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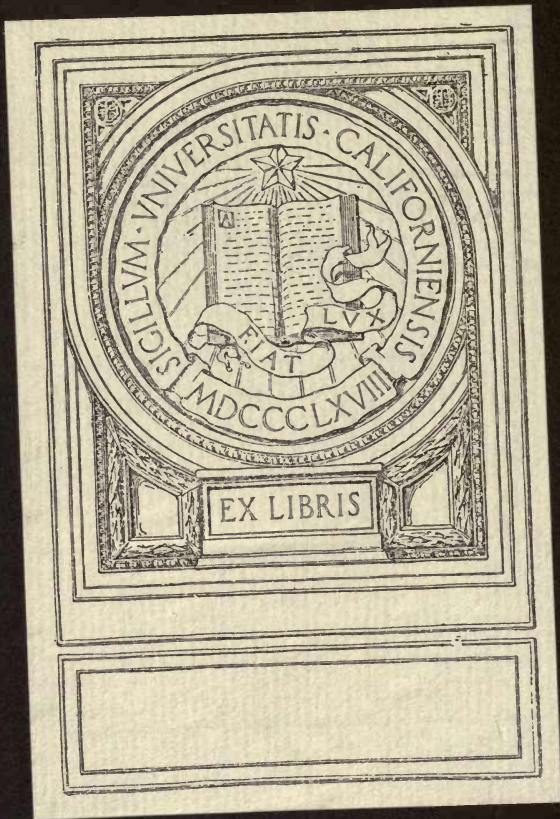
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Department of Entomology.

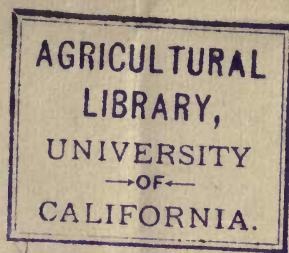
The Cinch Bug in Iowa.
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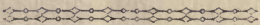
IOWA AGRICULTURAL COLLEGE

—FROM THE—

DEPARTMENT OF ENTOMOLOGY.



BY HERBERT OSBORN.



ISSUED JANUARY, 1888.

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THE CHINCH BUG IN IOWA.

The extensive ravages of the Chinch Bug (*Blissus leucopterus*, Say) during the past season, which have had no precedent in the history of the State, together with the present strong probability that it will be equally destructive, perhaps more so, the present year, make it important that the fullest knowledge of its habits and the best known methods of preventing its damages, should be thoroughly distributed throughout the State.

According to the Iowa Crop Report, issued July 16th, including reports from correspondents up to July 10th, this insect had already become noticeable in three-fourths of the counties of the State and its damage to the wheat crop had run into the millions of dollars. Availing myself of the kind offer of Secretary Shaffer, of the State Agricultural Society, to cooperate in getting statistics of damage in the State, I prepared a set of questions which he included in his blanks sent to correspondents, at the same time including a brief note on work that might profitably be done in Fall. The full result of the returns from these queries are not yet available, but will be published shortly in the final Crop Report of the season. Mr. Shaffer has however kindly favored me with estimates from the reports already examined, from which it appears that the damage to the crops, wheat, oats, barley and corn, will approximate twenty-five millions of dollars at least. An item by no means insignificant even when distributed among all the farmers of the State.

In the present Bulletin I shall not attempt an elaborate discussion of the Chinch Bug or of the methods of attacking it, but endeavor to give in brief space the facts of economic importance with recommendations for remedies that should be universally known.

The portion summarizing life history and habits, and the synopsis of remedies, have been published in the College Biennial Report for the years 1886 and 1887, pp. 60-67.

The observations and experiments with remedies were carried on as agent of the Division of Entomology, U. S. Department of Agriculture, at the instance of the Entomologist, Professor C. V. Riley. Detailed reports have been forwarded to him and he has very kindly granted permission to include such portions as have more immediate importance in this Bulletin.

Professor Riley will include in his forthcoming report to the Commissioner of Agriculture, an extended article on the Chinch Bug, with detailed discussion of its habits, remedies, etc. He informs me that this report will be issued early in Spring, and I would strongly recommend all farmers of the State to make early application to their respective members of Congress for copies of the report, and to carefully study the portion relating to the Chinch Bug.

LIFE-HISTORY AND HABITS.

The life-history and habits of the species have been very fully recorded, it having been studied in detail by such entomologists as Fitch, Riley, Walsh, LeBaron, Shimer, Thomas, Forbes and others. The facts here stated must not therefore be looked upon as given with any claim of origin-

ality, though I have, I think, verified by personal observation nearly every statement here recorded.

At the present time (Winter) Chinch Bugs are in the adult stage, and may be found secreted under grass, dead leaves, rubbish of various kinds, both in the fields and in thickets or timber, especially along borders of thickets or wood, under leaves, loose bark, etc. In the Spring these adults issue and after finding suitable plants for the food of the young deposit their eggs. The eggs are about one-thirty-second of an inch in length, rather slender, slightly curved, of a yellow color and one end (the head end) is truncated or apparently cut square across, and on this end are four small granules or tubercles, too small to be seen with the naked eye. The egg becomes darker as it nears the time for hatching, and at the head end the eyes may be seen plainly through the egg walls. Each female is said to be capable of laying about five hundred eggs, occupying about twenty days in their deposition, so that if wet weather destroys those deposited at one time, others are likely to escape. The process begins in April (possibly earlier in favorable seasons) and extends into May. If wheat is available this will be the principal crop attacked at this time, but eggs may also be laid in oats, rye, barley, corn and various grasses. The bugs depositing eggs live for some time afterward; if plenty, may even do some damage to the crop, but usually they are too few in number to cause trouble, and they gradually die off till by the time their offspring mature they are mostly dead.

The eggs hatch into minute yellow or light red bugs, which have the same general form as the adults. They begin feeding on the roots of the plant where the eggs were laid. (Eggs, it is said, may be laid above ground, but they are almost always found on the stems or roots of the plant, half an inch or more beneath the surface.) After growing for a time the larva sheds its skin, assuming a darker color, but retains a light band across the middle of the back. After growing for another period it moults again, assuming after this moult a brownish color with a whitish line across the back. After still another moult it becomes nearly black save the white band on the back, and in this stage the wing pads become well developed, indicating the pupa stage, and when another moult occurs (really the transformation from pupa to adult,) the insect assumes the winged condition. It is now three-sixteenths of an inch long, of a deep black color and with white wings, which have a black spot on the border near the middle. Bugs which have hatched in April or May become mature in the latter part of June or in July, and, after pairing, another lot of eggs is deposited to produce a second brood of bugs. The bugs which have been feeding in wheat, however, find upon its ripening that they must migrate or starve, so that there is a general movement of bugs, both mature and partially developed, from wheat fields into corn, etc., accomplished as a rule on foot by the winged bugs as well as the immature ones. Sometimes in July there is a general flight of bugs, and at such times the air will be loaded with bugs, and fields which have not been previously infested will swarm with them. This is bad enough, but as each female of this swarm deposits hundreds of eggs, it is not long till the field is so packed with bugs that the plants rapidly succumb. On corn they will cluster on the stalks from the roots to near the tops of the leaves, while on grasses such as Hungarian, fox-tail, etc., every part of the plant may be crowded with them. The second brood attains its growth during the late Summer and Fall, and by the time cold weather approaches nearly all have reached the mature form and are ready to secrete themselves for the Winter.

OBSERVATIONS AT AMES.

Chinch Bugs were observed in the Fall of 1886 but not in such numbers as to cause serious apprehension. Had the Spring of 1887 been an ordinary one I scarcely think the bugs would have been very noticeable here. They were not noted as particularly abundant early in the Spring, but, by the latter part of June, they were causing some damage in a small patch of experimental wheat on the College Farm.

By the middle of July they were accumulating on corn adjoining the small patch of wheat that had then been cut, though hosts of them could still be seen traveling in the stubble. They were also abundant in a field of Hungarian grass, which, at this time, had made a growth of about six inches, also, in smaller numbers, scattered through fields of sod corn. These last I think it not unlikely had developed from eggs laid in the grass, as the sod was not turned till late. The majority of the bugs at this time (July 14th and 15th) were in the pupa and imago stages though larvae were not scarce. Numbers of the adults were seen pairing at this time. On the 16th bugs were still plenty in the stubble and the stubble was fired (see experiments with remedies.) Adults were seen taking wing from the tops of corn stalks and other elevated positions. July 19th I found Chinch Bug eggs quite plenty in ground at base of corn stalks, between sheath of leaf and stalk and, in some cases, among the cast off skins of the bugs under lumps of earth. Some of these eggs were nearly ready to hatch, others apparently but recently laid. On the 20th both Chinch Bugs and their eggs were noted in sod corn. On July 25th Chinch Bugs were swarming in the air, at times passing my window in immense numbers. They appeared to be much thicker at times, at short periods, few, if any, being observed. They were first noticed shortly after one o'clock p. m. I saw no evidence of pairing as a result of flight. The bugs were mostly flying from southeast to northwest, the direction of the wind at the time. On July 27th Chinch Bugs were again noticed on the wing, but not in such great numbers as on the 25th. Flying from northwest to southeast, with the wind. On August 3rd newly hatched bugs were plenty on some hills of corn scattered through the field but the damage from them was not yet very marked. They could be found in greatest numbers on the roots and base of the stems of fox-tail grass. A field of Hungarian grass, late planted on sod, and having about two weeks growth, contained adult bugs in great numbers, many of them pairing, others laying eggs, and the air above the field contained hosts of them on the wing. It was evident that the field would suffer severely as soon as the eggs from the immense number of bugs congregated here should hatch. Both corn and grass showed effects of drouth at this time in curled and wilted leaves, this effect being seen in places where bugs were not yet abundant as well as where they were thick. The early planted Hungarian grass showed many spots wilted while young bugs were abundant on the roots and on stems at surface of the ground.

On August 12th bugs in corn were becoming fairly plenty in places and some parts showing damage. In the young Hungarian, on sod, the newly hatched bugs were very plenty and the grass suffering severely. A few adults were observed pairing but by no means

so plenty as a week or ten days previously. The older Hungarian was full of young bugs, many newly hatched. A portion of the field was cut a week before this but bugs were plenty in the stubble. Some of the grass still standing was nearly dry enough to burn.

On August 13th the Chinch Bugs in the older Hungarian commenced to travel to the adjacent corn, the greater number of the migrants being in the black larval and pupa states, though many were younger and some adult. The grass would burn in places and in such places great numbers of bugs could be killed, but in most places there was too much green grass for it to burn readily. Furrows detained many, and great numbers, particularly of the younger ones, died in and at sides of the furrows. Some of the adult bugs pairing at this time. On the 16th and for one or two days thereafter, which were cool and cloudy, there was not much migration, and while it continued to some extent for a number of days, at no time did they travel so rapidly as on the 13th to 15th. From this time on the bugs were at work in corn and Hungarian, but the corn was cut as early as possible to avoid loss, and much of the younger Hungarian was entirely destroyed so they were forced to scatter. As late as November 15th however a few adult bugs were to be found in these fields running over the surface of the ground or concealed under sods, tufts of grass, etc. A number were found secreted in a cabbage head between the outer leaves during the early part of December. There is every reason to believe that immense numbers of them have gone into Winter quarters in best of condition and that so far as the condition of bugs is concerned they may prove far worse the coming season than the season that has passed.

REMEDIES TRIED AT AMES.

KEROSENE EMULSION.—A number of tests of this remedy were made, first with a view to testing its value under various conditions, and afterward for the sake of checking the damage threatened to corn in some fields on the College Farm.

The first trial was made July 15th, the emulsion used being the common one consisting of kerosene, soap and water diluted to about five per cent kerosene. The bugs were killed very quickly by this application, and great numbers of them could be reached but many in particularly secreted places, in folds of leaves and under lumps of earth escaped. Thrown upon the leaves and running down between leaf and stalk, it dislodged and killed immense numbers. Thrown against stalks where they were congregated it would quickly dislodge the mass, and while it was impossible to see whether all driven off in this way were sufficiently wet to kill them it was certain that most of them were. This application was at the rate of about one gallon of emulsion or twelve gallons of the diluted mixture to five rows of corn, for thirty-two rods or what would equal five gallons of emulsion, sixty gallons of diluted mixture, to the acre, or a cost for material of less than sixty cents per acre. In trials of emulsion diluted to range from two per cent. to seven per cent. of kerosene, less than four or five per cent. was found unsatisfactory, and at the lowest figure bugs even when thoroughly drenched, and kept for a time in the fluid were able to recover. A mixture (about two per

cent. possibly a little less) which killed plant lice almost instantly, affected Chinch Bugs but slightly if at all, and they afterward recovered and lived in confinement for many days.

On August 15th applied kerosene emulsion to bugs accumulating on corn rows, using an emulsion diluted to contain about six per cent. kerosene and spraying with cyclone nozzle from a wagon; great numbers could be found dead within a few minutes after the application, and on the following day hosts of dead could be found on the ground around the hills treated. In places however the stalks had become well covered by live bugs that had moved in to fill the places of those destroyed. As this application was made irregularly on hills most infested on an irregular patch I cannot say as to the exact amount used on a given area, but think it was less than used in previous applications.

Subsequently the Farm Department applied on a large scale using a five to six per cent. emulsion, and spraying from barrels in a wagon, one man working the force pump and managing the team, while another manipulated the hose and nozzle, walking rapidly among the hills of corn and directing the spray upon masses of bugs. This resulted in the destruction of great numbers of bugs, but no record of the area being kept, it is impossible to state the exact cost.

The cyclone nozzle was found by all means the most satisfactory in spraying for this purpose.

I suggested the trial of emulsion to some of my correspondents, and I extract a paragraph from one letter received in reply.

DEAR SIR: Your most satisfactory letter received some time since. The emulsion is a success; it was instant death to the Chinch Bugs, but it takes so much when you want to go over five or six acres that one cannot stand the expense. It could be stood to go over it once or twice if I could have got the bugs all on the corn, but they would a part stay on the corn while the rest would lie under sods and anything else that would protect them from the sun.

J. E. WARREN, Cambridge, Iowa.

The use of kerosene can hardly be expected to prove of value except when the bugs are massing on corn; at this time application to an acre or two of the field next to stubble may do much to save the rest of the field. By arranging nozzles with special reference to most efficient work in corn rows and while corn is small enough to drive a team astride of one row I think spraying can be done thoroughly at a cost of thirty to forty cents per acre for material. A cyclone nozzle with pressure sufficient to do good work, discharges about one pint of liquid per minute. Adjusting three nozzles to play upon one row of corn, one each side and one from above, and allowing the team to walk slowly (two miles per hour) it will take thirty gallons of liquid per acre, which, using five or six per cent. emulsion, costs about thirty cents, exclusive of labor, which for team and man an hour and a quarter would be about forty cents more. First cost of force pump must of course be considered. The cost of labor on the farm however where the farmer uses his own team and does the managing of the apparatus himself might be considered

less. By using only two nozzles, or by driving faster than the above estimate allows, the expense would be lessened. It might do in applying in this manner to reduce the emulsion to four per cent., but beyond this I do not think it will do to go with any expectation of getting satisfactory results.

BURNING STUBBLE AND GRASS.—On July 16th the stubble adjoining a corn field was observed to contain large numbers of bugs traveling toward corn. In the afternoon this migration was going on quite rapidly, and as the stubble was now quite dry it was fired with a view to destroying the bugs remaining. Where tolerable thick and when there was a fair breeze it burned quite readily, but it was necessary to take some pains in carrying the flame along past thin spots to keep it from dying out. A considerable portion of the field however was successfully burned over, and the dead bodies of many bugs not entirely consumed, which could be readily found on examination of the burnt area, testified to the destruction of hosts of the pests. The bugs thus destroyed were mostly young larvae, the majority of the adults, pupae and larger larvae having moved out. The number destroyed must, I believe, have well repaid the little trouble necessary to burn the stubble.

Early in August the bugs had so multiplied in a field of Hungarian grass that no further growth seemed probable, and most of the field was mown and the hay secured. A narrow strip was left next the corn adjoining the field, the plan being to burn this as soon as bugs began passing from the grass to corn. When the bugs started, however, (August 13th) the grass was not dry enough to burn except in spots. In such places as would burn, however, hosts of bugs were consumed. This strip was at once mown, and after drying a few hours another attempt made to burn it, as also on the following day, but portions were still too green to burn rapidly, and unfortunately for the experiment the two or three days following were not hot and dry enough to render it fit to burn readily. A few days later, however, on a dry day with a fair breeze, most of the strip remaining unburnt was burned over, and examination showed that great numbers of young bugs, even at this late day, were consumed. Bugs if underground, or secreted in roots of stubble, will not be heated enough to kill them, hence to destroy the greatest number as well as to secure the most rapid burning, the fire should be started in the hottest part of the day when bugs in greatest number will be moving.

OBSTRUCTING MIGRATION.—The common method of checking migration by making furrows often proves unsatisfactory, and several tests were made to ascertain the conditions securing the most perfect check. It was found that a single mark, two or three inches deep, the sides of which were composed of fine dust, would form a complete barrier to their progress; the bugs accumulating in the furrows being utterly unable to crawl up the dusty sides. Any solid place, however, which would give them a foothold, would permit them to pass.

A couple of furrows were plowed between grass and corn, and pulverized by drawing a log along them, and the result watched. In

a very short time immense numbers were struggling to escape from the furrows and taking advantage of every object that would furnish them a foothold upon which to pass. Many of them would accumulate at the side of the furrow next the grass, not even entering the furrow. Subsequently many were found dead along the furrows, some within, and others simply at the edge next the grass. Knowing that the cast off skins of the larvae closely resemble dead bugs, I examined a number of handfuls in order to be sure that they were dead bugs and not merely the cast off skins of those that had moulted. Whether they died from starvation or because they could not secure the protection which they endeavor to obtain at night, I do not pretend to say, though the former seems the more likely, since many secreted themselves under weeds, straw and even in the earth, to which all had access. Some bugs collected along the furrows were destroyed by drawing heavy straw torches along over the thickest masses. As the corn in this case was pretty well grown, the farm management preferred to cut and shock it for fodder rather than keep the furrows in order, and in a short time they ceased to be any obstruction. The main difficulty with furrows as usually made, is that they present at many points solid walls, pieces of sod, large clods, tufts of grass, etc., which serve as highways for the migrating host. I believe that the most effectual check will be made by drawing a triangular block or weighted trough along a dry furrow or between rows of corn simply over the surface of the loose earth. The trough could be made by nailing together two pieces of plank four to six feet long, fastening a hook at one end to hitch a chain to, and weighting by putting in stones to which may be added the weight of the driver. When used between corn rows to prevent advance of bugs already in the field, it could be kept in position by side pieces, which could also be arranged to make shallow marks, thus forming three parallel furrows at once. To prevent the bugs passing from wheat stubble to corn, furrows should be plowed some days before migration begins, and the ground turned two or three times or till well pulverized, then, as soon as bugs show any signs of traveling, the trough should be drawn along the furrow to reduce the sides to dust, and this process should be repeated every dry and hot day, by ten o'clock in the forenoon, so long as bugs attempt to pass. The bugs accumulated in the furrow will thus many of them be crushed and the sides of the furrow kept finely pulverized.

Experiments were also made with Pyrethrum and Bisulphide of Carbon, the former proving entirely unsatisfactory, while the latter, though promising to be of some value under certain conditions, will need to be given further trial before a definite opinion as to its value can be formed.

While it is very desirable to find some cheap and efficient method of destroying the bugs when present and destroying any particular crop, the greatest reliance will probably always have to be placed upon preventive measures, and the success of these will depend upon the promptitude and energy with which they are adopted by the farmers of every community in the State where bugs are now present.

The best known methods are summarized below.

REMEDIAL AND PREVENTIVE MEASURES.

Professor Forbes, State Entomologist of Illinois, in a recent Bulletin makes the following pertinent remarks concerning the general neglect of applying remedies for this pest:

"There is a general but mischievous impression among the farmers of this State, especially to the southward, that it is useless to contend against the Chinch Bug, and that its visitations must be received, like those of the drought and the tornado, as evils beyond our power to prevent or remedy. A careful study of the literature of the subject, several years' observation in the field, and some experiments, have convinced me that this belief often doubles, at least, the calamity of the outbreak, by discouraging at the outset any except sporadic and individual measures of defense. This discouragement is, of course, not without its reasons. Commonest, I think, are the following:

"1. In this, as in many other cases of insect injury, the number of unreasonable and even preposterous recommendations that have been made have tended to discredit the whole subject of remedial measures.

"2. Few are aware of the very considerable number of valuable remedies which have been carefully tried, here and there, with decisive or highly encouraging results.

"3. Failures of measures not intelligently or thoroughly applied, or applied under exceptional circumstances, have often led to the conclusion that there was no value in them under any circumstances whatever.

"4. Partial or complete failure of the isolated efforts of individuals has sometimes illegitimately discouraged combined action by the farmers of a neighborhood.

"5. The use of proper measures in the beginning of an outbreak has been prevented by the failure, elsewhere or previously, of the same measures when the Chinch Bug had already overwhelmed the country. The best of remedies will fail when the patient is already in the article of death.

"6. Failure to accomplish everything has sometimes caused abandonment of measures which nevertheless do accomplish much.

"7. Many reasonable and promising remedies lack the endorsement of accurate experiment, and so fail to command the confidence of the practical farmer.

"8. The disposition to speculate on the weather is very common. A hope that heavy rains may intervene to destroy the bugs often prevents action which it is thought may be rendered unnecessary by the turn of events."

Much of this applies with equal force in our own State, but I believe that the majority of our progressive farmers will chose to adopt the best measures known in the way of prevention rather than run the risk of another Chinch Bug scourge in 1888. At present writing Chinch Bugs are apparently in best of condition for wintering, and while it is of course possible that next Spring may be a wet one, it would be folly to depend upon such being the case. The question then arises, what can be done to lessen the danger the coming season? I will attempt to give briefly, and without referring here to supporting evidence, the measures which I believe should be adopted in every neighborhood where the Chinch Bug has been present during the past season.

First.—As soon as it is dry enough so that grass, dry leaves, etc., will burn, set to work systematically to burn over every foot of land possible. Burn all old corn stalks, and grass and weeds along fences and in corners. This can be done quite safely with a little care for the posts where the fence is of wire; for board fences it would of course be dangerous. Carry the fire into thickets and edges of timber, burning off all the dead leaves, and attend also to the loose bark on fallen logs. In short, carry fire into every hiding place that the circumstances will permit. It should be done when the grass, etc., is dry enough to burn well down to the ground, otherwise many of the bugs may escape. One bug killed at this time may mean a hundred thousand or more prevented from working on the crops in Summer; and, on the other hand, every bug escaping may mean an equal number ready to devour the fruits of hard labor. While it will pay every farmer to adopt this method, even if his neighbors do not, since the bugs for the most part do not travel great distances, the best results will be reached if every farm in the neighborhood is thoroughly renovated by fire.

Second.—Make a careful study of the crops to be planted and reduce as much as possible the area planted to wheat, rye, barley and Hungarian grass especially, and to a less extent oats, corn and meadow grasses, remembering that bugs feed only on members of the grass family of plants, and have a decided preference for wheat, barley, rye and Hungarian. Where such crops cannot be suspended plant as early as possible and sow heavily. Defer planting corn as long as practicable to make sure that none of it is up in time for adults wintering over to be attracted to it. If possible avoid planting it next to wheat, barley or Hungarian grass, and if this is unavoidable sow strips of potatoes, turnips, buckwheat or some other crop not relished by the bugs between the fields. This will tend to retard migration and possibly starve some of the younger bugs, while if the maturing bugs take wing and scatter generally through the corn, the effect is not so severe. As far as possible plant crops not affected by the Chinch Bugs, such as clover, buckwheat, flax, beans, potatoes, turnips and other root crops. In fields intended for late planting of corn or some other crop, an early planting of strips of wheat or Hungarian to attract the laying of eggs, to be plowed under as soon as egg laying is over, will result in destruction of great numbers and prevent the damage they might have caused in other fields. Unless the strip is planted to some crop not eaten by the bugs, it should lie two or three weeks at least, to insure the death of the bugs before the second crop is planted, though when plowed under deep there is little probability of their getting again to the surface.

Third.—After crops are started keep a careful watch of fields in wheat, barley, etc. If portions of the field become badly infested before much growth has been made, while other parts of the field seem free, plow under deep and later plant to buckwheat, turnips or some crop not affected by bugs. If the whole field becomes infested early it may pay to plow under to destroy the bugs and plant as late as possible to fodder corn or other late crop. If crop is far enough along to pay for cutting as hay, or ripe enough for early cutting for the grain, clear the field at once; burn the stubble if dry enough, and plow under as quickly as possible. The bugs make very slow progress traveling over a rough plowed field, and most of the younger ones at least must perish.

Fourth.—When the bugs begin to migrate into corn from wheat and other fields, or rather before this has commenced, if no strips of crops

disliked are between the fields, see to it that a strip of at least three or four yards next to the corn is plowed and finely pulverized. Then as soon as bugs begin to travel mark this with several parallel furrows and pulverize the sides of these furrows thoroughly by dragging a heavy block or log along them. The bugs cannot crawl up the sides as long as the earth rolls back with them, and vast numbers will starve to death along such an obstruction. Spread straw along side of these furrows toward evening, and the bugs will go under it for the night, then set fire to it in the morning before the bugs start to travel again. Similar precautions can be used in connection with strips planted to potatoes, etc. At this time too the stubble, if it has not been plowed under, is probably dry enough to burn, if a little care is taken to carry the fire over thin spots, and if burned in hottest part of the afternoon hosts of bugs will be burned. While the older ones have already left, close examination will probably show hosts of small ones on the move. If the bugs reach the corn and begin to accumulate there, procure a few gallons of cheap kerosene and a few pounds of cheap bar soap. A hand force pump is almost essential, though the sprinkling can be done more slowly with a watering pot. The best nozzle I know of for the purpose is the cyclone nozzle, recommended by Professor Riley.

Heat a quantity of water (half as many gallons as you intend to use of kerosene) and dissolve in it half a pound of soap to each gallon. Add this boiling hot to the kerosene (one gallon of suds to two gallons of kerosene) and churn violently together from ten to fifteen minutes, or until it forms an emulsion. It will then appear thick and creamy, and will not separate on standing or cooling. The churning is best done by forcing the fluid through the force pump, driving it through a short hose without the spray nozzle back into the vessel from which it is drawn. Having prepared this emulsion it may be mixed at pleasure with pure water, or water with a little soap in it, using nine gallons of water to one gallon of the emulsion. This gives thirty gallons of mixture for every two gallons of kerosene. It may be diluted still further if desired, but should not at the farthest be diluted so as to use more than fourteen or fifteen gallons of water to each gallon of emulsion. The mixture in barrels may be drawn in a wagon along side the rows of corn, and the bugs sprayed by directing the nozzle upon the stalks where they are massed. To reach rows beyond the first two or three it will be necessary to have a long hose and one man to manipulate the nozzle, passing among the hills for as many rows as convenient, while another works the force pump and manages the team. This method is applicable where the bugs are massed on a few rows of corn next to wheat and may prevent serious damage to the bulk of the field,

Fifth.—When corn fields are infested throughout and liable to be seriously damaged, a plan already very generally adopted is to cut it up for fodder.

Sixth.—And lastly, after the season's crops are attended to, every effort should be made to reduce the number for the next year. The rubbish in fence corners, the dry grass, leaves, etc., may be raked into heaps from places not accessible to fire. These will form excellent attraction for the bugs when secreting themselves for their Winter hibernation, and then on some dry day in late Fall or early Winter, or in early Spring, the whole mass may be burned. At the same time, all ground covered with grass, leaves, etc., should be burned over as thoroughly as possible. There is an

advantage in doing this late in Fall, after bugs have taken up their Winter quarters, in that there is more probability of burning thoroughly to the ground, and bugs, if any escape, will have difficulty in finding shelter for the Winter, and many are likely to perish by the attacks of birds or other natural enemies.

Many of the measures recommended for the latter part of the season may be unnecessary, and of course the greatest gain results if careful attention is given to the matter at the beginning of the season. As far as possible there should be concerted action by all the farmers in a neighborhood, for though it may pay the individual farmer to do all he can for the protection of his own crops, he can but partially succeed if bugs are continually coming in from the neglected fields of his neighbor. Each man should study the conditions on his own farm, become thoroughly familiar with the habits of the bug, the crops it will infest and the time and manner of its work, and then adapt his crops and the remedies he applies to the particular conditions of his locality.

The first part of the paper is devoted to a general
 discussion of the subject. It is shown that the
 results of the present investigation are in
 agreement with those of other workers in the
 field. The second part of the paper is devoted
 to a detailed description of the experimental
 apparatus and the method of measurement. The
 results of the measurements are given in the
 following table. It is seen that the results
 are in good agreement with those of other
 workers in the field. The third part of the
 paper is devoted to a discussion of the
 theoretical aspects of the problem. It is shown
 that the results of the present investigation
 are in agreement with the theoretical
 predictions. The fourth part of the paper
 is devoted to a discussion of the practical
 applications of the results. It is shown that
 the results of the present investigation have
 important practical applications.

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