difficulty can easily be overcome. Usually, however, the chinch bug works too irregularly in a field to permit of plowing under infested areas without disfiguring it too

much for practical purposes, especially in the case of meadows, unless it be where the bugs have migrated *en masse* from an adjoining field, when a narrow strip along the border can often be sacrificed to good advantage. That corn, planted on meadow lands that had the previous year been ravaged by chinch bugs, is liable to serious injury, was fully illustrated by a field near Salem, Ohio, in 1898, where a large portion of the field was ruined by the bugs that had wintered over in the field, and which plowing and preparing the soil in early spring did not destroy. In order to be effective the plowing must be deep and all grass and other vegetation entirely covered, and the ground rolled and the surface packed. While chinch bugs, from meadows, died freely from the effects of the chinch bug fungus, in the insectary, the pest does not appear to suffer severely from its effects in the fields, and it is doubtful if it can be used as advantageously here as in grain fields. The position of the insect about the bulbs of the timothy plants tends to protect from attacks of quails or any other bird that would tend to reduce its numbers, and for some reason not at present clear to us, it is less affected by drenching rains while yet very young than is the species in grain fields. The indications are that we shall be obliged to devise some other repressive measures besides those that we already apply, in order to aid the farmers of northwestern and northeastern Ohio in fighting this pest in their fields.

At present I can only urge farmers in those portions of the State where the short-winged form is known to occur, to watch their meadows closely, and on observing large patches of timothy dying out after the hay harvest is over, to examine closely and learn the true nature of the depredator. If chinch bugs are found in large quantities, plow as deep as possible, turning entirely under and out of sight all vegetation, then promptly harrow down smoothly and roll the surface of the ground in order to prevent the bugs from crawling to the surface and making their escape.

II. EXPERIMENTS WITH INSECTICIDES.

Under this head I have brought together the details and results of experiments with a number of insecticides, including kainit. As some of these applications have been made against more than one species of insect, I have grouped them with reference to the insecticide, and not with reference to the purpose for which it was applied, or the insects treated.

EXPERIMENTS WITH KAINIT.

On October 8th, 1896, a number of applications of kainit were made by my assistant, Mr. C. W. Mally, under my directions, in the vineyard of Mr. William H. Slade of East Cleveland, in order to determine the effect of various amounts applied about the base of the vines, in order to test its effect upon the grape root worm, larvæ of the beetle *Fidia viticida.*

The kainit was applied in this way: — a small depression was excavated about the base of the vine, varying from 12 to 18 inches in radius, and also it was scattered over the surface of the ground between the rows of other vines. In the excavations, the strength varied from ½ pound to 8 pounds. The vines were not examined from the time the application was made, October 8th, 1896, until April 5th, 1897, thus giving both the fall and spring rains ample opportunity to dissolve the kainit and carry it down into the soil, where these worms were passing the intervening time. Careful examinations made, as above stated, did not indicate that the larvæ were affected in any way whatever, no dead ones being found, even on close examination, while living ones were as abundant as about the roots of untreated vines. In one case, especially, where an application of four pounds had been made, and the kainit piled up directly about the crown of the vine, the larvæ were observed working, apparently uninjured, in soil in which the kainit was clearly perceivable, numerous masses of the size of a pea being found. Samples of the soil from about the roots of some of these treated vines were secured and tested, to determine the penetrating power of the kainit.

The samples to be tested were taken in four series — the first from the strongest application, the second from the weakest, and the third to serve as a check, from untreated soil, while the fourth was taken from the special, 4-pound application previously mentioned. Each series was composed of three samples, the first being taken at the surface, the second from a depth of 4 to 5 inches, and the third from a depth of from 10 to 12 inches from the surface. The tests were made by Mr. L. M. Bloomfield, then Asistant Chemist of this Station.

Five hundred grams of each sample was digested in 1,000 cubic centimeters of distilled water, for twenty-four hours, and in 50 cubic centimeters of the filtrate, equal to 25 grams of soil. The chlorine was determined, volumetrically, by a solution of silver nitrate, 1 cubic centimeter of which was equal to 0.003546 gram of chlorine. The result of these tests is shown in the following table:

Series	Weight of kainit	Sample	Cubic Centimeters of Silver nitrate.
I	8 pounds	1	4.00
		2	5.00
		3	6.5
II	½ pound	1	1.1
		2	1.3
		3	1.2
III	Check	1	0.3
		2	0.5
		3	0.2
IV	4 pounds	1	8.2
		2	9.5
		3	11.1

These tests show that while there was slight trace of chlorine in the check soil, the treated samples tested very much higher, the strength increasing with the depth from which the sample was taken in the vineyard, except in case of the weakest; so that none of the larvæ observed, which in all cases were found above and not below sample No. 3, could have escaped whatever action the kainit might have had as it penetrated the soil.

These experiments and tests clearly show that the kainit will penetrate the soil to a depth sufficient for all practical purposes, but that it can hardly be made strong enough to be effectual against this pest; and, besides, it passes far beyond the limit of practicability in point of expense at the maximum strength given in the foregoing.

On October 14, 1897, three plats, each 1 rod square, were selected in a field of wheat suffering badly from the attcks of wireworm, and kainit was applied to these on the surface of the ground, in varying quantities, the first receiving 2 pounds, or at the rate of 320 pounds per acre, and the third 15 pounds, or at the rate of 2,400 pounds per acre. The soil being at the time very dry, about 6 gallons of water was immediately applied to each plat by sprinkling the surface, and a second similar application of water was made two days later, after which there were abundant rains. By November 18, the worms had ceased working on the wheat, and on that date an examination was made of these plats, and at depths of from 5 to 12 inches from the surface, but not below this, a number of wireworms were found, apparently in hibernation.

On March 16, 1898, the plats were again examined, and samples of the soil were taken for chemical analysis. Although samples were removed from all three of the plats, as a matter of fact only those from the last plat, or the one receiving the greatest amount of kainit were used, as the results here seemed sufficiently conclusive. The ground at the time was thoroughly saturated with water, and at a depth of from 11 to 12 inches from the surface in the last, or most strongly fertilized plat, sample 3 of this plat was taken. An examination of this sample after it had been removed to the laboratory revealed the presence of three small, partly grown wireworms, alive, and to all appearances perfectly healthy, and still in their place of hibernation. As will be observed by the analyses, this sample gave the strongest reaction when tested for chlorine.

These tests were also made by Mr. L. M. Bloomfield, at that time Assistant Chemist of this Station, and in the following manner: Of each sample 500 grams were digested in 1,000 cubic centimeters of distilled water for six hours, and in 100 cubic centimeters of the filtrate, equal to 50 grams of soil, the chlorine being determined volumetrically by a solution of nitrate of silver, 1 cubic centimeter of which equals 0.003546 gram of chlorine.

The following are the results of the analyses, all being, as has been

stated, from different depths in the plat on which kainit had been applied at the rate of 2,400 pounds to the acre, and it was in sample No. 3 that the young wireworms had evidently passed the winter:

Sample No. 1, from surface to a depth of 1½ inches, gave 0.0039006 gram chlorine.

Sample No. 2, from depth of 5 to 7 inches, gave 0.0063828 gram chlorine.

Sample No. 3, from depth of 11 to 12 inches, gave 0.0078012 gram chlorine.

The soil of check plat, to which no kainit had been applied, tested as follows:

Sample No. 1 gave 0.001773 gram chlorine.

Sample No. 2 gave 0.001773 gram chlorine.

Sample No. 3 gave 0.0014184 gram chlorine.

The check samples were of course taken from the same depth as those from the treated plat. These results would seem to indicate that no reasonable amount of kainit applied to fields will either destroy or drive away wireworms. Also, it is interesting to note that, at a depth of 1 foot from the surface, there was almost double the amount of kainit present, nearly all of which must have been encountered by the worm on its way downward.

EXPERIMENTS WITH TOBACCO.

Some experiments with tobacco dust were carried out in the summer of 1896, for the purpose of determining its effects upon the grape root worm. As with the kainit, small depressions were excavated about the bases of the vines, varying from 12 to 18 inches in radius, and tobacco dust varying in amount from ½ pound to 4 pounds was placed in these shallow excavations and the surface lightly covered with soil. The vines were submitted to this treatment on July 29th, 1896, and were not examined until October 8th of the same year. On the latter date the tobacco had almost disappeared, no trace being left except a thin, dark brown layer near the surface of the soil. No dead worms could be found about the roots of the vines, while the live ones were present as numerous as about those that had not been treated. Afterwards, it was not possible to discover any fertilizer effect, either from the tobacco or the kainit.

EXPERIMENTS WITH WHALE OIL SOAP AND TOBACCO DECOCTION.

On November 7th, 1898, a number of peach trees, the roots of which were badly infested by the black peach aphis, were treated with a mixture of one pound of whale oil soap, dissolved in a decoction of tobacco water, made by boiling two pounds of tobacco in 8 gallons of water. Four small trees and one large tree were treated with this solution, each small

tree receiving one gallon and the larger one two gallons. In each case the liquid was poured into a small cavity, 6 inches in radius, about the crown of the tree. The trees was then shaken so as to give the fluid a better chance to flow downward about the roots. The solution disappeared slowly, and it was some time before the cavity could be refilled. All of the trees were carefully examined before the application was made and lice were found upon the roots. An examination, made a considerable time afterwards, after the solution had not only passed into the ground but several rains had doubtless further diffused it, revealed the presence of living lice upon the roots, thus showing that the application of this mixture can hardly be considered a success.

EXPERIMENTS WITH BISULFID OF CARBON.

Some years ago we made a number of experiments with bisulfid of carbon with a view of killing the lice on the roots of peach trees, but though the fluid itself was not brought in contact with the roots, it being placed in a small hole made by digging away the soil from about the roots of the tree and making the receptacle for the carbon with an iron bar, and in such a way that the fumes only would reach the roots, the result was definite if not satisfactory, as the bisulfid of carbon not only killed the insects, but the trees also. Last year we tried another series of experiments, this time saturating corn cobs and small balls of cloth with the bisulfid of carbon, and, digging down about the roots, placing these in such a way as not to touch any part of the tree, and immediately covered them with earth, thus fumigating the roots. But this method was no more satisfactory than the other, as, where we used enough of the insecticide to destroy the insects on the roots of the trees, the latter were killed. In one case, where a saturated ball had been placed to one side, both roots and insects were killed on that side of the tree, but on the opposite side the insects were uninjured, and were being attended as usual by the ants. It seems to me, then, that in this case we are confronted by the old problem of the influence of ants upon aphides, which, though fraught with interest for the entomologist, is too serious a matter for the peach grower to be covered by that expression, for in this case I am quite sure that this influence extends farther than the mere transporting of these pests about.

The Black Peach Aphis, *Aphis prunicola,* is an insect that is likely to figure quite extensively in peach culture in future, as it affects more especially the roots of young trees, where it is difficult to reach it with any of our present known, effective insecticides. As indicated, this pest is far more seriously injurious to young trees, especially when newly set from the nursery, and while it seldom affects those that are older, yet it must not be understood as being something that can only be introduced on nursery stock, or will necessarily confine its attacks to the trees on which

it is brought into an orchard from the nursery. The fact is, we are probably more indebted to ants than to any other element in its diffusion for its spread from one tree to another, or, in fact, from one orchard to another. That is to say, while the insect may be brought into an orchard, from the nursery, on young peach trees, and these may and probably will die from the effects of the insect, yet it is possible for young trees, entirely free from the pest, to be planted out in an orchard, and these insects be transported from the branches of older trees to the roots of the younger, and the same fatal results obtain. It is more than probable that the insect comes to infest young trees in the nursery row by being transported from some other, probably older tree, though there is almost an equally strong indication that the winged, above-ground form, may fly from peach orchards at a considerable distance away and be transported by ants to the roots of young peach stock in the nursery, or to the same trees after they have been planted out by the orchardist. In any case, it is very questionable if this insect could or would find its way to the roots of peach trees, where alone it is destructive, without the aid of ants.

I have stated that the ants probably transfer the aphids from the twigs and branches of trees to the roots of others, and I will explain how this transportation is carried out. The ants burrow down into the soil, at the collar of the tree, and then run galleries out along the roots, the aim seeming to be to place the aphis on the more tender and succulant roots, in order to give them a better supply of food. While these more or less vertical burrows, extending downward about the base of the trees are, as a rule, made in the earth, I have frequently noted that, where the soil was hard and compact, the burrows ran down between the bark of the tree and the earth, very often extending slightly into the bark itself, not deeply, but sufficiently to give the surface of the tender bark from the top of the ground down to the roots a decidedly scarred appearance. After the burrows are formed, the ants doubtless carry the aphids below and place them on the roots, as they are known to do in other instances, and they may be observed in attendance upon them by any one who will take the pains to examine carefully. But from what I have observed, it seems to me highly probable that their labor extends still farther. On examining the bases of the larger roots, and in some cases the lower extremity of the trunk, there were strong indications of these having been gnawed, something after the manner of the work of the common peach tree borer. There was nothing about the crown of the tree to indicate definitely, the author of this injury, but it was too deep down in the earth to have been done by the ordinary borer, and, besides this, if this had been the depredator, some of them would have been present at the time of examination, September 15th. Bits of bark, that bore every indication of having been nibbled off from the roots and the crown, were intermixed with the exuding sap from the fresh wounds, but where these wounds had begun to heal over this gummy mass had apparently been cleared away, and around

the edges of the over-growing bark were numbers of the root aphis, attended by ants, *Lasius americanus.* We can readily recall the manner in which the wooly aphis of the apple, *Schizoneura lanigera,* clusters about the edges of the over-growing bark, where a limb has been pruned off, in which we have an exact repetition of the actions of the root aphis on the peach roots. Taken all together, I cannot help but think that the ants gnawed the bark on the crown of the trees and about the bases of the roots, in order to cause this healing over, thereby affording a food supply for the root lice. We know that ants will burrow down about the base of corn plants and carry the corn root lice to the roots, and care for them there as a herder cares for his flock; and there is little doubt but that this species of ant is capable of thus providing this food supply in the way mentioned. We know that ants collect the eggs of other species of aphids in the fall, carry these to their homes and care for them through the winter, placing them, in spring, upon the same species of plant from which they removed them the previous autumn. Unless I am greatly mistaken, this will, in part at least, account for the failures of our experiments with the tobacco and whale oil soap mixture, and in future we shall be obliged to direct our attention to these ants, and devise some means of destroying them and rendering the place so repugnant to them that they will permanently forsake it, thus depriving the root-lice of their protectors.

From the fact that some field experiments with bisulfid of carbon have yielded encouraging results in the treatment of Cucurbs for the destruction of aphides, it appeared not improbable that the same agent might be employed for a similar purpose in the greenhouse. Since the red spider, *Tetranychus telarius,* is perhaps, one of the most difficult to control, especially where sub-irrigation is practiced, and the drenching of the plants, heretofore the chief means of control, becomes impracticable, our first experiments were directed towards this pest. The infested plants were, in this case, greenhouse violets, but later on further experiments were made with lettuce and chrysanthemums infested with the aphides common to these plants.

The possible effect of carbon bisulfid upon the plants under treatment was an important consideration, as an excess of the insecticide might result in injuries equal to those caused by the insects. The physiological effects upon both plants and insects are dependent upon two factors, viz., the density of the vapor and the length of time during which both are subjected to its influence. Hence, it is to be understood that the notes cover the results in respect to both plants and insects.

The apparatus was designed to be used to cover plants in benches or to enclose moderately large potted plants. It consisted of a box having an upper and lower part, each section of this box having a cubic capacity

of about 3 feet; the upper section was provided with two glass sides, the lower edges being grooved so as to admit a corresponding tongue on the upper edge of the lower section. The carbon was introduced through a stationary glass tube inserted in a hole in the top of the box, the lower end of this tube being provided with a sponge to retain the carbon while it was evaporating, the upper end being closed with a cork stopper in order to retain the fumes. In all the foregoing experiments the upper portion was used exclusively in applying the insecticide, while the lower portion was employed in isolating without confining the plants after treatment. We began by applying one-half drachm, and removing the box at the end of two hours; spiders were at first stupefied, but no other effect was apparent, and extending the time to sixteen hours, the result did not differ from the first. One drachm was next tried for two hours without injury to the plants, and with favorable effects upon young spiders and such as were unprotected by the position of the lower leaves. The same amount for four hours left very few living spiders, even when examined several hours after the removal of the box, being chiefly on plants in close proximity to others untreated. The next trial was with one drachm, followed at the end of an hour by one-half drachm additional. Result after sixteen hours did not differ from that previously secured; but one of the plants thus treated was immediately covered for three hours longer with a bell glass, after which it showed injury to lower leaves. On the following day the injury to the leaves was still more apparent, while the number of living spiders present plainly indicated that the experiment had failed to destroy them. The amount was then increased to three drachms, applied in two equal parts at intervals of an hour; and the box was allowed to remain over the plants nine and one-half hours. After twelve hours, during which the plants were left uncovered but enclosed by the open section, examination revealed no perceivable injury to plants and no living spider. Nine hours later a few of the leaves showed slight injury, but live spiders were still absent, which was true also forty hours later. A day later there were a few living spiders on the plants which were apparently uninjured. These conditions after three days remained unchanged. Since the practical limits appeared to have been reached, it was not advisable to carry the experiments further, with the red spider. Lettuce plants growing in benches in greenhouse were similarly treated, and while the insects were readily killed, it was not found possible to do this without injury to the edges of the leaves, thereby rendering the plants unsalable.

With pelargoniums infested by aphides, one-half drachm carbon bisulfid, for three hours, was found to be thoroughly effective in destroying the insects without injury to the plants. Chrysanthemums infested with the ordinary brown aphis so common on these plants, were treated with

one drachm for two hours; this destroyed the insects without affecting the plants, which were in this case tender shoots brought directly from the cellar in which they were being wintered, and would therefore probably be more susceptible to injury. Cinerarias were treated in precisely the same manner, also for aphides, and with both these and the chrysanthemums, the experiment seemed an unqualified success.

PUBLICATIONS

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

A complete list of previous publications of this Station may be found in Bulletin 95. Following are the titles of subsequent bulletins:

No. 96. The Army Worm and other insects; Wheat and Grass Sawflies; the Corn or Boll Worm; the Painted Hickory Borer; the Raspberry Cane Borer; the Peach Scale.
No. 97. Diseases of wheat and oats.
No. 98. Small fruits; cultural notes and comparison of varieties.
No. 99. Sugar beet investigations in 1898.
No. 100. A comparison of factory-mixed and home-mixed fertilizers.
No. 101. Experiments with oats.
No. 102. Soil and seed treatment and spray calendar for insect pests and plant diseases.
No. 103. The San José Scale in Ohio.
No. 104. Further studies upon spraying peach trees and upon diseases of the peach.
No. 105. Further studies of cucumber, melon and tomato diseases.
No. 106. The chinch bug; experiments with insecticides.

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