KENTUCKY

AGRICULTURAL EXPERIMENT STATION

OF THE

STATE COLLEGE OF KENTUCKY.

BULLETIN NO. 74.

---

1. The Chinch-bug.
2. Earthworms a Source of Gapes in Poultry.

LEXINGTON, KENTUCKY.

MAY, 1898.

KENTUCKY

Agricultural Experiment Station.

NOTICE.

The Bulletins of the Station will be mailed free to any citizen of Kentucky who sends his name and address to the Station for that purpose.

Correspondents will please notify the Director of changes in their post-office address, or of any failure to receive the Bulletins.

ADDRESS:

KENTUCKY AGRICULTURAL EXPERIMENT STATION,

LEXINGTON, KY.

BULLETIN No. 74.

1. THE CHINCH-BUG.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

Kentuckians have not, until within the two years just past, been disposed to admit that the chinch-bug is to be feared as an enemy of growing crops in this State. Eight years ago careful men might have been heard to declare that it never does serious mischief in Kentucky. To many of our farmers it was, and is yet in some localities, absolutely unknown. But the insect has been present in this State, to my personal knowledge, all the time since 1889. On the Experiment Farm at Lexington a few individuals can be found at almost any time during the summer. Flying individuals are not infrequently encountered as one travels along the pikes in blue-grass Kentucky. In short all the evidence we have indicates that it is never entirely absent from this region.

Why then should it not be destructive in Kentucky as it is in Illinois and Iowa? In a general way our farmers are right in the belief that the climate is unfavorable to the chinch-bug. Much of the State has been, and a large portion of it is still covered with forest. The retention of moisture brought about by such natural growths encourages the development of the fungus enemies of the chinch-bug, to which from its habit of gathering together in large numbers it is especially subject. Moisture is well known as an enemy of the insect in States where most of its mischief is done. Our own farmers have not been slow to learn the beneficial effect in checking injury of a few good showers of rain in summer. Quite often packages of chinch-bug fungus sent out from the Station are reported "not used," the reason given being that opportune rains "scattered" the bugs before the fungus could be set at work.

It is quite probable, from all we know of the effect of moisture on this insect, that its abundance here during 1896 and 1897 was the result of the unimpeded multiplication of the bugs permitted by the exceptionally dry summers of several years preceding. A couple of wet summers may be expected to reduce their numbers again. This is what the history of the insect in other States teaches, for with few exceptions in Illinois, Iowa and Kansas notable outbreaks have followed a succession of dry seasons, or have taken place while drought prevailed. Not only this, but the early writers on the injuries in the South Atlantic States complain of the dry weather prevailing during outbreaks. A gentleman named Sidney Weller, resident at Brinckleyville, Halifax County, North Carolina, wrote in 1840 after a very severe drought :*

"Our fears were disappointed and our hopes exceeded as to this pest, by the hand of an overruling Providence. The season turned off wet and very propitious to crops of all kinds, and the ravages of this bug were arrested. Even fields of wheat that had been greatly injured, suddenly revived and produced tolerable crops; and the corn, which last season in places here was ruined, escaped uninjured."

The chinch-bug is a native American insect. Before the settlement of the country by whites, it probably subsisted on native grasses, just as it does to some extent now. As an injurious insect it appeared first in wheat fields of the South Atlantic States about 1783, and was called Hessian fly under the mistaken impression that it was the same pest that had appeared in wheat fields farther north. At this time it was a much more serious pest in the Carolinas than it is now, and in some sections, we are told, farmers were compelled to give up growing wheat for several years. Subsequently it appeared in the upper Mississippi valley, and since 1840 has been a constant menace to wheat and corn throughout much of the very best wheat and corn sections of the United States. For some unexplained reason it does not do much damage in New

*As quoted by Dr. Asa Fitch in his second report on the noxious insects of New York.

York or the New England States. Writing in 1885 of an instance of its occurring abundantly in New York, Dr. J. A. Lintner used the following words:

"The insects being submitted to me by Secretary Harison, of the State Agricultural Society, they were at once, greatly to my surprise, recognized as the notorious chinch-bug of the Southern and Western States. It was the first instance of a New York specimen of the species coming under my observation, nor had I knowledge of its occurrence within the State, beyond the record of Dr. Fitch of his having met with three individuals of it. Dr. Harris had seen one specimen in Massachusetts."

Distribution and Injury in Kentucky.

It appears that the insect is distributed over much of the Eastern United States, but that its injuries are confined largely to those Middle States in which most of our wheat and corn is grown. Illinois, Iowa, Kansas and Missouri embrace within their limits much of the territory in which the chinch-bug is at present seriously destructive. Kentucky is at the border of this region, and, generally, complaints of damage come from counties along the Ohio river. So far as we have information on the subject, outbreaks in Kentucky occur about the same time as those in the upper part of the valley, but are less marked even in the upper counties, and sometimes do not attract general attention. In 1887 when, according to J. R. Dodge, Statistician of the Department of Agriculture,* the states Kentucky, Ohio, Indiana, Illinois, Wisconsin, Minnesota and Kansas, together lost $60,000,000 from chinch-bug injury; this State as her share lost on her corn and wheat crop, $569,813. Yet the injury was restricted to the counties Bracken, Pendleton, Carroll, Estill, Mercer, Union, Marshall and Ballard. The insect, as already stated, did not again attract attention in the State until 1896, when it became locally troublesome, showing a disposition to occupy the interior counties and did mischief at isolated places even in

*See Bulletin 17, Division of Entomology, U. S. Department Agriculture, by L. O. Howard.

Tennessee. The complaint of severe injury in Kentucky came from two widely separate localities. Kenton County, immediately opposite Cincinnati, seemed to be the center of greatest abundance in Eastern Kentucky. Another isolated center occurred in the western part of the State, near the mouth of the Tennessee River, the injury being greatest in Marshall County. From most of the counties between these two widely separated centers few complaints of injury were received. The only intermediate counties from which complaints came were Shelby, Mercer and Marion, all three away from the Ohio River, and constituting a third center, though not far removed from the group of counties opposite Cincinnati. In this last region but little injury was done, only five complaints being received from the three counties. In 1897 the centers of injury were shifted to some extent. The Kenton County center appeared to have moved eastward along the Ohio River, the largest number of complaints being from Lewis County, not far from the eastern limit of the State. The same eastward shifting appears to have taken place in western Kentucky, no complaint at all coming from Marshall County, while from McLean County more were received than from any other in this part of Kentucky, and injury was observed in all the neighboring counties along the Ohio River, except Hancock, from Livingston to Meade, inclusive. The insects became especially abundant and troublesome in Marion, Washington and Nelson counties, more complaints being received from this region than have been received before from any part of the State. This is very near the center of Kentucky, and the prevalence of the insect here and its presence in small numbers in Clark, Russell, Warren, Simpson, Graves and other isolated counties, shows that it is capable of doing mischief in any part of the State where wheat and corn are grown. In truth the chinch-bug was in 1897 distributed throughout crop-growing Kentucky.

An interesting feature of its injuries in 1897, as compared with those in 1896, is the fact that in 1897 no injury of consequence was suffered in the counties in which the greatest destruction was wrought in 1896. In the latter year more

complaints came from Kenton than from any other county, while in 1897 only one complaint came from this county. Marshall County in 1896 was, next to Kenton County, the seat of greatest injury, but in 1897 not a single complaint came from Marshall County. To what extent the distribution of the chinch-bug fungus in these counties contributed to this result it is impossible to say, yet that it did contribute in some measure is altogether probable, and with this feature of the subject in view it will be interesting to note in 1898 the condition of the chinch-bug injury in the counties that received most of the fungus in 1897. The study of the chinch-bug in the State indicates that it is spreading from the west towards the east and south, and unless the weather of 1898 continues damp, we are likely to witness its injuries more widespread than they have yet been. The promise at present is for a wet season, yet it is not well to depend on anything so uncertain as the weather, and it is with this thought in mind that the present account of the chinch-bug has been drawn up.

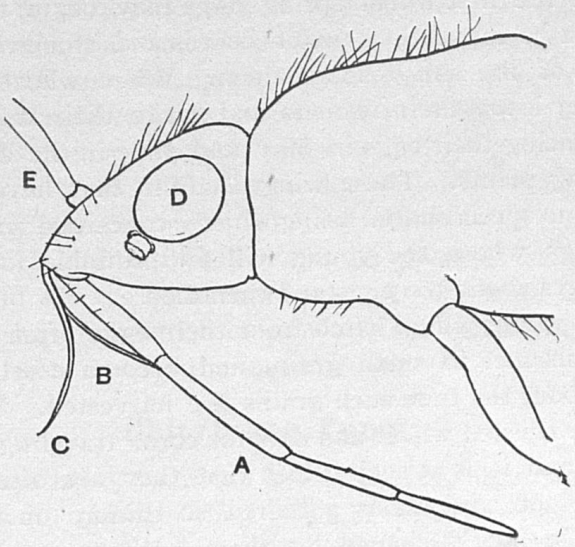

FIG. 1.—A side view of head and part of thorax of chinch-bug, as seen through the microscope. A, jointed beak; B, the slender mouth parts used in puncturing plants, partly withdrawn from groove on dorsal side of jointed beak; C, the slender upper lip, or labrum; D, the eye; E, base of antenna.

What It Is Like.

The adult bug is about 3-16 inch long and 1-16 inch wide; black in general, with white wings lying flat on the back, each with a black dot at the middle of the outer margin. The legs and bases of the feelers are red. The young without wings are more or less red in color. Very young have a cross-band of pale yellow. Older examples with rudiments of wings are largely black in front, approaching in this respect the adult insect.

The chinch-bug feeds at all times after it leaves the egg. It is provided with a beak and takes only the sap of plants for food.

Habits.

The winter is spent as an adult under boards, logs, leaves and the like at the edges of cultivated fields. The bugs do not remain *in* the fields as a rule at this season. As long as cold weather continues the hibernating individuals lie torpid, but with the first warm spring days they begin to stir, and may then be found close under boards and stones, where the warmth of the sun reaches them. When wheat begins to grow they leave their retreats and make their way into the fields, placing their eggs in May and June in the earth about the young plants. These winged adults that have wintered over do no special harm, being chiefly concerned with placing their eggs where the young will find suitable food. Each female lays about 500 eggs and then dies.

The young which hatch from their eggs often do a great deal of mischief to small grain, and become nearly or quite grown about the time such grains are harvested. They then leave the ripened wheat and oats for corn, traveling along the ground, and it is at such times that they are often seen at the edges of corn fields gathered so thickly on the stalks that these are blackened by them. When very abundant these traveling bugs sometimes accumulate in heaps several inches deep on the ground. The brood matures on corn, when not already matured, and places the eggs for a second brood under the enfolding parts (boots) of the lower blades,

as well as in the ground. The second brood may either remain upon corn, or when very abundant, sometimes leaves cornfields for fall wheat. There is evidence of the development of a third brood at this latitude, but the injury is done by the two broods above mentioned.

The chinch-bug may be recognized by the peculiar pungent buggy odor given off when it is handled, or when suddenly exposed in its retreats between the husks of corn ears. When thus uncovered, it quickly conceals itself again, often dropping to the ground and hurriedly getting out of sight under clods. Its expertness in making its way through crevices and small openings is truly remarkable, and enables it not only to avoid its enemies, but to reach the inner tender parts of the plants upon which it feeds.

Its Enemies.

Probably no American insect has fewer natural enemies. Very few birds prey upon it because of its repulsive smell and taste. It is questionable if any of them are fond of it, and it is certain that none feed upon it to such an extent that they are worth considering as checks upon its increase. Several lady beetles have been observed to prey upon it, yet seem never to have an appreciable effect in reducing its numbers during an outbreak. From its disposition to devour foul-smelling bugs, the common toad is calculated to be very useful during chinch-bug outbreaks, and its presence about grain fields should always be encouraged. A good word must also be said for the quail, which is known to eat chinch-bugs, occasionally at least, and for the meadow lark.

Chinch-bug Fungi.

Yet there is no American insect that is subject to greater fluctuations in numbers than this one. For a series of years it may not attract attention at all, even where it is best known and most destructive. Then an outbreak comes that means almost total ruin to the wheat and oats of some sections, and serious reduction of yield throughout the greater part of our wheat-growing area. If the chinch-bug were attacked by

small ichneumon flies, as is the grain louse, we might suppose it was the work of such parasites; but the chinch-bug has no enemies of this kind, as far as known; and as stated, is not much hampered by insect enemies of other kinds.

The periods of exceptional abundance come almost invariably during dry seasons. But why should this be? Is moisture directly hurtful to the bugs, and do they simply multiply without check when drought and sunshine prevail? The quickness with which they disappear after a couple of heavy showers in midsummer, gives some ground for the belief that a drenching rain actually kills them. But after witnessing the manner in which they endure drenching and even immersion in water when kept in confinement, one is compelled to abandon this belief. Furthermore, there is evidence gathered from field observations showing that the chinch-bug will endure as much soaking with water as most other insects. In the account by Dr. Lintner, referred to above, of its depredations in New York, it is stated that it multiplied in spite of persistent rainy weather. He says:

"The past year and the present have both been years of excessive rainfall in St. Lawrence county; spring, summer and autumn have been exceptionally wet. In the spring heavy and continued rains flooded meadows now showing the chinch-bug attack. At haying time, when the bugs were young, and according to all statements hitherto made, readily killed by wet, the rains were so frequent and severe that the grass cut could only be secured with difficulty. Upon Mr. King's farm much of it was drawn in, upon favorable days, by improving the opportunity of extending the labor into nightfall. At the present time grass is lying in fields in stacks, which could not be gathered, owing to continued rain, and fields of oats are still unharvested."

Dr. Lintner suggests in explanation of this immunity that it was a recent introduction into the State, and that it followed the rule with such recent importations in becoming more destructive in its newly invaded territory than it was in regions where it had been long established. It is a fact that insects not especially injurious in their original home often

become exceedingly destructive and difficult to deal with when by some chance they reach a foreign country. The notorious San Jose scale is an example. The cottony cushion scale of citrus fruits is still another. The reason why they are more destructive when transplanted is not far to seek. In the case of the cottony cushion scale, it appears that it was brought to our western orchards without its natural checks, and when they were sought out and imported also this insect was no longer to be greatly feared. Unfortunately, we do not yet know positively the native land of the San Jose scale, but it is very probable that we shall yet find its natural check when we have learned more of it in foreign countries.

Now, in the Middle States, the chinch-bug is attacked by several parasitic fungi, which appear to be very generally scattered ready to destroy the bug when the weather conditions are proper for their growth. They are here in Kentucky, in Illinois, in Kansas, and other States of the Ohio and Mississippi valleys. They are dependent on moisture, and when rains come they get their opportunity. But in New York, where the chinch-bug is commonly very rare, these parasites, we may suppose, were not common in cultivated fields, and hence, the bugs, once started, had, for a time, everything their own way.

Two of these plant parasites are known to be particularly effective in destroying chinch-bugs. They are fungi, somewhat more highly organized than the microbes so often mentioned as causing epidemic diseases, but seem to act in much the same way, getting into the bodies of insects through the breathing pores, and by their growth in the interior, destroying the life of the attacked bugs, and then pushing through to the outside, where the fruit or spores are developed. The small growing threads are too small to be discerned with the unaided eye, and hence, the only way to get a knowledge of the structure and manner of fruiting is by the use of the compound microscope. The presence of these fungi is to be known by the white or gray powdery coats formed on the backs, and often completely covering the dead bugs. The most common and active species has received the name

"Chinch-bug Fungus."* It is pure white as commonly seen on the bodies of insects, but, when old, becomes of a light cream-yellow color. When it is grown in large masses, this change is especially marked.

The second fungus† is not so common as the other, and has not, as far as I know, been grown artificially for distribution. It appears on bugs in the field at times, and the *Sporotrichum*, mentioned above, has sometimes received credit for good work done by this species. It produces a gray coat on the bodies of dead bugs.

But chinch-bugs sometimes die in large numbers, and present none of the symptoms of attack by either of the above fungi. The fluids of these bugs examined under the microscope are often swarming with a micro-organism, which received, many years ago, the name "*Bacillus insectorum.*" It is one of the microbes such as we find associated with certain infectious human diseases, and although it is easily grown artificially in beef broth and in nutrient gelatine, it has not, thus far, in experiment, proved of value in destroying the chinch-bug in the field.

These are the enemies most useful to us, it is thought, from their destruction of chinch-bugs. The chinch-bug fungus (Sporotrichum) has been quite extensively grown artificially in several of the Middle States, and thousands of farmers have used it in their fields. In Kansas it has been more extensively used than elsewhere, and the testimony of farmers there has been at times strongly in favor of its effectiveness as a remedy for chinch-bug injury. The testimony of those who have been chiefly concerned in its culture and distribution is, however, somewhat less positive, owing,

---

*The botanical name is *Sporotrichum globuliferum.* It attacks many insects of several different orders; in fact, will probably attack, spontaneously, most of those that live in such a way as to give it an opportunity. It is especially destructive in Kentucky to the false chinch-bug (*Nysius angustatus*). The harlequin cabbage bug, the tobacco worms, the cabbage Plusia, and the bird grasshopper (*Schistocerca americana*) have proved especially liable to its attacks when confined in the Vivarium of my Division.

†*Entomophthora aphidis.*

partly, to unquestionable failure of the fungus to catch under some circumstances, and partly to the fact that the fungus appears spontaneously in fields, making it impossible to say, under any ordinary field test, that it was actually introduced artificially. In Kentucky the fungus has been cultivated and distributed now for two summers to all farmers who applied for it. Not all who received packages have reported to me, but the majority of those reporting to date, who actually used the fungus, assert that it cleared their fields of the bugs. Some were in doubt, not being sure but that the disappearance of the bugs was caused directly by rainy weather. But in view of all chances of error, the outlook in the direction of destroying this and other pests with artificially grown parasites does not seem to me discouraging. I know from my own experience that an enclosed area of 900 square feet can be so thoroughly infected with the chinch-bug fungus, that not only the chinch-bug, but the harlequin cabbage bug and the bird grasshopper are not safe from it. This area is under glass, it is true, and the moisture and warmth no doubt furnish conditions calculated to preserve the fungus and encourage its activity. But I can see no practical difficulty in cultivating the fungus on so large a scale that a whole county, or even a State, could be thoroughly sown with the spores so that the bugs would be in constant danger from them. It is largely a question of money. Illinois is estimated to have lost in a single year $73,000,000 from chinch-bug injury, a sum which could be made to establish and maintain laboratories that would furnish quantities of the fungus at any time to all who applied. But, it will be urged, you cannot control weather conditions, and what is the use of sending out parasitic fungi when the drought is such that they will not attack the insects? In reply it may be said that the spores of the fungus retain their vitality in soil for a considerable period, and one of the purposes of such laboratories should be to keep the parasite alive in chinch-bug infested regions in such quantities that it would quickly do its work as soon as the weather admitted. The experience with the insect in New York during rainy weather illustrates the importance of having the fungus at hand at all times.

Can fields be kept stocked with the fungus? I believe they can. It is well known that certain bacteria become established in rooms so that it is extremely difficult to keep them out of any fluid or nutritious matter suitable for their growth. Certain yeasts* causing so-called "diseases" in alcoholic beverages, are sometimes in similar manner established in distilleries where they become exceedingly troublesome; and one of the reforms introduced by recent scientific method is the suppression of the disease-producing yeasts, and the isolation in pure cultures, the cultivation and introduction into such beverages of the micro-organism known to produce the aroma desired. If injurious micro-organisms may become established and prevalent because of simple neglect, in the nature of the case it should be practicable to establish useful ones by design. It is true the difficulties become greater when one leaves the laboratory, the dairy, and distillery for the grain field, where conditions cannot be controlled. But where so much is at stake, difficulties should not stand in the way of a thorough test of a remedy in any degree promising.

The Method of Using the Fungus.

In Kentucky we have thus far adopted the practice originally recommended by Prof. Snow, and detailed in a circular which we send out with each package of the fungus. The central idea of this method is to infect the bugs by confining them for a time in a box with some of the fungus, and then set them free to carry the contagion to their comrades out of doors. The box can be made of any lumber, but must be so constructed that the bugs cannot escape. It is not so easy to make such a box as might be supposed, because the bugs get through very small crevices and persist in getting away, no matter how inviting the box is made. A layer of damp earth is spread over the bottom of the box, and fresh food in the shape of young oats or corn is kept constantly in the box. When the bugs begin to die, a part of them are taken to the field where bugs are abundant, and set free, and other

**Saccharomyces pastorianus*, for example.

healthy bugs are substituted for them in the box. By repeating this from time to time, the box is made a source from which a steady supply of diseased bugs can be obtained.

The method has defects that stand in the way of its success. The quantity of the fungus sent out is small in the first place, commonly not exceeding half an ounce, and the confined chinch-bugs may not contract the disease in less than five days or a week, during which time the mischief is going on out doors, or else the bugs become scattered to carry on their work in the neighborhood the following season. Then again, it is often not possible in Kentucky to collect the bugs in sufficient quantities to carry out the directions given in the circular, yet, at the same time, they are abundant enough to do a great deal of harm, and in any case are a threat for the future. Some method must be developed, if possible, that will enable the farmers to set the fungus at work as soon as the bugs appear, and before they become abundant.

It is my personal opinion, though, that the sending out of small packages of the fungus is to be commended, even though the benefit is not at once apparent, and reports received are in the main unfavorable. These small packages contain millions of spores, and the chances are very good indeed that some one of these would destroy a bug or two, and thus introduce the parasite where it was not before present. If the one receiving the package did no more than empty the small box in his infested field, there would still be a chance that the fungus would obtain a foothold and do future effective work. If this is haphazard practice, so, it may be replied, is the sowing of bluegrass, crimson clover, and even wheat during a dry fall. The seeds of these crops fail to catch under much the same conditions that prevent the catching of the chinch-bug fungus.

A Suggestion as to Practice.

When the spores of the chinch-bug fungus have been as systematically sown in our fields for a series of years as are the seeds of clover or wheat and the result carefully observed and recorded we shall be in a position to say whether or not

the treatment is a success. And I wish here to offer a suggestion as to practice which I hope to employ myself when opportunity comes. Briefly told, it is this: Moisten seed wheat and dust it thoroughly with the fungus before sowing.

The hot water treatment for smut in wheat seems destined to be very generally adopted by growers of the crop. It is a very simple matter to suspend wheat in a barrel of water heated to 131-132° F. for fifteen minutes, and when it is spread out to dry it will take but a few minutes more to dust it with the fungus, just as it is dusted with lime after it has been soaked in bluestone. The fungus can easily be grown by the quart, with a little outlay of money, and I should judge that this quantity would be sufficient to charge all the seed wheat commonly planted by one farmer.

How to Grow the Fungus.

The methods of growing the fungus have no practical interest for the farmer, since he cannot be expected soon to grow it for his own use, no matter how effective it may prove to be; but as explaining the nature of the fungus some observations on methods of handling it may be worth giving. My own practice is based upon methods in use everywhere in bacteriological laboratories. The fungus is obtained from an insect that is covered with the white growth by the use of a platinum needle (a piece of wire two inches long) in the end of a glass rod and a dozen or more test tubes containing sterilized potato, or gelatine charged with meat infusion and peptone, the tubes, of course, being kept carefully plugged with sterilized cotton. By simply touching the needle to the white powder on the dead bug and then introducing it up into a tube and drawing it over the surface of the potato, or gelatine, the spores for a culture are sown. In the majority of such tubes several different organisms, moulds and bacteria, appear, often growing so promptly and rapidly that the fungus wanted is crowded out, but when a number of cultures are started, some one or more will very likely show, *on the third day*, the characteristic white cottony growth, which may, a little later, be transferred pure to other tubes. The potato used is cut in the

form of a cylinder by a cork cutter, and afterward each piece is sliced so as to give a large oblique surface. By cutting under water, then putting in test tubes at once and sterilizing with steam, the potato does not blacken.

One trouble the beginner must be warned against. When other work is pressing he is likely to let his cultures dry out, and if left too long in this condition the fungus dies, when it is necessary to get a fresh start, not an easy thing to do at a moment's notice and at any season of the year. I have kept the fungus alive by starting pure cultures in several large flasks, stopped with sterilized cotton and partly filled with nutrient gelatine. The quantity of gelatine is so great that it will not dry out if kept several months. Flasks of this sort should be placed where the temperature does not range widely. The fungus will not grow at a temperature of 103°F., as I find by testing it in an incubator. I prefer to start fresh cultures each spring from fungus found growing spontaneously out of doors, for the reason that continued cultivation seems to weaken the vitality of the fungus.

Gelatine is not convenient as a medium on which to grow the fungus in large quantities sufficient for distribution. Corn meal charged with meat infusion is used instead. The meal, dampened with meat infusion, is put in shallow glass dishes, known as Petri dishes, or in a large culture dish ten inches in diameter, and sterilized with steam, being heated for an hour on each of three or four successive days. The spores are introduced from the pure culture in a test tube by using the platinum needle. I have sometimes sterilized the meal by a single heating in the hot-air sterilizer, and then quickly lifting the lid of the culture dish, poured from a flask over the dry meal sterilized beef broth containing the spores. The method practiced by Prof. Snow has also been followed to some extent, namely, using Mason fruit jars with perforated screw caps, though the opening in the cap *is not indispensable, provided the culture medium has been thoroughly sterilized*, but the fungus requires air to grow well, and my cultures on a large exposed surface have been better, as a rule, than those made in jars. Slightly crushed and steamed wheat makes a

rather better medium than corn meal, because the air penetrates the mass more readily. Hominy, after steaming an hour or two for several days, is an excellent medium.

With the best management, moulds and bacteria will sometimes be accidentally introduced into the meal and take possession of it. Bacteria of fermentation are especially troublesome in hot weather, and soon convert the meal into an offensive sour mass, upon which the Sporotrichum will not grow. Once these organisms get a start in a dish before the fungus appears, it is useless to waste further time with it, and the only thing to do is to have it washed out thoroughly, sterilize it in the hot-air sterilizer, and start again. To avoid loss of time occasioned by such failures, it is well to start a dozen or two cultures at one time. Then a few failures are not of so much consequence. Quite often a green mould will appear on the meal at one or two places, spores floating in the air having fallen on the surface when the cover of the dish was lifted. With a broad blade of a sterilized scalpel, or spatula, one can often remove such growths before they have spread much, and thus preserve the culture of Sporotrichum from further contamination. The culture must be allowed to dry somewhat before being put in tin boxes for distribution; otherwise, the moulds and bacteria take possession. Of course, drying in the sun is not to be thought of, and drying for too long a time anywhere is sure to destroy the spores.

The most important thing to keep in mind in growing the fungus is thorough sterilization of everything used in starting cultures. It is not safe to hurry the process. The medium used *must* be sterile, otherwise, it is useless to sow the spores of Sporotrichum on it. When introducing the spores into dishes or jars, shut all windows and lock all doors. Do the work at night, if possible.

Other Treatment.

Numerous other ways of fighting the chinch-bug have been advocated from time to time in the northwest. Some are utterly valueless, while others are of very limited application, and cannot be expected to have much effect on the gen-

eral abundance of the insect. One of them has been proved in practice effective in preventing injury. It is the use of barriers.

Barriers. When small grain ripens, the chinch-bugs are driven to other plants in the vicinity, and even when the wings are developed, prefer to creep along the ground. Corn or oats adjoining infested wheat suffers severely about the time of cutting wheat, because of the inroads of these migrating bugs. For at least thirty years farmers in the Middle States have been accustomed to plow furrows along the edges of fields liable to invasion, and at intervals of two rods, or thereabouts, dig holes, like a post hole, in which the bugs will accumulate and where they may be destroyed with coal oil. Sometimes, several such furrows, parallel with each other, are made. When tar can be conveniently obtained, fence boards are set on edge in the ground end to end, and the upper edge painted with this substance, which is offensive to the bugs and prevents their passing over. Sometimes the tar alone is used as a barrier, a strip of ground at the edge of the threatened field being smoothed off and the tar poured from the spout of a kettle in a narrow line in the midst of the smooth area. The strip must be worked from time to time to keep the soil pulverized, The bugs will not pass over such a line of tar as long as it is fresh, but it hardens in time and must be renewed. However, if the bugs can be kept out of the field for about ten days, the barrier will have accomplished its purpose, since what bugs are not actually destroyed will have scattered in other directions. Instead of digging holes along the barriers, it is customary in some localities to sink cans or pails in the ground and keep them partly full of coal oil.

A barrier used in Kansas and recommended by Prof. Snow in one of his reports consists of a ridge of earth made by plowing two furrows so that the turned earth falls together, and then smooth this by dragging over it a heavy drag with concave under side. Along the top of the ridge is poured a line of tar, petroleum, or salt and coal oil. On the side of this barrier, next the field from which the bugs come, post holes are dug about one hundred feet apart, and the bugs falling in

them are killed by using a little coal oil from time to time. Writing of the use of this barrier, Prof. Snow says: "Notwithstanding the success reported in former years by a large percentage of farmers using the white fungus infection, there have been enough failures to teach us not to put entire dependence on this, but to supplement the infection by a method that will succeed where the infection fails. The barrier method just described has succeeded admirably in our experience."

Prof. S. A. Forbes, State Entomologist of Illinois, corroborates the testimony of Prof. Snow as to the effectiveness of the barrier method. In his report for the years 1895 and 1896 (published this year) he writes:

"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." And then after giving in detail the result of work done in Effingham County, Illinois, 1895, where a dusty furrow was made by plowing a strip and then dragging a piece of heavy timber back and forth, he continues: "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 average part of a 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. * * *In short, the success of this field enperiment, 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 italics are Prof. Forbes'.

To give the words quoted above the weight with Kentucky farmers that they are entitled to, I need only add that Professors Forbes and Snow have given more time in study and experiment to the chinch-bug problem than any one else in the country. Their conclusion with respect to the barrier method is to be accepted as the very best information we have ou the subject.

The Use of Coal Oil. Under some circumstances coal oil is to be recommended for use against the bugs in preference to other treatment. When it happens that they have already collected on the outer rows of corn, having been driven there from ripening wheat or oats nearby, spraying with oil is about the only thing to be done. It can be used to advantage also to supplement the barrier method, when the barrier becomes defective from the effect of rain, for example. Very dilute preparations of the oil are destructive to the bugs, hence it is possible to apply the oil to corn in an emulsion* without injury to the plants. The application must be made promptly, while the bugs are on the outer rows, since they soon scatter into the interior of the field where it is not easy to reach them. The cost of spraying the outer rows of corn is not great, amounting to about $3.00 per acre for materials.

The Use of Steam. Steam generated in the field in a boiler hauled about by horses, has been recommended as a bug exterminator. Carefully made tests have shown it to be too destructive to vegetation to be safely used.

Deep Plowing. It has sometimes been suggested that the chinch-bug in badly infested wheat be plowed under when

*The emulsion has been repeatedly described, but for convenience may be given here. Dissolve one-half pound of whale oil or laundry soap in one gallon of hot water. Add to it while still hot two gallons of coal oil, then churn it vigorously for ten minutes by passing it through a garden force pump. The oil mixes with the soap solution, forming an emulsion, looking somewhat like thick cream It can be bottled and kept until wanted in this condition. When ready to use, dilute the three gallons with water, so as to make thirty gallons in all. It must be applied with a force pump and spray nozzle.

there is no hope of saving the grain. This, too, proves to be impracticable. The bugs, as already stated, are capable of making their way through crevices that would thwart most other insects, and readily make their way out of loose soil.

Early Planting. The first brood of bugs is the one which injures small grains. The eggs for these are placed in wheat fields in May and June. If, when threatened, the grain can be given an early start, by the time the bulk of bugs are hatched it will be better able to withstand attack.

Fertilizers. Chinch-bugs do most harm to crops on poor land. The plants succumb to the attacks of their enemies the more quickly because feeble, just as the weak and ill-fed among human kind perish, as a rule, quickest in the presence of disease. The use of a stimulant in the shape of fertilizers has been employed with complete success in the case of chinch-bug injury to wheat. The plants are being drained of their fluids by innumerable beaks, and are tided over the trouble by a good supply of nourishing food.

Planting Timothy with Wheat. This practice has been claimed to be a good means of preventing injury to wheat. Just why it should serve this purpose is not very clear, unless it be that the moisture retained by the double growth encourages the fungus parasites of the bugs. A very satisfactory instance of benefit from the practice was reported some years ago to the Illinois State Entomologist by Mr. E. E. Chester, a thoroughly reliable and successful farmer of Champaign County, Illinois. Mr. Chester wrote: "A field of 28 acres was sown to wheat in the fall of 1874, when the chinch-bugs were innumerable throughout this region; twenty acres with timothy and the remaining eight without, timothy being sown on the latter in the spring. This eight acre plot, like the rest in every respect except that mentioned, was overwhelmingly infested with chinch-bug, the grain at harvest yielding only seven bushels per acre, while the twenty acres bearing a thrifty growth of fall timothy, remained wholly unaffected, except for a short distance adjoining the other plot, and yielded an average of twenty bushels to the acre."

The Use of Fire. Burning grass, leaves, weeds, and rubbish

along fences at the edges of infested fields has always been a favorite "remedy" for chinch-bug injury with writers ever since the insect became troublesome in the Middle States. Dr. Fitch, of New York (second report, 1896, p. 295) mentions it; Walsh (Insect Injuries to Vegetation in Illinois, 1861, p. 14) recommends it; Riley (Practical Entomologist, 1866, p. 48) endorses it; and so on down the list to the present time. It is a well known fact that the bug does not remain in cultivated fields, but searches out more secure retreats from winter weather in neighboring woods and at the edges of fields. Of course, the destruction of even a single bug is something accomplished, since one female, as suggested by Walsh, may become the parent of 50,000 descendants during a season. To be effective, however, the fire must burn very closely, and from the habit of the insect in winter to go under bark of logs, under stones, etc., most of them are likely to escape fire that simply burns off the grass and leaves. Even in warm weather it has been found by actual test that bugs may escape a very well managed fire. Fires must be managed with intelligence. First, determine by search whether the bugs are hibernating on the land, and in what situations they are most abundant. Stumps, logs, boards and stones should be overhauled, and the fire given a chance to reach the bugs. Any green growths should have special attention if the burning is done in the fall of the year, and an extra supply of dry material be scattered over them to make sure that the heat will penetrate to concealed bugs.

The insects often migrate in fall some distance from cultivated fields, and since they fly readily in spring, are likely to invade fields to some extent in infested localities whether the growths along fences are burned out or not, yet the practice, if it should be general in a region, would very probably do good. It is only fair to state that there is some difference of opinion even on this point, and Le Baron, one of the most careful economic entomologists this country has produced, wrote in 1872 (Second Annual Report on the Noxious Insects of Illinois, p. 149): "My own observations have led me to the conclusion that this remedy, also, in the way that it would be likely to be generally put in practice, can be of but little avail."

The Literature of the Chinch-bug.

The papers of the following list contain much of what is valuable on the history, habits, and injuries of the chinch-bug. Many articles of more or less worth have appeared also in agricultural papers, those from Le Baron and others in the early issues of the Prairie Farmer having a special interest and value.

1831. Thomas Say, Descriptions of New Species of Heteropterous Hemiptera of North America. This pamphlet was published at New Harmony, Indiana, and contained the original scientific description of the insect, to which Mr. Say gave the name of *Lygæus leucopterus*, since changed in conformity with the recognized rules in scientific nomenclature to *Blissus leucopterus*. The original publication has long been out of print, but in Say's collected papers it is re-published. (Complete Writings, vol. 1, p. 329).

1856. Asa Fitch, Report on the Noxious, Beneficial and Other Insects of the State of New York, 2, p. 277. Dr. Fitch gives an exhaustive account of the chinch-bug, detailing its history as an injurious insect, its habits, and the nature of its injuries. The author had little personal experience with the pest, and his paper is drawn very largely from statements that had appeared up to that time in agricultural papers.

1861. B. D. Walsh, Insects Injurious to Vegetation in Illinois, 1, p. 14. This is a brief paper, in which the use of fire is recommended, and attention is called to four lady beetles believed to prey upon chinch-bugs.

1866. B. D. Walsh, The Practical Entomologist, 1, p. 95. The Prairie Farmer is quoted with reference to the use of tarred fence boards for barriers. A detailed account is given of the use of such a barrier in Ogle county, Illinois, where the bugs were stopped and led into post holes. According to the writer, thirty or forty bushels were collected in a day, and one hundred acres of corn "were completely protected and yielded bountifully." Walsh endorses the statements made.

1868. Henry Shimer, Proceedings of the Academy of Natural Sciences of Philadelphia, 19, p. 75. In this paper Dr. Shimer states his belief that the chinch-bug was destroyed in

FIG. 2.—The adult chinch-bug, the line at the right of figure denoting the natural size. From a photo-micrograph made by H. Garman.

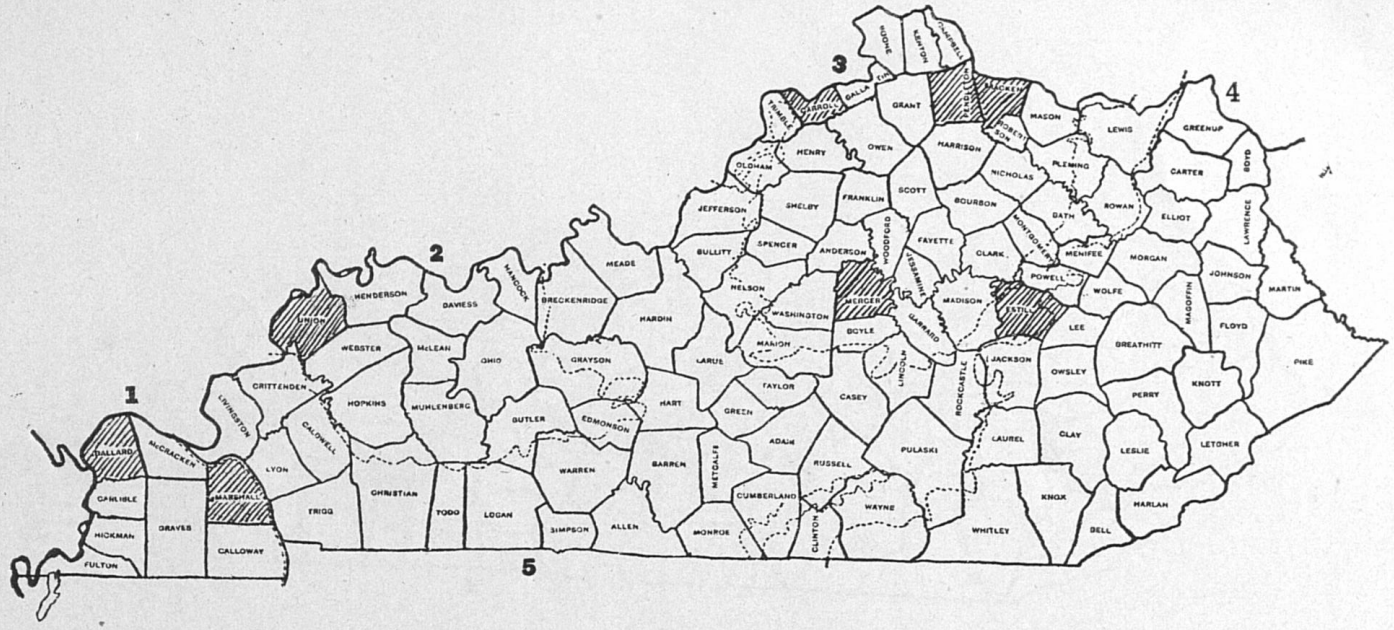

FIG. 3.—The counties marked with lines infested with the chinch-bug in 1887, according to the statistician of the U. S. Department of Agriculture.

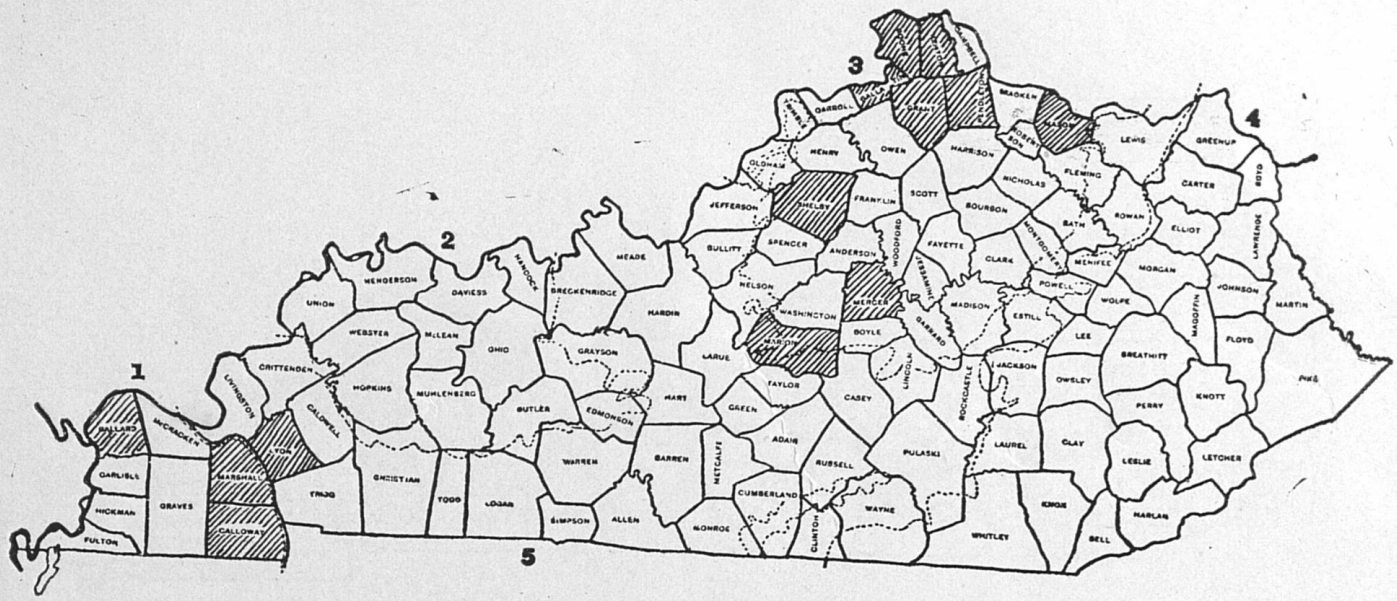

FIG. 4.—The chinch-bug injurious in 1896 in the counties marked by cross lines.

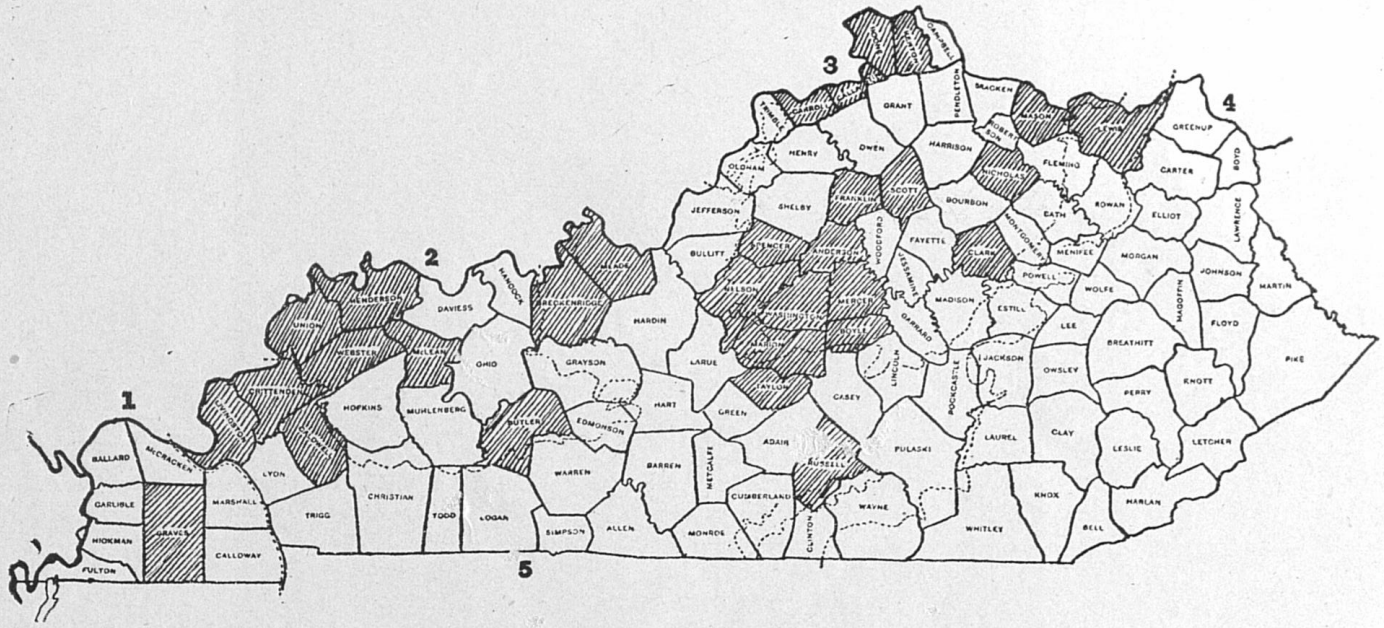

FIG. 5.—The chinch-bug injurious in 1897 in the counties marked by cross lines.

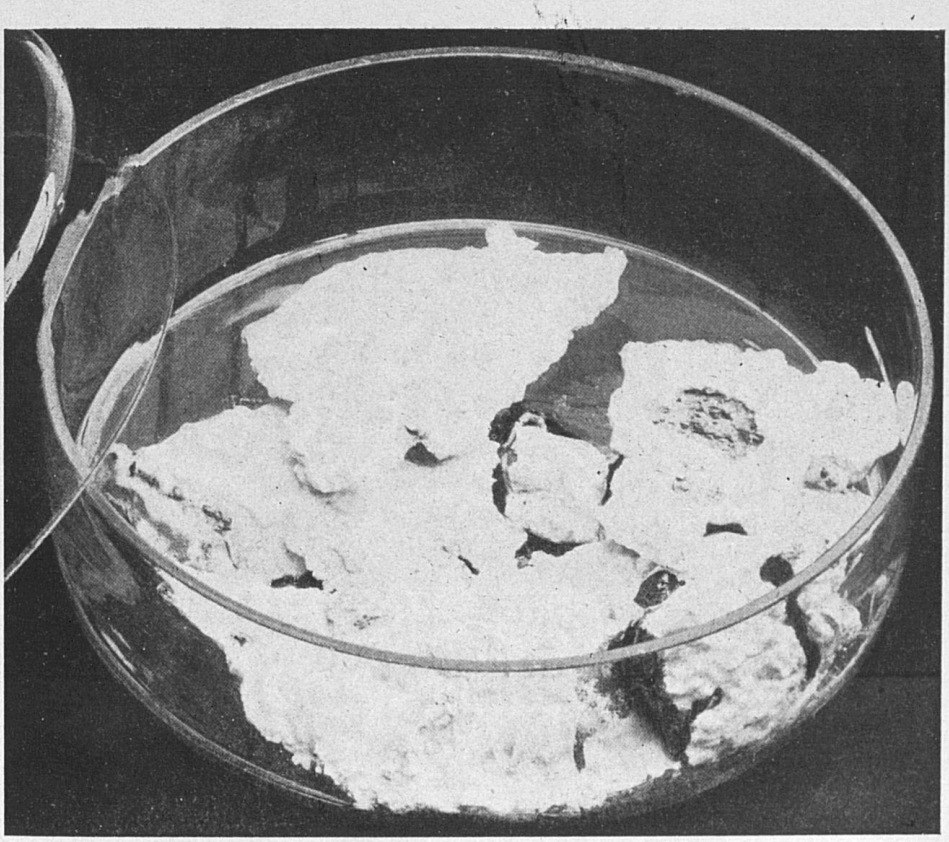

FIG. 6.—A large culture dish with the chinch-bug fungus growing on corn meal. Reduced to less than half real size.

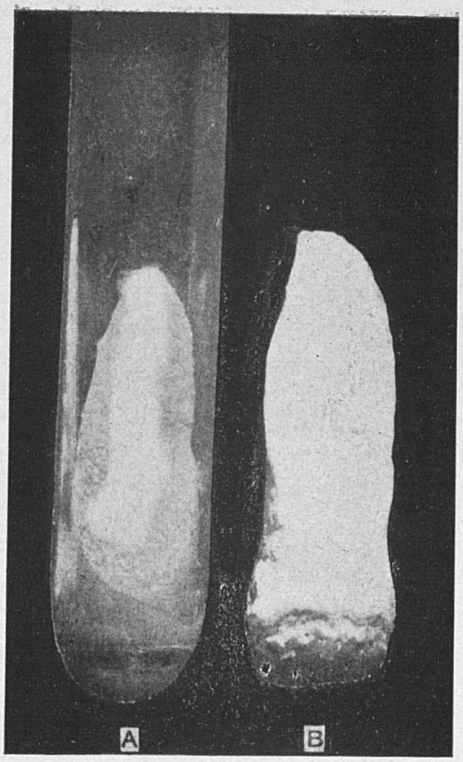

FIG. 7.—A, test tube with chinch-bug fungus growing on potato; B, growth removed from test tube.

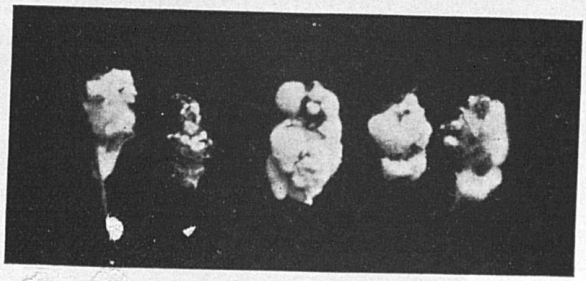

FIG. 8.—Chinch-bugs with bodies covered with the fungus. Enlarged to about twice natural size.

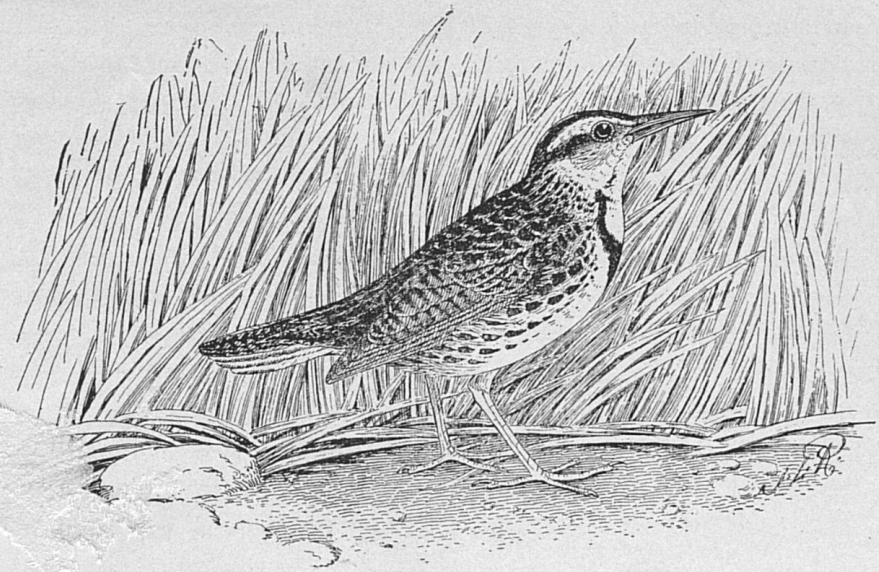

FIG. 9.—The Meadow Lark (*Sturnella magna*), a friend of the farmer. (From Beal, Yearbook, U. S. Dep. Agr., 1895. By courtesy of Division of Ornithology and Mammalogy).

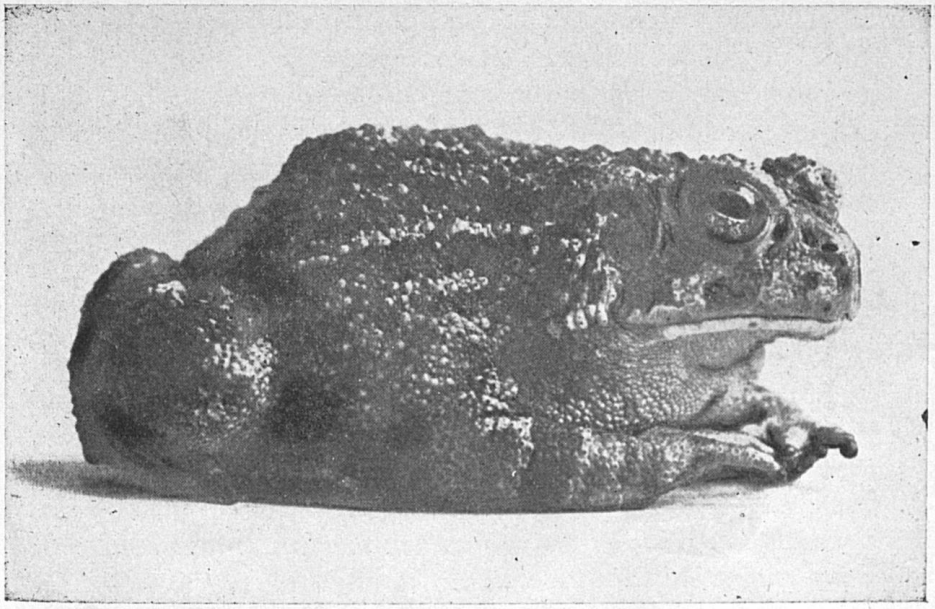

FIG. 10.—The common toad, an inveterate bug hunter and a good friend of the farmer. Photographed from life by H. Garman.

1865 by an epidemic disease, and although this explanation of their sudden disappearance met the usual fate of new and strange truth, it has since been quite generally accepted as well founded. Walsh's unfortunate attitude toward Shimer's work has, however, retarded its acceptance at its real value.

1869. B. D. Walsh and C. V. Riley, The American Entomologist, 1, pp. 179 and 194. This is an extended account of the chinch-bug, giving the experience of western farmers with it, its life history, the effect of weather on its numbers, and remedies.

1872. William Le Baron, Second Annual Report on the Noxious Insects of the State of Illinois, p. 142. This is a general account of the life history and habits of the insect, together with a discussion of the different remedies that have been advocated.

1880, Cyrus Thomas, The American Entomologist, 3, p. 240. The relation of temperature and rainfall to chinch-bug outbreaks is here discussed, and a diagram given showing a pretty constant relation between rainfall and chinch-bug injury in Illinois. Data relating to rainfall and outbreaks in this state were collected for a period extending from 1840 to 1877, inclusive. He shows conclusively that where the rainfall is great and the mean temperature below the average, that chinch-bugs are not destructive, and that their outbreaks have occurred at intervals of about seven years. The same subject is discussed by this writer in the 10th report of the Illinois State Entomologist (1881), p. 47.

1883, S. A. Forbes, 12th Report of the State Entomologist of Illinois, p. 32. This paper marks an advance in the study of the chinch-bug, giving, as it does, positive evidence of the presence of epidemic disease among the chinch-bugs, and describing a micro-organism (*Bacillus insectorum*) that is constantly associated with the disease. It may be considered the starting point for the work that has since developed along the line of preventing injury by the use of artificially grown parasites of the chinch-bug. Brief notices of his results were, it is true, printed elsewhere somewhat earlier, but the sub-

stance of Forbes' study of the bacterial disease of the chinch-bug will be found in the above report.

1885, J. A. Lintner, 2nd Report on the Injurious and Other Insects of the State of New York, p. 148. This is a general account intended for the information of the farmers of New York. It is of special interest as the record of an outbreak in a locality where the insect is commonly very rare.

1888, L. O. Howard, Bulletin 17, Division of Entomology, U. S. Department of Agriculture. This is a summary of the results obtained by a study of the chinch-bug up to that time. Interesting matter on the distribution and injuries is given, especially with reference to the year 1887.

1892, F. H. Snow, 1st Annual Report of the Experiment Station of the University of Kansas. This is an extended illustrated report of 230 pages, giving the results of growing and sending to farmers the chinch-bug Sporotrichum during the year 1891. A total of 1,400 packages was sent out, and the reports received indicated that 76.5 per cent was successful; 13.0 per cent was unsuccessful, and 10.5 per cent was doubtful.

1895, Otto Lugger, Bulletin 37, Minnesota Agricultural Experiment Station. The habits of the chinch-bug are given at length, and remedies are suggested. The author thinks that the distribution of packages of the fungus parasite is calculated to do good, but deprecates sensational articles, sometimes published, which lead farmers to believe that the disease can be introduced without labor. "Many farmers actually expected that by throwing a pinch of the diseased bugs in a large field infested with bugs, these would—presto!—be found dead next day. They did not realize that the introduction of a disease requires very careful work," etc.

1895, F. H. Snow, 4th Annual Report of the Experiment Station of the University of Kansas. The results of field tests of the fungus are given for 1894, the percentage of successful trials being, however, but slightly greater than the unsuccessful. Thus, in Kansas, 875 farmers reported success, while

741 reported failure. The reports obtained from other states give 196 successes and 185 failures.

1896, F. H. Snow, 5th Annual Report of the Experiment Station of the University of Kansas. This report is a continuation of those above cited, and gives results of laboratory and field experiments with the fungus in 1895. The author states that the evidence from field tests was unsatisfactory, and not conclusive as to benefit. The total number of packages sent out was 7,271.

1896. H. Garman, Eighth Annual Report of the Kentucky Agricultural Experiment Station, for the year 1895, p. LIV. A few complaints of injury in Kentucky were received at the Station in 1895, at which time the outbreak of 1896 and 1897 had its beginning. In the report cited is given a brief notice of its occurrence in the State, of methods of growing the fungus, and attention is called to the fact that the Station will furnish packages of the chinch-bug fungus for experiment. Figures of well and diseased bugs are given.

1896. S. A. Forbes, Nineteenth Report of the State Entomologist of Illinois. One hundred and eighty-nine pages of this report are given up to a record and discussion of laboratory and other experiments with several chinch-bug fungi, a list of papers on the parasitic fungi of insects, and some experiments on the effect of water on chinch-bugs. The author thinks that the white fungus serves to hasten the beneficial effect of wet weather, but is not sure about the exact part it takes in lessening the numbers of the bugs. It is plain, at any rate, from the experiments recorded, that immersing chinch-bugs in water has no effect on them sufficient to account for their rapid disappearance after heavy rains.

1896. Otto Lugger, Bulletin 43 Minnesota Agricultural Experiment Station. The general subject of insect disease is discussed, and then the chinch-bug fungi are taken up and some laboratory and field experiments with them are described. The Station furnished 1941 farmers with the fungus in 1895.

1898. S. A. Forbes, Twentieth Annual Report of the State

Entomologist of Illinois. Considerable space is given in this report also to the discussion of chinch-bug fungi, and to the effects of heat, moist and dry, on the insect. The author strongly recommends the use of dusty furrows or strips along the edges of threatened fields, with a line of tar to make them more effective.

2. EARTHWORMS A SOURCE OF GAPES IN POULTRY.

BY H. GARMAN, ENTOMOLOGIST AND BOTANIST.

Bulletin No. 70 of the Kentucky Station contains an account of an experiment made in the spring of 1897 by the writer, with a view to getting information as to the source from which chickens obtain gape worms, and it was shown that the worms were not obtained by chicks kept from the time they hatched on a wooden floor, and the conclusion was drawn that the lot under experiment which became affected with the disease obtained the gape worms either from the soil or from fish worms.

This spring six chicks taken direct from the nest in which they hatched were divided into two equal lots and kept in two cages with wooden bottoms and wire gauze sides, which were suspended at first over the hot water pipes of the Vivarium of my Division, and later were placed upon slate-topped tables. One lot was given a daily ration of earthworms with its other food, while the check lot received no earthworms. Some sand and gravel was put in each cage, but was first thoroughly sterilized by baking in an oven used commonly for bacteriological work. They were confined in the cages March 19th. It soon became evident that the lot which received the earthworms was growing faster than the other, and to supply the place of the worms, cooked meat was thereafter given to the check lot. Chicks in both lots suffered from a trouble resembling rheumatism, in its effect on the legs, probably caused by dampness in the Vivarium, or lack of exercise. Later, a bowel trouble became apparent, culminating April 26th in the death of one of the check lot. Its trachea was examined for gape worms, but none were present.

On April 27th one of the lot which ate earthworms was

observed to show symptoms of gapes. April 28th a second chick was affected. On the night of April 29th both of these chicks died. Both had gape worms in the trachea. The third chick appeared to suffer occasionally from an obstruction in its trachea, and sometimes when it exercised more vigorously than usual became afflicted with something resembling a spasm, lying upon the bottom of the box, opening its mouth and twisting its head about as if suffering acutely. It was now of considerable size, and although these outward symptoms were not those usually presented by fowls suffering from gapes, it was decided to kill it and make an examination of the trachea, which was done May 3rd. On opening the trachea the lower part was found empty and in good condition, but just below the glottis it was plugged with a mass of mucus in which was a single gape worm.

The two remaining chicks of the check lot are still alive, and have not thus far shown any symptoms of the disease.

I can draw only one conclusion from the experiment, which is, that the earthworms conveyed the disease to the treated lot. So far as the experiment is of immediate practical interest, this is all that need be said.

Several questions arise, however, that have a scientific interest, and may eventually prove to have important practical bearings. How does the gape-worm get into the body of the earthworm; is it swallowed with earth or other matter taken into the alimentary canal as food; or does it make its way in by boring through the skin? How long does it remain alive in the bodies of earthworms, and in what situation and condition? Does it infest the bodies of all earthworms, or only of particular species?* It may be suggested that since earthworms live in soil, it is possible that the young gape-worms adhere to the outside of their bodies in particles of

*The worms fed to the chicks were largely obtained on my own place, and consisted of three or four species. The most common was *Allolobophora turgida*, the next in numbers was *Allolobophora fœtida*, the small brown-banded worm, common everywhere in the United States and Europe. The others I am not sure about, but think I observed among them *A. mucosa*.

dirt. The worms were always washed carefully to remove all traces of soil, under the tap of a sink, before being fed to the chicks. But even with this precaution it cannot be denied that a minute gape-worm might adhere to the moist skin of an earthworm. I have no desire to argue this question now, but merely to point out the possibilities. The experiments have been made from the point of view of the practical man, to whom it is immaterial what the condition of the gape-worms may be when introduced. *The main question is settled that earthworms will convey the gape disease to poultry*, and the common practice of feeding young chicks with these worms is consequently not to be commended.

By itself the experiment made in 1897 was not conclusive as to the part taken by earthworms in conveying the gape-worm; but taken in connection with the experiment just reported, it has more weight as evidence that the gape-worm is obtained by chickens from earthworms. Briefly told, the result of the experiments, taken together, is: Number of treated chicks affected with gapes, 100 per cent.; number of untreated chicks affected, none.