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The Mexican Cotton Boll Weevil

BY
E. W. BERGER

Fig. 1—Weevils Feeding on Boll. Slightly magnified.
(From Bul. No. 51, Bur. Ent., U. S. Dept. Agric.)

Issued under the direction of the Board of Control by the Inspector of Nursery Stock

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1. Improvement in cultural method is the foundation of all cotton boll weevil control.

2. The so-called Cultural Method consists essentially in the forcing of a main crop of cotton to maturity.

3. In boll weevil-infested regions it is not possible to produce a "top crop."

4. The greatest losses are sustained during the first year while the growers are being forced to adopt improved methods or quit growing cotton.

5. The Cultural Method begins in the fall by (1) destroying (plowing under or burning) the cotton plants; (2) preparing the soil early; and (3) planting a cover crop. It continues into the next year by (4) planting early maturing varieties and planting them early; then (5) forcing a main crop and harvesting it early.

6. Destruction of nearby hibernating places, such as weeds, Spanish moss, and rubbish is a necessary accompaniment of the fall destruction of the cotton plants.

7. Methods of destroying weevils, such as poisoning and hand-picking are useful only to supplement the cultural method.

8. The weevils feed only on cotton. This fact makes it possible to temporarily eradicate the weevil in isolated fields and localities, by omitting the planting of cotton for a year.

THE MEXICAN COTTON BOLL WEEVIL

(*Anthonomus grandis*)

By

E. W. Berger, Ph.D.

State Inspector of Nursery Stock

The Mexican Cotton Boll Weevil arrived at the western border of Florida in October, 1910. By the end of the season for 1912 it has advanced until the weevil line now passes thru Prosperity and Ponce de Leon in Holmes County (see map). There is no doubt but that it will continue to advance about 40-60 miles annually, altho it may, at certain times, receive a temporary setback, as indicated in the map for the northern and western areas of the cotton belt; or it may advance more rapidly.

The Case Stated.

From whom shall we take our advice? The weevil is about to infest our fields of cotton and some method of control, or avoiding its injuries, must be adopted. Shall we go to the man who has never seen a weevil, or to the growers of cotton who have succeeded in spite of the weevil? From the information available, cotton growing is still an important industry in the localities that the weevil has infested. It therefore behooves us to adopt, as far as possible, the practices in cotton growing followed in those localities.

Sources of Information.

The information given in this paper is a compilation from the writings of the many investigators and successful growers of cotton since its advent into Texas in 1894. Literature on the cotton boll weevil may be obtained from the U. S. Department of Agriculture by addressing your senator or representative in Washington. In order to keep in *close* touch with the work of the U. S. Dept. of Agriculture, all who are interested should receive the *Monthly List of Publications*, which may be obtained regularly by addressing the *Editor and Chief, Division of Publications, U. S. Dept. Agric., Washington, D. C.* It is well, also,

to keep in *close* touch with the State Agricultural Experiment Station at Gainesville, Fla., and specimens of all suspicious insects and diseases of plants should be sent there at once upon finding them. The weevil being of only recent advent into Florida, practically no work has been done upon it here, hence the importance of keeping posted thru the publications of the Department of Agriculture, whose field workers have studied this pest since 1894 when it first loomed into importance in southeast Texas.

What to Do.

Observations and investigations of entomologists and other investigators with the U. S. Department of Agriculture and the several Experiment Stations of the cotton-growing states, are to the effect that the injury of the cotton boll weevil can largely be avoided by the adoption of some changes in methods in the time of planting, fertilizing, cultivation, in the selection of early maturing varieties, and in the destruction of old plants. The method is spoken of as the Cultural Method.

Summary of the Cultural Method.

The following quotation from Bulletin 51, pp. 161-163, Bureau of Entomology, U. S. Department of Agriculture, is a brief but good summary of this subject:

. . . . "In the cultural method of avoiding damage by the boll weevil, it is considered that a fairly effective remedy has been discovered. In some respects the term cultural method is misleading. It is frequently used simply in the sense of careful and persistent cultivation of the crop. However, the term includes the various modifications of the cropping system which have been suggested by the study of the life history of the pest as useful in avoiding damage. Consequently the cultural system is not altogether a system of the proper cultivation of cotton, but a system of the proper cultivation of cotton to mitigate the damage by the pest. Necessarily, it implies a thorough preparation of the soil and a strict attention to all the details of cultivation.

"The cultural method begins with reducing the numbers of the pest in the fall by the destruction of the plants as soon as it becomes apparent that no more cotton is to be produced. The enormous importance of this procedure is shown by the fact that the late issuing weevils are the ones which successfully hibernate. . . . . Hosts of weevils may thus be killed, a very small percentage surviving the winter, and in the same operation the ground is better prepared for planting the following season. A large proportion of the weevils thus destroyed would otherwise

pass through the winter successfully and increase the damage to the planted cotton the following season. Whenever the cotton is all to stand in the fields in the hope that a top crop may be produced, opportunities are furnished for the development of a very large number of weevils. As explained before in this bulletin, the possibility of a top crop has always been exceedingly remote. Wherever the weevil exists it is not a possibility at all. The method of fall destruction only involves applying labor that is necessary in any case in preparing the land for planting a few months earlier than is the normal practice among cotton planters. It has been the custom to leave the land uncleared until shortly before planting time in the spring. Now, however, this clearing is necessary as the last step in the production of the preceding crop. This method, as a matter of fact, is the only practicable strictly remedial method that has been devised.

"The remaining portion of the cultural method consists in furthering the advantage gained by fall destruction by bending every effort toward obtaining a crop that will mature before the weevils have had an opportunity to do considerable damage. The most important factors in obtaining an early crop are early planting, selection of a rapidly growing variety, fertilization, and thorough cultivation. The success of the planter will be in direct proportion to the extent to which he is able to combine these essentials. Early planting of early varieties will be found to be of comparatively little avail unless followed by thorough cultivation, and in case of unavoidably delayed planting the best hope of the planter will be in persistent cultivation.

"As the details of the cultural method have been dealt with fully in the Farmers' Bulletins of this Department, and as the basis for them in the habits of the weevil was fully explained in the preceding pages, it is unnecessary in this connection to more than summarize them:

(1) Fall destruction [of plants and weevils].

(2) Early planting of rapidly maturing varieties.

(3) Wide spacing, which, besides favoring rapid maturity of the plant, also acts as a remedial measure by allowing the sun to reach the ground, causing the drying up of the squares in which the larvæ occur.

(4) Thorough cultivation.

(5) Fertilization with commercial preparations containing high percentage of phosphoric acid.

THE CULTURAL METHOD IN DETAIL.

Fall Destruction of Cotton Plants.

The fall destruction of cotton plants is recommended for the following reasons:

1. To destroy all the larvae and papae (that is, immature stages) of the weevil in the squares and bolls at that time.

2. To destroy large numbers of the adult weevils.

3. By destroying the late-maturing weevils, the number that successfully hibernate, or pass the winter, is greatly reduced, since large numbers of the early-maturing weevils die during the winter. Thus, in a carefully observed instance, out of 240 weevils placed in hibernation in mid-December, 15.8 per cent. passed the winter successfully; while out of 116 that became adult in mid-November, less than 1 per cent. survived.

4. It reduces the shelter places of the weevil during winter, resulting in the death of many.

5. The effect of 1 to 4 is to greatly reduce the number of adult weevils that attack cotton in spring.

6. "Clearing of the field in fall makes it possible to practice fall plowing, which is not only the proper procedure in any system of cotton raising, but also greatly facilitates the early planting of the crop the following spring." (Circular 56, Bureau of Entomology, U. S. Department of Agriculture.)

The plants should be destroyed as soon as the main crop is harvested. No "top crop" should be allowed to grow, for the weevils will get it. This point is specially emphasized by those who have investigated the weevil; do not expect a "top crop," but proceed to destroy the plants as soon as the main crop is harvested, or as soon as it is evident that the weevils are puncturing all or nearly all of the squares, or flower buds, and some of the bolls. The farmer should then wait until the bolls set have opened, collect the lint, and proceed to destroy the plants, whether it is in October, November, or earlier.

Method of Fall Destruction.—The plants must be removed, root and stalk, as otherwise sprouts may grow from the roots and provide food for the adult weevils remaining in the field. The plants should be plowed out or otherwise uprooted, cut with a stalk chopper, and immediately plowed beneath the surface. The deeper they are plowed under the better. Unless the plants can be plowed under deeply they had better be burned, as weevils can work their way up thru two or three inches of loose earth; especially is this important in Florida where the soil is generally loose and sandy. To plow under, the chopped plants and thereby effectively destroy the weevils plowed under, is considered to be most practical only on wet and stiff soils. The land should afterwards be harrowed to make it still more difficult for the weevils to emerge.

Burning the plants has been strongly recommended in the bulletins of the U. S. Department of Agriculture, and plowing them under only where this can be effectively done. In view of the fact that Florida soils are generally loose and sandy, and that they soon dry at the surface, experience may prove that burning the plants after uprooting them is the only method to employ in Florida. The uprooted plants should be collected in piles or windrows, either by hand or by means of a horse-rake. They should be raked up at once before the leaves drop off, as these aid in the burning. Two weeks, in fair weather, is sufficient time for drying. If rain prolongs this period, sprinkling with crude petroleum may be necessary to facilitate the burning. After the plants have been burned, the ground should be plowed in order that the bolls and squares remaining on the ground, many of which still contain immature weevils, become deeply covered with soil.

But it is objected that the tenants will not destroy the cotton plants in fall and that burning destroys valuable fertilizer constituents. For the first, it may be made part of the agreement between owner and tenant that the tenant must destroy all old plants in the fall. The fertilizer value of the cotton plant is not great and, under the circumstances, humus can be supplied by some fall or winter cover crop, such as oats or rye. The investigators of the weevil tell us that it would be impossible to produce cotton under weevil conditions unless the plants are destroyed in fall.

Maturing the Crop Early.—While the object of destroying the cotton plants in fall is to reduce, as far as possible, the number of weevils that can live over until spring, the object of maturing the crop early is to keep the crop ahead of the weevils. In other words, one should undertake to grow the crop faster than the weevils can increase. The weevil will, of course, eventually increase to the extent that all new squares, or flower buds, and bolls will be punctured as rapidly as they are formed; but as the weevil develops slower in the early part of the season than later, when it becomes warmer, this fact gives the grower his opportunity to force the cotton ahead of the weevil.

Early Planting.—After the fall destruction of the old plants the preparation of the soil for the next crop should be taken under consideration. It may be well to plant a cover crop of some kind to protect the soil, and for humus. At all events, the soil should be put into condition, plowed deep, pulverized,

etc., ready for planting at the earliest possible date. Better plant ten to twenty days earlier, and take the risk of replanting. Volunteer cotton should not be allowed to fruit before the regular crop, as it would result in the propagation of young weevils, which require squares and bolls in which to develop.

EARLY MATURING VARIETIES.—Early maturing varieties must be planted to get the best results. This is self evident in view of what has been already stated. Such varieties may be obtained from seed dealers or growers that have selected their seed for early maturity. Farmers' Bulletin No. 314, "A Method of Breeding Early Cotton to Escape Boll Weevil Damage," by R. L. Bennet, should be in the hands of every grower. (A copy of this bulletin may be obtained by any planter from the Secretary of Agriculture, Washington, D. C.)

SPACING OF COTTON PLANTS.—That weevil larvæ are killed when the infested squares fall to the ground, exposed to the sun's direct rays, suggests the desirability of so spacing the plants that a maximum of sunlight will be admitted to the ground. This may mean 4 to 5 feet apart on the richest soils. Check-rowing is considered to be good practice, because it admits the greatest amount of sunlight to the ground and facilitates cultivation. To further take advantage of this fact, that the miniature stages of weevils are killed by the baking of the fallen squares on the ground, the chain cultivator was devised (see p. 11).

In Circular No. 115, Bureau of Plant Industry, Washington, D. C., O. F. Cook discusses a *New System of Cotton Culture.* (This circular should be read by all cotton growers. Copies can be obtained at 5 cents each from the Superintendent of Public Documents, Government Printing Office, Washington, D. C.) The "conclusions" are herewith quoted:—

"The new system of cotton culture is based on the application of a principle not hitherto recognized in cultural experiments —the control of the vegetative branches by improved methods of thinning. The formation of vegetative branches can be controlled by leaving the plants closer together during the early stages, until the stalks have grown beyond the stage where vegetative branches are produced.

"The essential feature of the new system is later, or more gradual, thinning. This makes it possible to leave more plants in the rows than is now customary, and yet injurious crowding is avoided through suppression of the vegetative branches.

"The control or suppression of the vegetative branches also permits an earlier development of the fruiting branches and leads

to the production of an earlier crop. In regions where the period of crop production is limited, either by short seasons or by the presence of the boll weevil, increased earliness is a means of securing larger yields."

CULTIVATION OF CROP.—Besides early planting, planting of early maturing varieties, and spacing the plants consistent with best results under weevil conditions, the crop must be cultivated often in order to stimulate it and keep it growing. "Once a week and once in a row" should be made to apply. This does not destroy many weevils, but keeps the plants growing continuously. However, cultivation should not be deep, nor too close to the plants to cut the roots, as this may cause shedding of squares (flower buds) and the benefits lost.

COMMERCIAL FERTILIZERS.—It should go without saying that fertilizer (plant food) is as necessary for cotton as food is for the mule. Plenty of plant food forces the crop and experiments have shown that a high percentage of phosphoric acid in the fertilizer hastens the maturity of cotton.

CROP ROTATION.—The weevil feeds only on cotton and this fact gives the grower another opportunity to reduce its numbers, especially in isolated fields, by omitting cotton every alternate year and planting corn or another crop instead. When cotton is again planted, it will become infested only by weevils migrating from other localities, the weevils originally in the field having died from starvation. Crop rotation is especially useful in fields near woodlands, in which trees, moss, leaves, etc., furnish excellent hiding, or hibernating places, during winter.

Messrs. Evans and Doyle, of the U. S. Dept. Agr., have recently found where cotton is grown successfully under weevil conditions, in southern Mexico. The method consists in planting cotton every alternate year, and allowing the weevils to starve during each intervening year by planting corn or beans instead. It appears that the Indians practiced this method before the coming of the Spaniards. The case is interesting as illustrating how primitive people may come to follow correct practices without knowing the reason why.

THE CHAIN CULTIVATOR.

Fig. 2 and Plate I.

When infected squares drop and come to lie on the ground exposed to the direct rays of the sun, the heat is so great that the larvae in the squares are killed. This observation led to the in-

vention, by Dr. W. E. Hinds, of the Chain Cultivator, a device for drawing the fallen squares to the middle between the rows, where there is the least shade and the ground hottest. It has been found, on the other hand, that this cultivator produces a very important cultural effect aside from its use for drawing the squares to the middles. The chains (so-called "log chains") are

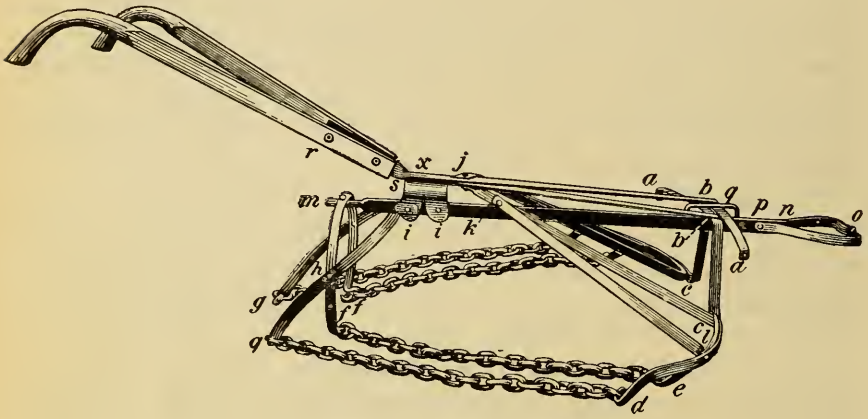


Fig. 2. Chain Cultivator. (For description see p. 11.)
(From Farmers' Bul. No. 344, U. S. Dept. Agric.)

heavy enough to establish a perfect dust mulch and to destroy small weeds.

The following description and accompanying figure (Figure 2) have been copied from Farmers' Bulletin No. 344, U. S. Department of Agriculture, Washington, D. C. (This bulletin may be obtained by addressing the Secretary of Agriculture.)

"*Chain Cultivator.*—When the foregoing facts came to light efforts were made to perfect a device that would bring the infested squares out of the shade of the plants to the middles of the rows. After much experimental work one of the writer's former associates, Dr. W. E. Hinds, devised an implement that accomplishes the desired work in a satisfactory manner. This implement is known as the chain cultivator or chain drag.

"The following specifications should enable any blacksmith to construct an effective chain cultivator.

"The draft bar *n m* (Fig. 2) made of ½ by 5-16 inch tire steel, about 52 inches long, is designed to be about 16 inches above the ground, and this is the height of the rear arch *f h m*, which is

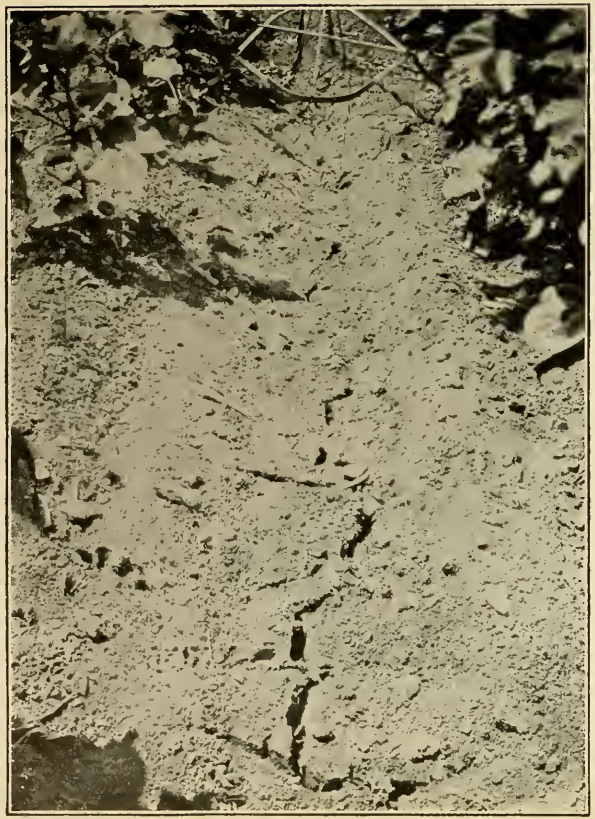


Fig. a. Space between cotton rows before passage of cultivator. Note fallen squares and crack in soil.

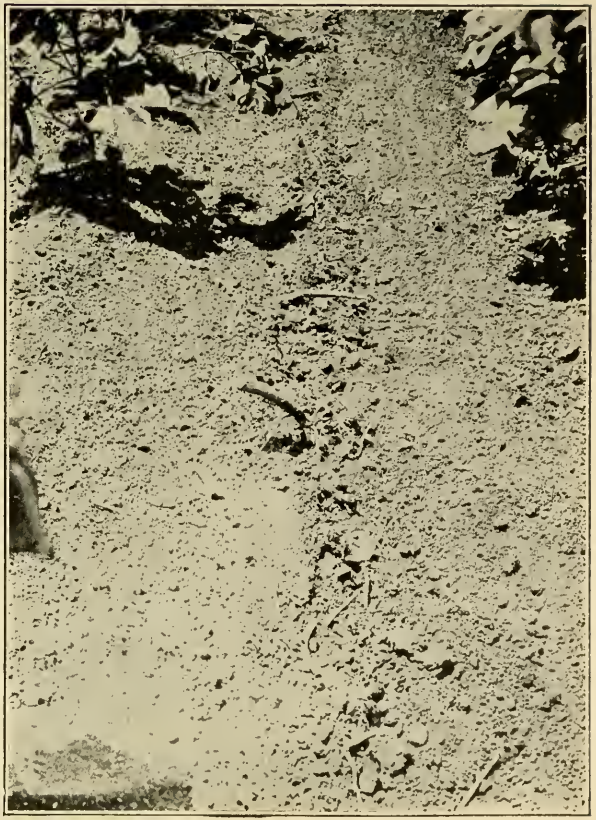


Fig. b. Effect after passage of cultivator. Squares brought to middle, crack filled, dust mulch established.

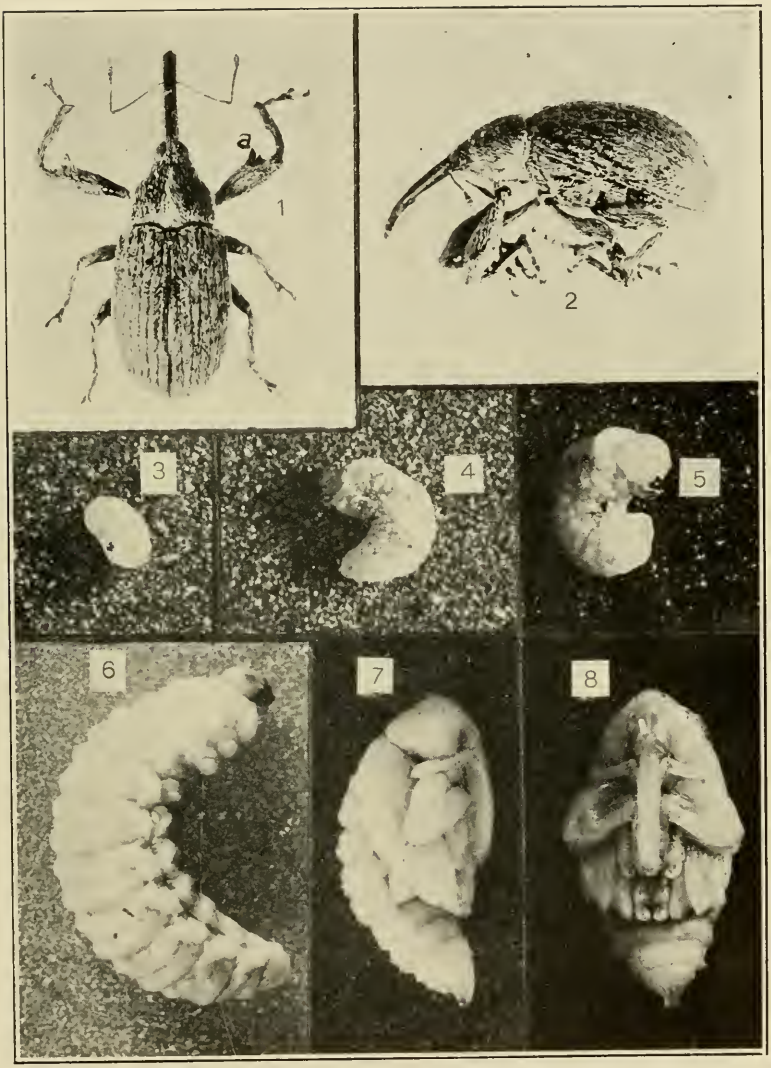
USE OF CHAIN CULTIVATOR

(From Bulletin No. 114, Bur. Ent., U. S. Dept. Agric.)

PLATE II

Typical weedy fence-row, affording excellent shelter for weevils.

(From Bul. No. 77, Bur. Ent., Dept. Agric.)



LIFE HISTORY OF THE BOLL WEEVIL.

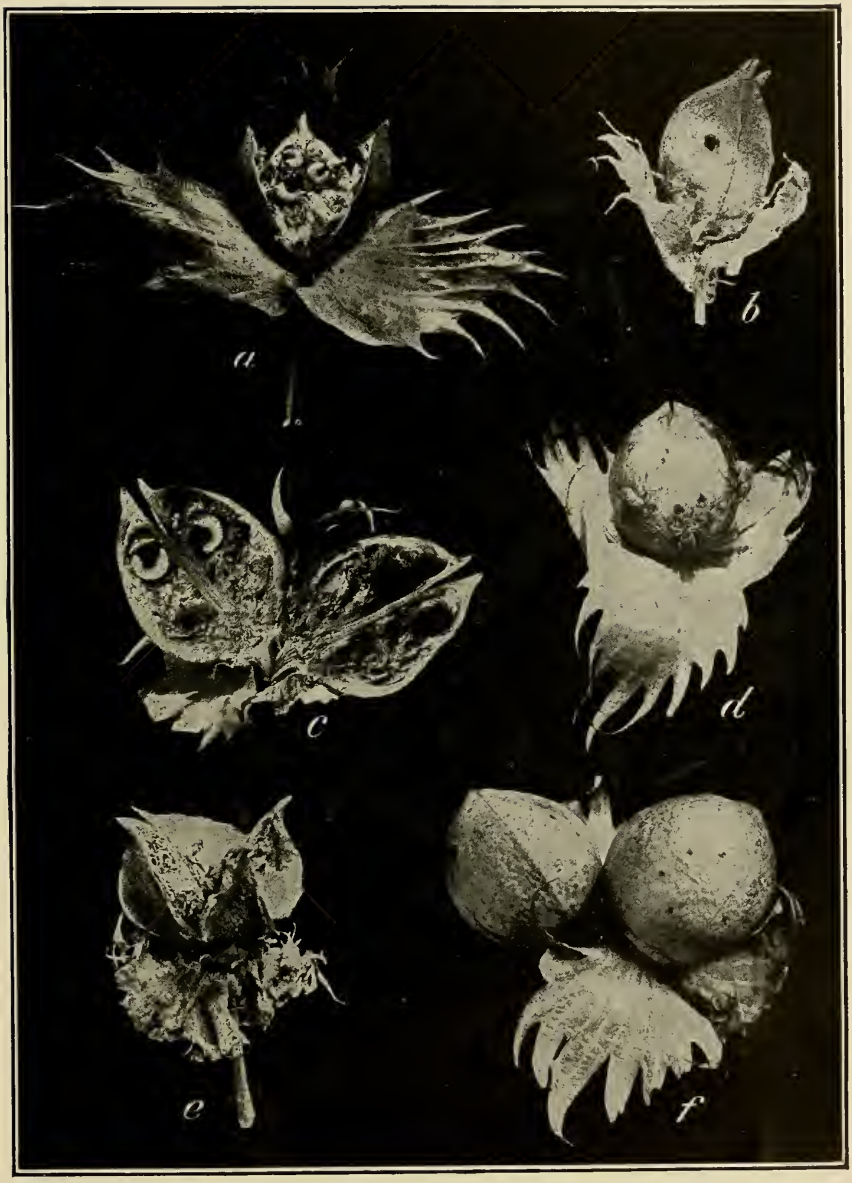
Figs 1 and 2, adult weevils; 3, egg; 4, grub about two days old; 5, grub about 3 days old; 6, grub fully grown, about 10 days old; 7, side view, and 8, front view of pupa, or transformation stage. Nos. 1, 2, 6, 7, 8, enlarged 10 diameters; 3, 4 and 5 about 20 diameters.

(From Bul. No. 146, Ala. Expt. Station.)

INJURY BY BOLL WEEVIL TO SQUARES.

a, Bloom checked by attack of larva; b, square opened, showing grown larva; c, square showing pupa; d, dwarfed boll opened, showing one larva and two pupae; e, weevil escaping from square; f, emergence hole of adult in square.

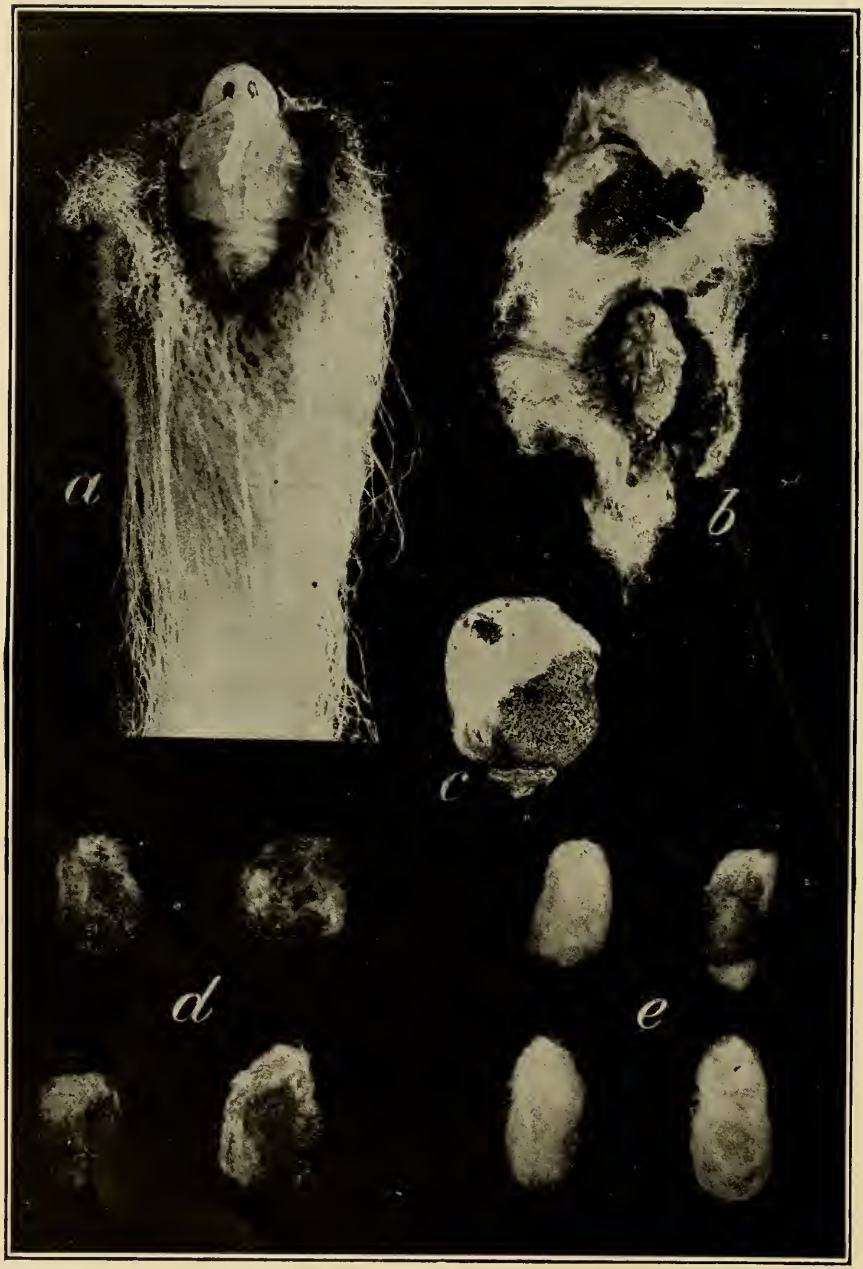
(From Bul. No. 114, Bur. Ent., U. S. Dept. Agric.)



INJURY BY BOLL WEEVIL TO BOLLS.

a, Three larvae in boll; b, emergence hole in dry, unopened boll; c, two larvae in boll; d, weevils puncturing boll; e, opened boll, with two locks injured by weevil; f, large bolls severely punctured.

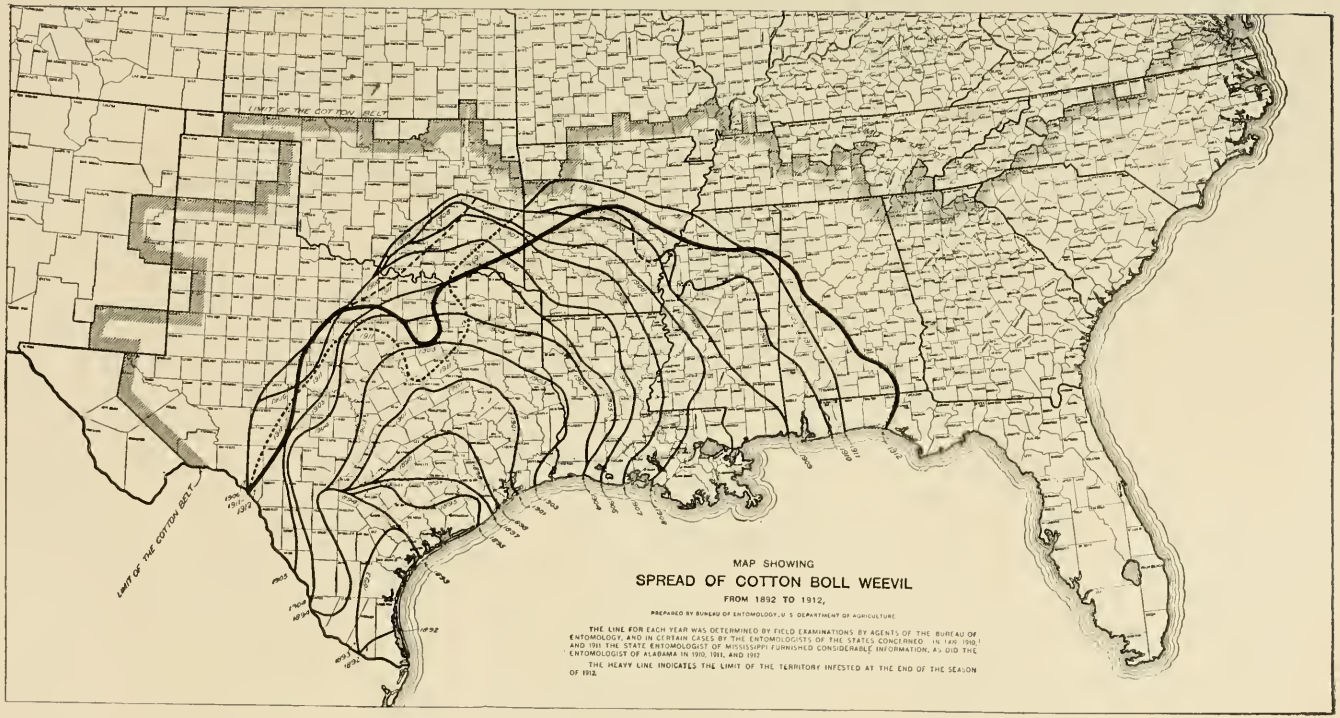
(From Bul. 114, Bur. Ent., U. S. Dept. Agric.)



RELATION OF BOLL WEEVIL CELLS TO SEED.

a, Boll weevil pupa found in cotton seed; b, boll weevil pupa in cell of lint from boll; c, weevil cell in dwarfed cotton boll containing live pupa taken among seed; d, weevil cells in bolls; e, cotton seeds.

(From Bul. 114, Bur. Ent., U. S. Dept. Agric.)



The Spread of the Cotton Boll Weevil in the United States from 1892 to 1912.

(After map prepared by Bureau of Entomology, U. S. Dept. Agric., Washington, D. C.)

of this size and form to allow old cotton roots, etc., to pass through freely without clogging at the rear.

"The distance between the rear ends of the chains *g g*, *f f* is in each pair fixed at about 10 inches. The distance between a chain of one pair and that of the other at their front ends should be about 9 inches. The chains used are of the size known as "log chains," having short, close links of $\frac{3}{8}$-inch iron. This style of chain can be cut to the ength needed in each case. The chain is easily attached by simply making the hooks at *d*, *e*, *f*, and *g* so that the end of the hook is as wide as will pass through the length of the link and narrow enough at the middle of the bend to allow the link to turn and bag the other way. So long as the chains are kept tight they cannot become unhooked. The hooks should also be turned, or faced, in such a way that they will not be likely to catch the passing plants or rubbish.

"The clevis *o p* is simply hinged, so that there will be no tendency to pull the front of the machine off of the ground, and it is also broad enough in front to allow of the point of draft being moved from one side to the other, so that the front of the machine may be thrown closer to one row if desired.

"The front guard on each side *a b c d* is made of one piece of spring steel, $\frac{7}{8}$ by 3-16 inch. This size seems sufficiently strong and best adapted to carry the tension of the chains *d g* while still yielding to the pressure against the bases of the plants as they may strike the outer, sloping ends near *d*. The inner ends of these guards *a b* are horizontal, about 18 inches each in length, and serve to carry the front guard above the draft bar *n m* and, passing through the keeper *q*, guide in the adjustment for width. The machine cannot be extended beyond the bent ends at *a* or closed beyond the angles at *b*. The vertical section between *b* and *c* is about 12 inches long, so that the remainder of the front guard from *c* to near *d* will be about 4 inches above the ground. This prevents the pushing of dirt and squares toward the plants and allows the chain to catch them where they lie. The hooks at *d* and *e* are therefore bent downward and somewhat backward through about 5 or 6 inches. Care must be taken especially in forming the outer ends between *c* and *d* to secure best results. The downward bend for the hook at *a* should not be abrupt, as the gradual slope helps to prevent catching on any obstacles. The hooks at *f* and *g* are formed so as to hold the chains firmly and yet not interfere with the passage of rubbish. The method of carrying the rear ends of the outer

chains is shown at *i h g*. The piece *k l* is nearly parallel with the chains and may be used for their proper adjustment as to tension by several holes near the end where it is bolted at *k*. The chains are between 30 and 36 inches long. The stand *s* upon which the handles are pivoted by a ½-inch bolt is made of a piece of boiler plate bent and cut so as to have a horizontal top surface about 4 inches square and standing about 2½ inches above the draft bar, to which it is securely bolted. The handles are bolted, as at *r*, to the heavy pieces of iron (about 2 by ½ inch tire steel) which are bent to receive them just behind the pivotal point at *x*, at such an angle as to bring the handles to the proper height and position. In front of *x* these pieces bearing the handles need not be so heavy and may therefore be tapered and welded to smaller steel running forward to *b*, where it is bolted to the front guard. The operation of this arrangement is similar to that of a huge pair of shears—when the handles are pushed apart the front of the machine is spread wider, and vice versa. The braces *j c e* serve to support, strengthen, and carry the front guard. They are riveted to the adjusting irons at *j*, one above and one below the "shear" pieces, to prevent their interference with the closing of the machine. At *c* this iron is bent to conform to the front guard, to which it is riveted between *c* and *l*, at which point it is bent downward and forms the hook *e*. Ordinary tire steel about 1 by ¼ inch may be used for all parts like the clevis *o p*, rear arches *f h m* and *i h g*, and braces *k l* and *j c e*. The front guard *a b c d* should be of spring steel, as specified. The rivet heads on the front guard should be round and fit smoothly. In nearly all other places the irons are fastened together by ¼-inch square-headed bolts, with washers as needed.

"In operation the implement is drawn by a single animal. The chains at *d* and *e* pass under the branches of plants and close to the stems. The forward motion of the machine causes these squares to be drawn inward by the chains, which must keep taut, and leaves them in a narrow pathway where the chains approach within a short distance of each other at the opposite end of the machine. The two chains are provided so that squares that may pass over the first are taken up by the second on either side. In actual practice it has been found that more than 90 per cent of squares may be brought to the middle of the rows. This means that the natural mortality among the weevils due to the effects of sunshine can be at least doubled.

"Although the chain cultivator was designed primarily for

bringing the squares to the middles, it was found in field practice to have a most important cultural effect. The chains (so-called "log chains") are heavy enough to establish a perfect dust mulch (see Plate I) and to destroy small weeds that may be starting. In fact, it is believed that this cultural effect would more than justify the use of the machine, regardless of the weevil. With the effect against the insect and the important cultural effect it is believed that this implement or one similar to it should be used by every farmer in the weevil territory.

"*In order that the use of this machine could be obtained by all farmers at the smallest possible cost, a patent has been taken out in then ame of the Department of Agriculture and for the benefit of the people of the United States. Under this patent it is impossible for anyone to manufacture the machine exclusively and to charge unnecessarily high prices."

Destroying Weevils in Hibernation.

Plate II.

Weevils live over winter, or hibernate, in many places, but principally in grass, leaves, Spanish moss, and old sorghum or corn fields. Any rubbish, however, and buildings, especially cotton gins, will harbor them. It therefore becomes very important that all rubbish in and near cotton fields should be burned in order to destroy as many of the weevils as possible. Plowing and harrowing of the fields will strengthen the blow. We may better appreciate the importance of destroying every weevil that can be found, when we contemplate that the progeny of one pair of weevils may reach the enormous number of 12,755,100 during one season. This number is, however, never actually realized in the field because of the many accidents to which all stages of the weevil are subject.

Poisoning.

Poisoning with paris green has been found to be ineffective. This poison injures the plants and poisons few weevils. Placing this poison on volunteer cotton early in spring may kill many weevils, since they feed to some extent on the leaves, but it is considered best to destroy all volunteer cotton, since weevils deprived of food live only six or seven days, except in hibernation.

Arsenate of Lead.—In Louisiana, preliminary experiments with powdered arsenate of lead (Cir. No. 33, State Crop Pest

*The machine can now be obtained thru dealers in agricultural implements.

Fig. 3. Applying a powdered insecticide by means of a Champion Duster. The secret of success in dusting cotton with powdered arsenate of lead, lies in forcing the powder into the terminal buds with a strong current of air.

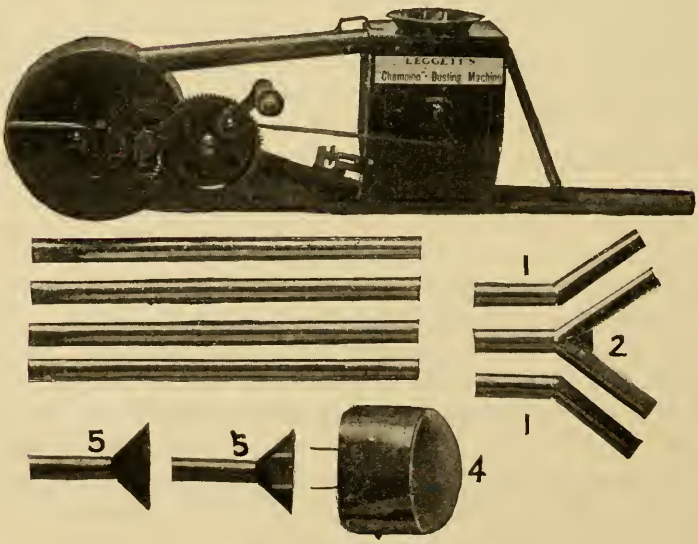


Fig. 4. Champion Duster with extension rods and nozzles.

Commission of Louisiana, July 1908) indicate a remarkable degree of success. However, early fall destruction of the cotton plants is a necessary antecedent to successful poisoning. Neither must any step in the "cultural method" advocated be omitted, because poisoning is only another help for reducing the number of weevils, but not a panacea. The experiments further show that profitable results were obtained only by using the powdered arsenate of lead against the weevils early in the season, namely, against the weevils on the first buds. It would be useless to employ it in an effort to save a "top crop" or during summer.

This poison should be applied about five times at intervals of five to seven days apart; the first application is made when the first square is found in the field. The powdered arsenate of lead must be applied with a powerful current of air by means of a blow gun and driven into the terminal buds (between the small leaves that make up the buds) on the main shoots and on the ends of the fruit limbs. Do not dust on by means of a sack, as that has been found useless. The "Champion Insecticide Duster" (Figs. 3 and 4), made by Leggett & Brother, New York City, is the type of machine found most satisfactory by Mr. Newell.

Hand Picking.

Collecting the live weevils and infested squares by hand may be practiced in small fields and when cheap labor is abundant. The live weevils should be placed in a dish with a small amount of kerosene, which is certain death to them. The infested squares and bolls should be placed in wire cages or in boxes covered with wire netting. The net must be 16 mesh (17 strands) per inch so that the weevils, as they emerge, cannot escape; but any useful insect parasites which happen to be infesting weevil larvae will be able to escape and find their way back to other cotton plants and parasitize other weevil larvae. This is the object to be gained by placing the squares under the wire screens. If such are not available, the squares must be burnt.

Useless Methods.

Mineral paint, sulphur, spraying, trapping with lights, poisoned sweets and cotton seed meal, as bait, have all been tried and found ineffective. Trapping with lights is useless, because weevils are not active at night, but only in daylight. If weevils or infested squares are buried they must be buried deep, since adult weevils can work their way through at least three inches of

dry soil. This also implies that probably very few weevils are ever killed when buried by ordinary plowing or cultivation.

Diseases and Parasites.

The weevils appear to be exceptionally free from diseases. A promising number of insect parasites, however, are known; according to Farmers' Bulletin No. 344, p. 15, U. S. D. A. there are 23 species. These appear to be on the increase and will undoubtedly become a more useful factor in the future, although they may never be able to control the weevil without the aid of the cultural methods described. These parasites deposit their eggs upon the grubs of the weevils in the squares or bolls. The parasite larvae that hatch from these eggs destroy the grubs of the weevil and later, instead of a weevil, a parasite of the weevil emerges from the squares or bolls.

Of 22 species of predaceous insects (Bul. 344, previously cited), 12 are ants. These are the minute brown and yellowish ants that frequently occur in cotton fields. Their work is directed against the grubs and pupae of the weevils in the squares, and not against the adult weevils.

The effectiveness of the predaceous insects, as well as that of the parasites of the weevil, increases more or less accordingly as the numbers of the weevil are reduced in other ways.

How Each Grower Can Protect Himself.

He can help himself to some extent even if his neighbors are indifferent and do nothing to reduce the numbers of the weevil in their fields. The fact that weevils do not fly much from field to field during the period when the cotton is setting its main crop, and the fact that the first weevils in the field at the beginning of each season are mainly those that succeeded in hibernating successfully in and near the field, make this possible. With these facts in mind, and a close application of the cultural method, any grower can protect himself unmindful of his neighbors, unless their fields immediately adjoin his, when it may be necessary to locate the cotton field elsewhere.

What the Bankers and Merchants Can Do.

The following quotation is from a circular issued by the Bureau of Plant Industry (B. P. I.—619, No. "A"—71, January 19, 1911): "The Production of Cotton Under Boll Weevil Condi-

tions." "The second cause noted is the lack of confidence, first on the part of the farmer. *If a man doesn't believe that he can accomplish a thing it is about half way toward not doing it at all.* He loses force and energy. The second result of the loss of confidence is that the bankers and merchants withhold credits, and since much of the cotton crop is made upon the credit system, the planter is crippled and prevented from planting as many acres as usual."

In view of the fact that the bankers and merchants represent one of the strongest factors in the intellectual and business life of a community, it appears that they might take the lead in encouraging the adoption of the newer methods necessary for successful cotton culture under boll-weevil conditions. A Cotton Protective League, or society of the bankers, merchants and leading growers could be organized for the purpose of studying weevil control, especially in its application to local conditions. Then credits might be conditioned upon the application of the proper cultural methods. The citrus growers have Citrus Protective Leagues for the purpose of controlling the whitefly and other pests.

How the Weevil Spreads.

The adult weevil is not a good flier, but successive short flights may carry it over long distances. Thus it has been known to cover more than 40 miles in a brief period of time. Favorable winds aid in its dispersion. The main dispersion period is some time in August or September. At this time the weevil's instinct to migrate becomes active and it flies in all directions. Only those, of course, that fly in the direction of non-infested territory succeed in extending its range. The weevil may advance something like 30 to 60 miles per season.

Besides the general migratory period first noted, weevils move short distances in all directions from the fields in fall, searching for hibernating quarters. In spring there is a corresponding movement back to the fields, but after that the weevil keeps busy in the field until the crop is mainly grown. Railways and water courses are two principal lines of spread, also traffic along highways. Shipments of cotton and seed from infested localities are almost certain to carry weevils. Hulls and other by-products used for feeding cattle may carry them to the farmer. In this connection it should be noted that the artificial spread of the weevil may be greatly retarded if growers will look to getting

their supplies of seed from non-infested localities. Tennessee, north-eastern Alabama, north Florida (east of Holmes Co.), and the states east of those just named, are localities still free from the weevil.

Food of the Weevil.

The weevil has no other known food plant but cotton.

Early in the season the adult weevils feed on the tender foliage of the young cotton, but later principally on the squares and to some extent on the bolls. Experiments prove that the female weevils do not produce eggs until they can feed on squares or bolls.

The immature stages of the weevil, or grubs, feed only within the squares and immature bolls, and no other known insect feeds in this manner on cotton.

Varieties of Cotton Infested.

All varieties of cotton may become infested. The foreign varieties, however, are preferred when grown side by side with American varieties. Thus Sea Island cotton is 2 to 4 times as attractive; Egyptian over 4 times as attractive as American cotton.

While these observations show clearly that the Egyptian and Sea Island cottons would be at a great disadvantage when grown in the same weevil infested locality with American cotton, they do not show that the weevil would be more prolific upon them when grown alone. The longer period required for the maturing of Sea Island cotton will, however, in all probability, place it at a decided disadvantage, and may even eliminate it as a profitable crop when the weevil reaches the parts of Florida where it is grown.

Growers of Sea Island cotton in the eastern parts of Florida had, therefore, better cast about for a substitute of this crop, early, in order that they may be fortified when the weevil reaches them. It is not impossible on the other hand, but that early maturing varieties of long staple cotton may be found, suitable to this part of the State. According to the rate of advance during 1912 (see map) we may expect the weevil to have arrived at or near Quincy by the fall of 1913, at or near Madison in 1914, and Macclenny in 1915. Should the rate of advance be only half that in 1912, the weevil may be expected at Quincy in 1914, at Madison in 1916, and at Macclenny in about 1918.

How to Know When the Weevil is Present.

The adult weevil (Fig. 1, Plate III) is one of the snout-beetles. Its snout, shiny black, slender and slightly curved, comprises about one-third of the total length of the beetle. The insect is about one-fourth inch long, and dark brown, ashy-gray, or yellowish brown in color.

The fully grown grubs (Fig. 6, Plate III) are about three-eighths inch long, curved, and can be found only in squares and bolls. The pupa (Figs. 7 and 8, Plate III) or transformation stage, is not quite as long as the fully grown grub and is also found in the squares or bolls. All the immature stages (eggs, grubs, pupae) occur only in squares and bolls (Plates III, IV, V).

Squares and bolls from which fully grown weevils have come have holes about 1-20 to 1-16 inch in diameter (Plates IV, V). These cavities lead to larger excavations in the interior and are the openings through which a weevil emerged.

Some observers state that the squares with holes somewhat resemble those injured by the boll-worm. Generally only one weevil develops in a square. Small elevated growths, called "warts," on the surface of squares and bolls, mark the punctures where an egg was deposited. Orange-colored excrement on the buds and abundant flaring and shedding of squares without apparent cause are other signs of the boll weevil.

Hibernation of Weevils.

Soon after the first frost the adult weevils hide away in concealed places and remain dormant until spring. This is called hibernation. Large numbers of them perish during this period so that sometimes only one in six, or about 16 per cent. survive. The longer the hibernation period the fewer will survive. The hibernation period can be practically lengthened by the early destruction of the plants. In other words, it is the late maturing weevils that survive in the largest number while the earlier maturing ones mostly die before spring. Destroying the food supply early, therefore, has the effect of greatly reducing the numbers of weevils that hibernate successfully. Records show that of adult weevils taken from the field in December and placed in hibernation, about 16 per cent. survived, while of some taken before November less than 1 per cent. survived. The number that survives depends also very much upon suitable hibernating quarters, so that by destroying these in fall the number of weevils can be

greatly reduced. They will hibernate in and about almost anything that furnishes a place for concealment. Grass, Spanish moss and fallen leaves are preferred. Rubbish along fence rows and ditches, the edges of forests, about gins, oil mills, etc., are places of refuge in winter.

The Weevil Described.

The cotton boll weevil is a beetle (Fig. 1 and Plate III). It belongs to the family of weevils, technically known as Curculionidae. It is about one-fourth inch long and of a dark brown, ashy-gray, or yellowish brown color. Its snout, which is shiny black, slender and slightly curved, comprises about one-third of its total length.

Life History of the Weevil.

Plates III, IV, V, VI.

The Egg.—The egg is about 1-30 inch long, white and delicate. A square or boll is always selected as the place for its deposition. The female eats a small cavity for it. This small cavity generally grows over, forming what is called a "wart." From the egg there hatches, in a few days, a minute grub or "worm."

The Immature Stages.—The grub or worm hatched from the egg increases in size from about 1-25 of an inch to $\frac{3}{8}$ of an inch, when it is fully grown. During its period of growth it feeds on the inside of the square or boll. When fully grown it passes into the resting, or transformation stage, called the pupa. The pupa is the marvel of the insect world and is a stage in the development of nearly all insects. The transformation from the grub to the fully grown, or adult, weevil takes place in the pupa, and the entire life of a weevil, from egg thru pupa, is passed in the square or boll. The adult, after it emerges from the pupa, also remains within the square or boll for a few days, and then eats its way out, leaving the visible hole previously described.

Number of Generations and Length of Life Cycle.—In most sections infested by the weevil, there are eight generations each season, and the length of the life cycle, or the time required for the development of a fully grown weevil, from egg to adult, is three or four weeks. In the more northerly parts there are only four generations, because the prevailing temperature is lower and the season shorter. The females begin to deposit their

eggs within a week after they begin to feed, and continue to do so for about 56 days or until within a few days of death. The average length of life during warm weather appears to be about 70 days. Those that hibernate may live for six months or even longer.

History.

The cotton boll weevil, more properly called the Mexican Cotton Boll Weevil, sometimes erroneously the Texas Cotton Boll Weevil, appears to be native in Southern Mexico. It was described and named by Boheman in 1843 from specimens received from Vera Cruz. In 1871 it was recorded from Cuba. Serious injury to cotton near Monclova, Mexico, was reported to the Commissioner of Agriculture, in September, 1880, by Dr. Edward Palmer (Bul. 51, Bu. Ent., U. S. D. A.). The pest appears to have existed near Brownsville, Texas, in 1892, and in 1894 had spread to half a dozen counties. How it came across the Rio Grande is not known.

The deplorable fact remains that but for the indifference or incompetence of Texas at that time this pest could have been stopped in its advance in 1894. Considering the average damage per year due to the weevil as $10,000,000, we have for 19 years the enormous sum of $190,000,000 lost, not counting the money spent in the attempt to control it. This sum could, very probably, have bought the entire half dozen counties first found infested in Texas in 1894 several times, and over.

The establishment by law of a belt 50 miles wide along the Rio Grande in which cotton growing should be prohibited, was advised by the U. S. Department of Agriculture, but this advice was not heeded by the State of Texas, and subsequently disastrous results followed.

One wonders, sometimes, whether one state should not be held financially liable to other states for such gross neglect of duty. A United States law to that effect would probably result in a wholesome clearing of the atmosphere in that respect.

Territory Infested.

(Plate VII, Map.)

At the end of 1910, 268,000 square miles of territory were infested by the weevil. This is 40 per cent. of the total cotton-growing area. The average advance per year is about 50 miles and it has been estimated by those who are observing the

advance of the weevil closely that the whole cotton-producing area may be infested by the end of another 15 years (counting from 1910). At the end of 1912, 278,800 square miles were infested.

The area infested comprises the larger part of Texas, all of Louisiana, a large part of Oklahoma, about half of Arkansas, the larger part of Mississippi, southwest Alabama, and the four or five western counties of Florida.

The Prospects.

The weevil will not put the cotton grower out of business. Neither would the loss in the beginning be great if all the growers in a locality would co-operate in applying the methods found by experience to give results. The greatest loss generally occurs during the first two or three years when growers neglect to adopt the new method. Co-operation should be the keynote in cotton-growing communities.

Bulletins and Circulars.

For a list of bulletins and circulars referred to and recommended, the text may be consulted. See pages 5, 6, 8, 10, 12, 15, 18.

*The principal large bulletin on the Mexican Cotton Boll Weevil at present is Bulletin No. 114, Bureau of Entomology, U. S. Department of Agriculture. If copies of this bulletin cannot be obtained free thru the senators and representatives of Florida in Washington, the same can be obtained from the Superintendent of Public Documents, Government Printing Office, Washington, D. C., at 25 cents per copy. This bulletin has also been published as Senate Document No. 305, 62d Congress, 2d Session, 1912.

Other recent numbers of the *Farmers' Bulletin* are herewith listed. These can be obtained by addressing the Secretary of Agriculture, Washington, D. C.:—

F. B. No. 500. The Control of the Boll Weevil. By W. D. Hunter. This is a brief extract and summary of Bul. 114, previously noted.

F. B. No. 501. Cotton Improvement Under Weevil Conditions. By O. F. Cook.

F. B. No. 512. The Boll Weevil Problem, With Special Reference to Means of Reducing Damage. By W. D. Hunter.

F. B. No. 519. An Example of Intensive Farming in the Cotton Belt. By M. A. Crosby.

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*Copies can still be obtained free by addressing the Secretary of Agriculture, Washington, D. C.