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THE SWEET POTATO WEEVIL IN LOUISIANA AND ITS CONTROL

BY

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IN COOPERATION WITH

AGRICULTURAL EXPERIMENT STATIONS OF LOUISIANA STATE UNIVERSITY
THE SWEET-POTATO WEEVIL IN LOUISIANA
AND ITS CONTROL

By CHAS. E. SMITH,

INTRODUCTION.

The sweet-potato weevil* has long been recognized as a very
destructive insect enemy of the sweet potato. It has, however,
received unusual attention in the United States during the past
few years because of the fact that the growing of sweet potatoes
has rapidly become of more importance, particularly in the
cotton-growing States. This rapid development of the sweet
potato industry has been due to various causes. Following the
spread of the cotton-boll weevil across these States many farmers
turned their attention to the sweet potato as a possible money
crop. The demand for more food crops during the World War
and the development of satisfactory methods of curing and hand-
ling the crop have also given an impetus to the growing of sweet
potatoes. Under these conditions the production and value of
the crop in Louisiana increased more than five times between
1915 and 1920 and the whole country experienced a great in-
crease. The sweet potato, therefore, entered commerce as never
before and, because the sweet-potato weevil may be carried in
sweet potato plants and tubers, this serious insect pest was in-
troduced into many new localities.

The seriousness of the sweet-potato weevil situation was
revealed by a preliminary survey made in 1917 by various agri-
cultural workers, especially county agents, located in regions
where the pest was present. Through an appropriation made
by Congress, an organized study of the insect was begun in the
spring of 1918 by the Bureau of Entomology, United States
Department of Agriculture, in co-operation with the agricultural
forces of the several states in which the weevil occurred. This
was done for the purpose of checking the spread of the pest and
finding practical means for its control. The work in Louisiana
was begun in April, 1918, and continued through June, 1920.

* Cylas formicarius Fab.
Fig. 1.—The sweet-potato weevil *Cylas formicarius* Fab.: a, male beetle; b, pupa; c, larva, dorsal view; d, larva, side view—all enlarged. (After Chittenden, U. S. Dept. of Agriculture.)

FOREIGN DISTRIBUTION.

The native home of the sweet-potato weevil is not known, but is thought to be in the Orient. A careful study of its distribution abroad has never been made but it has been reported from different parts of Asia and Africa and outlying islands of both continents; the list including India, Ceylon, Cochin China, Hongkong, Mauritius, Uganda Protectorate, Gold Coast of Africa, Friendly Islands, Liberia, Madagascar, Hawaii, Guam, Formosa, Philippine Islands, and practically all of the West Indies (Cuba, Porto Rico, Haiti, Grand Cayman and Jamaica). It has also been reported as a pest from Australia, from British Guiana, in South America, and from Java and Sumatra of the East Indies.

DISTRIBUTION IN THE UNITED STATES.

Before the Bureau of Entomology began its special investigations of the sweet-potato weevil in 1917, it had been recorded as occurring in three states only; namely, Louisiana, Texas, and Florida. However, Government agents soon determined that the insect had established itself in several localities in Southern Mississippi, Alabama, and Georgia. The weevil was found scattered throughout the eastern half of Texas, extending to and including several counties bordering on Oklohoma, in which it has more recently (1922) been reported to be present. With a few exceptions, it had made less progress inland in all the other infested states, confining its ravages for the most part to the coastal regions.
The first report of the occurrence of the sweet-potato weevil in the United States was made from New Orleans, Louisiana, in 1875. It was next reported from Manatee, Florida, in 1878, and from Galveston and Harris Counties, Texas, in 1890. The source of the first introduction is unknown.

**Distribution in Louisiana.**

The sweet-potato weevil had been unsuccessful, up to and including the time the preliminary survey was made in 1917, in permanently establishing itself in the upper two-thirds of Louisiana. More than six thousand properties were inspected during the survey (many of them were visited two or more times) and of these 736 were found to be infested. These infested properties were situated in 122 different localities (postoffice address) in 27 parishes. This does not include all the infested properties that existed in the State at the time because no farm-to-farm inspection was made in localities that were found to be generally infested. The territory that was found to be quite generally infested with the weevil consisted of Ascension, Assumption, Calcasieu (southern half), Iberville, Iberville (southern half), Jefferson, Lafayette, LaFourche, Orleans, Plaquemines, St. Bernard, St. Charles, St. James, St. John the Baptist, St. Martin, St. Mary, St. Tammany, Terrebonne and Vermilion Parishes. One infested property was found in each of the Parishes of Acadia (at Estherwood), Caddo (at Greenwood), East Baton Rouge (at Burtville), and St. Landry (at Bayou Current); on about half a dozen farms in Livingston (at Port Vincent), and on a like number in Tangipahoa (at Roberts and Ponchatoula) and West Baton Rouge (at Addis and Cinclaire).

The introduction of the weevil into several new localities has come to the attention of the writer since the Government discontinued its work on the weevil in the State. The pest found its way to Stevensdale (East Baton Rouge Parish), supposedly in planting stock in the spring of 1921, and had spread to a number of farms in the surrounding community by the end of 1922. It was noticed by a grower in a community two miles west of Ponchatoula (Tangipahoa Parish) in the 1921 crop, and severe losses resulted to the 1922 crop. H. F. Cassell, County Agent of Tangipahoa Parish, reports that the weevil was introduced into a locality just north of Independence, and caused losses ranging
up to 100 per cent of the 1922 crop. An introduction was made in 1921 at Blanchard (Caddo Parish), through slips received from Texas, and a loss of about 25 per cent of the crop resulted that year. No sweet potatoes were grown on the infested property in 1922, and W. E. Anderson, Entomologist of the Louisiana Department of Agriculture and Immigration, informed the writer that this infestation had apparently been stamped out. On April 2, 1923, the writer found one infested property at Denham Springs (Livingston Parish). The introduction was made by a tenant moving on the property in 1922 from Port Vincent (Livingston Parish) and bringing infested seed potatoes with him.

During the intensive survey of 1918-1920 the sweet-potato weevil was not found in several localities from which it had been previously reported, and where it doubtless had occurred. Among these were localities in Caddo and Bossier Parishes near Shreveport, Cheneyville (Rapides Parish), French Settlement (Livingston Parish), and several communities in Calcasieu and Jefferson Davis Parishes. The pest was reported to have been introduced at Shreveport and Cheneyville in 1915 in planting stock from the southern part of the State, when a number of cotton growers turned their attention to the sweet potato as a possible money crop because of the slump in cotton prices caused by the World War.

The disappearance of the sweet-potato weevil from these localities was probably due to several factors; the principal ones being the destruction of all infested potatoes, discontinuance of the crop, the use of clean planting stock and crop rotation, the absence of wild host plants, and possibly, weather conditions.

DESCRIPTIVE *

The Adult: "The adult of the sweet-potato weevil is a snout-beetle of ant-like appearance, about one-fourth of an inch long, with metallic dark-blue elytra or wing covers. It is slender, cylindrical, with distended or 'swollen' body and long legs. The prominent head and beak are dark blue and the thorax or 'waist' is brick red, as are also the sides of the legs; and the

long antennae or 'feelers' are yellowish red. The antennae have long, thick clubs at the ends, and the male, which bears the longer clubs, can be distinguished from the female.

The Egg: "The egg is pale yellowish, broadly oval, somewhat narrowed at the attached end; the surface is not polished, but shows slight granulation and a faint appearance of division into facets. The length is about one-fortieth of an inch (0.65 mm.).

The Larva: "The larva, when grown, is cylindrical, robust, with the lateral edges of each segment prominent and rounded. The color is nearly pure white, the head pale brown, and the mouth parts dark brown. A few sparse, delicate hairs can be seen under the microscope. On the thoracic segments there are three pairs of broad leg-pads. The length is about three-eighths of an inch (9 mm.).

The Pupa: "The pupa is at first the same color as the larva, but grows darker just before transformation to adult. The wing pads are short and narrow and are folded over the lower side of the body. The head and beak fold down upon the breast. The last segment is furnished with two backward and outward curved tubercles. On the head are several minute tubercles, each of which bears a slender hair. It is about one-sixth inch (4 mm.) long, or the same as the beetle without the beak.

"The pupa is inactive, not partaking of food. The lower half of the body is mobile, enabling the pupa to turn about in its burrow or pupal case."

LIFE HISTORY AND HABITS.

The adult sweet-potato weevil never enters a true state of hibernation in Louisiana, though it becomes less active and egg laying ceases under low temperatures. Freshly laid eggs were found in leftover tubers in the field at Mandeville and Audubon Park, New Orleans, in January, 1919, at which time the weather was very mild. Eggs, larvae, pupae and adults can be found at any time of the year in the vicinity of New Orleans, especially, in protected sweet potatoes.

From 28 to 30 days are required for the development of the weevil from egg to adult in warm weather. The egg hatches in five or six days, the larva reaches maturity in about 15 days,
and the pupal stage occupies a period of about eight days. About seven days elapse after the adult issues before egg laying begins. All these periods are lengthened with the lowering of the temperature.

Fig. 2.—Cross section of sweet potato showing injury by sweet-potato weevil. Larva in burrow at top; pupa below; openings to tunnels elsewhere. Enlarged 3 diameters. (After Chittenden, U. S. Dept. of Agriculture.)

Several series of experiments were conducted at Audubon Park in 1919 to determine the length of life of adult weevils without food; when given access to weeds that are common in the field in early spring; and when given sweet potato for food. No evidence of the weevil feeding on any of the weeds was detected. Due to the scarcity of infested material at hand adults from all obtainable sources were used in the experiments,
many of which were collected in the adult stage in the field. The first series was started on February 7, beetles that were collected in the adult stage being used. The maximum life of beetles kept without food was 72 days, and of those having access to weeds 51 days. Of the 10 given sweet potato as food, two did not die until April 15, one on June 21, and one lived until October 28, or a total of 264 days. This was a female and egg laying continued throughout the whole period. The body of the weevil became covered with the “chinch bug fungus” a few days after death, so this disease was possibly responsible for its death.

There are no clear cut generations of the sweet-potato weevil in Louisiana, partly or wholly due to the long period of oviposition, as is illustrated by the above mentioned female. On account of the almost continuous breeding in Southern Louisiana there are at least eight broods or generations produced during the year.

Sex determinations were made of a number of collections of adults made in connection with observations on the overwintering of the weevil and it was found that about ninety per cent of those found in early spring were females. Out of 88 individuals collected on one occasion, only five were males, and of another collection of 42 individuals only three. These two collections are representative of a number of others that were made in the vicinity of New Orleans in early spring.

The adult stage is directly responsible for but a small amount of the damage caused by the sweet-potato weevil, the larva being the most destructive stage. In feeding, the adults make small, shallow punctures in the stalks and tubers and eat irregular holes in the leaves. Eggs are not deposited in the perpendicular feeding punctures, but are placed in specially prepared cavities bored at an angle of about 60 degrees and having very small openings. The outer surface of the stalk or tuber directly over the egg cavity usually becomes slightly sunken, making a small concave spot adjacent to the opening, by which it can be distinguished from a feeding puncture. Upon hatching, the small white grub, or larva, begins to tunnel, or make “runs” through the stalk, or tuber. These are filled behind the larvae with excrement. Tubers badly infested have such a bitter taste that hogs and cattle will not eat them.
The first injury to a crop begins soon after slips are set in the field. Eggs are deposited in the crown, or stem, near the surface of the ground, and the grubs that issue from these eggs sometimes tunnel vines so severely as to kill them, or weaken them to such an extent that no roots are produced. After roots, or tubers, are formed, the female will enter the soil, usually through cracks caused by the developing roots or dry weather, and deposit eggs directly in them. The larvae from these eggs tunnel through the tuber, thus rendering it unfit for human consumption. This work may be continued throughout the growing season and also in the tubers placed in storage.

There are several insects that injure sweet potatoes in much the same way as the sweet-potato weevil. The "coffee-bean weevil" (*Araecerus fasciculatus* DeG.) is often found in sweet potato storage places. It has only been observed feeding and breeding on dry, decayed tubers. Wire worms often do considerable injury to sweet potatoes especially when grown on sod land. These click beetle larvae bore holes of considerable size and depth into the tubers before the crop is harvested and these holes might be mistaken for exit holes of emerging adult sweet-potato weevils. The injury caused by *Diabrotica* larvae is probably more often wrongly diagnosed than any other insect damage to sweet potato. This injury resembles the feeding punctures of the adult weevil, though it is usually considerably deeper. The larva of the "belted cucumber beetle" (*Diabrotica balleata* Lec.) is the only species of *Diabrotica* definitely known to injure sweet potato tubers.

**WILD HOST PLANTS.**

The sweet-potato weevil was found feeding on and breeding only in plants belonging to the morning-glory family—to which the sweet potato belongs—during the investigations in Louisiana. Eleven wild morning-glories and tie-vines were found growing in that part of the State infested with the weevil. Larvae were found infesting eight of these; namely, *Ipomoea pandurata*, *I. pes-caprae*, *I. trichocarpa*, *I. triloba*, *I. lacunosa*, *Pharbitis hederacea*, *P. barbigera*, and *Jacquemontia tannifolia*. The last three named tie-vines were each found infested with larvae once only, and in each case the plants were growing in the midst of very severe infestations of the weevil. These tie-vines
grow promiscuously over the infested part of the State, and were found uninfested many times when growing close to other infested plants. The other three tie-vines collected in which no weevil larvae were found were *Ipomoea littoralis*, *I. speciosa* and *Convolvulus repens*. *Ipomoea littoralis* was found growing on the sandy beach of Grand Isle only, and four or five hundred yards from the closest weevil infestation. This infestation was supposed to have been introduced the spring before in seed potatoes. The other two uninfested species were collected in several infested localities, but not in the very midst of other infested plants.

![Image of beach, showing characteristic spreading growth of the beach morning-glory, *Ipomoea pes-caprae*, a wild food plant of the sweet-potato weevil. (After Chittenden, U. S. Dept. of Agriculture.)](image)

The "seaside morning-glory", (*Ipomoea pes-caprae*), was found growing only on the sandy beaches of Grand Isle and Cow Island (a small island located off the coast of Terrebonne Parish) and was infested only on the latter island. Land on Cow Island was cultivated at one time and sweet potatoes raised, but no farming was done on the island for 12 years just previous to the time the infestation was noted.

The large-rooted perennial morning-glory, (*Ipomoea pandurata*), was noticeably the preferred wild host plant of the weevil on the mainland and is liked equally as well, if not preferred,
to the sweet potato itself. This plant was found growing on practically all types of soils in Southern Louisiana, which included the red hills of Avery Island, the stiff black soils, as those in the vicinity of New Iberia, the bluff soils at Baton Rouge, and along the ravines that drain the pine woodlands of Livingston and St. Tammany Parishes.

Inland, Ipomoea trichocarpa ranked next to I. pandurata as a wild host of the weevil. While it is listed as an annual, the roots of this plant were found to be very heavily infested with the larval, pupal and adult stages of the weevil at Audubon Park, New Orleans, on January 15, 1919. This plant is seldom found in cultivated fields, but is one of the most common weeds of the ditch banks, hedges, and fence rows throughout South Louisiana.

Those parts of the wild host plants in the proximity of the surface of the soil are most commonly infested by the sweet-potato weevil. Larvae are seldom found more than one or two inches below the surface of the soil. They were never taken in the "seaside morning-glory" vines when covered by more than one inch of sand. After the season was well advanced larvae were common in vines of Ipomoea pandurata growing on hedges on Avery Island, some being found ten or twelve feet above the ground. On but one occasion were larvae found mining the large tuberous root of pandurata when green, but they worked freely in those that had been dug and allowed to dry for a while. A number of plants of this species were found dead on Avery Island, having been practically severed just above the ground by the larvae.

**DISSEMINATION.**

Commerce is largely responsible for the spread of the sweet-potato weevil. The transference of infested seed potatoes is the most common medium of introduction of the pest, but a number of conspicuous infestations noted in Louisiana originated from slips shipped in from infested territory. The introduction of new varieties of sweet potatoes into South Louisiana has contributed indirectly to the spread of the pest. The variety known as the "Porto Rico" was responsible for the rapid spread in some communities.

The sweet-potato weevil has well developed wings, but sel-
dom uses them for flight. During the course of the survey, inspectors observed three adult beetles in the field spread their wings, but none of them took flight. On a hot sultry day at Audubon Park, several beetles were noted flying across from side to side in a glass jar which measured about 10 inches in diameter, but not one flew away when offered its liberty.

Rains, winds and overflowing streams have had little or no effect on the dispersion of the sweet-potato weevil in Louisiana. Since practically all streams in South Louisiana rise in uninfested territory and pass through infested territory, this would tend to check rather than assist the natural spread.

Observations indicate that the sweet-potato weevil will not travel very far unaided; that is, that the natural spread is very slow. This is especially true when plenty of food is at hand. The "seaside morning-glory", which is known to be very much liked by the weevil, was found growing uninfested within about four hundred yards of an infested sweet potato patch on Grand Isle. This observation was made on September 18, 1918, and the infestation was supposed to have been carried to the Island the spring before.

In the spring of 1920 sweet potato tubers were placed as traps at different distances from places where known infestations of the weevil existed the fall before at Audubon Park, and all materials that might have served as food for the insect through the winter were destroyed. Over 90 per cent of the beetles caught on these traps came from those placed within a few feet of the old infestations.

Two other observations made on 1918 crops indicate the slow dispersal of the sweet-potato weevil when plenty of food is at hand. One was in Orange County, Texas. Slips were taken from a "mother patch" and planted about 200 yards away. Vine cuttings were taken from the "mother patch" and the "slip patch" for another patch that was planted about 100 yards from the "mother patch" and 200 yards from the "slip patch". Tubers in the "mother patch" were fairly riddled by fall, and about 50 per cent of the tubers in the "slip patch" were infested when harvested, but no trace of the weevil could be found in the "vine patch". The other observation was made at Nine Mile Point, which is situated just above and across the Missis-
Fig. 4.—A main root of the perennial morning-glory, *Ipomoea pandurata*. Weight, 61 pounds; length, 4.8 feet; average of 3 circumferences, 2 feet. Grows on nearly or all types of soil in Southern Louisiana; and is a favorite wild food plant of the sweet-potato weevil.
sippi River from New Orleans. Cuttings were obtained from a "mother row" and two acres were planted adjacent to the "mother row". About 75 per cent of the tubers in the seven or eight rows next to the "mother row" became infested, while it was difficult to find a weevil in rows distant from the "mother row". Besides indicating the slow natural dispersal of the weevil, these observations indicate that there is greater likelihood of the weevil being transported from one place to another in slips rather than in vine cuttings.

FACTORS GOVERNING AMOUNT OF DAMAGE.

During our observations no variety of sweet potato was found immune to attack by the sweet-potato weevil, though practically all growers questioned advanced the theory that all varieties commonly classed as "yams", such as the Porto Rico and Nancy Hall, were preferred to those of the Southern Queen type. Several growers, however, advanced an opposite view, and an observation made by W. T. Dillard and J. P. Landry, Assistant Entomological Inspectors, would seem to strengthen this idea. The Southern Queen was found growing intermingled with "yams" and was being severely attacked while the "yams" had been injured but slightly. During the survey, however, every variety grown in South Louisiana was repeatedly found severely infested.

With hardly an exception, tubers grown from slips were more severely infested than those grown from vine cuttings. This was doubtless not due to any quality possessed by either, but to other factors. Slips are always planted earlier and catch all straggling adults that might have been in the field. The crop is allowed to remain in the ground longer, unless harvested for the early market, and therefore, the insect has more time to multiply and do damage. The factor that possibly has more to do with bringing about the condition is, however, that the weevil on issuing from infested tubers in the bed deposits eggs in the slips and these are carried into the field and start early infestations in the planting.

The "mother row" method of propagation has aided, in no small degree, the sweet potato weevil in its ravages. This method is quite generally practiced in many localities of South Louisiana, and consists of the planting of the tubers in rows in the field.
Vine cuttings are obtained from these rows for the planting of the main crop. The worst feature of this method is that, if infested "mothers" are planted adjacent to the ground to be planted for the main crop, the insect is carried into and early established in the very midst of the main crop. The seed or slip bed method is a much better one to follow, as this tends to move the main planting away from any infested tubers that may be used as "mothers".

A sweet potato crop on an infested property should be harvested just as soon as it is mature because the longer it is left in the field the more damage the weevil is able to do. Growers that practice planting early and harvest for the early market, in July and August, almost always reported small losses, while their old fields, if left undisturbed, would be very heavily infested with the weevil by fall.

There is considerable variance in amount of injury done on different types of soil. Usually the loss is much less on the light sandy soils than it is on those of a heavy stiff character. The color and texture of a soil are not the determining factors, as many growers believe, but the difference is due to the natural entrances provided. The stiff soils crack much more from dry weather and root formation.

Other conditions being equal, injury is much less severe in years when there is a constant rainfall while the roots are forming—thus preventing the cracking of the soil—than it is during a year when the weather is dry during this period. It was noted in connection with some cage experiments conducted at Audubon Park that during dry weather, when the soil was cracked, practically all of the weevils would disappear from the surface, but would reappear when it started raining. The adults did not appear to like the wet ground and would usually be found clinging to the sides of the cages. Rains were so continuous in the fall of 1918, that crops practically free of the insect were harvested from fields in which the weevil was plentiful in the vines throughout the growing season. This condition existed on a number of farms under observation.

Freezes aid greatly in reducing the weevil under outdoor conditions. Practically 100 per cent of the different stages present in exposed tubers in a field at Lacombe were killed by the freeze of January, 1919. This was apparently not directly
due to the low temperature, but to the fermentation of the tubers that followed the freeze.

Infestations of equal severity were found to exist in Louisiana both in the presence and absence of preferred wild host plants. Information obtained, however, indicated that the average loss over a number of years is considerably higher when one or more preferred wild hosts are present.

The activity of the sweet-potato weevil is reduced under low temperature conditions, that may exist in storage places, especially when the temperature is kept around 50 degrees F. Egg laying ceases and the immature stages develop very slowly.

NATURAL ENEMIES.

The sweet-potato weevil is remarkably free from natural enemies. A ground-beetle, *Scarites subterraneus* Fab.,* gained entrance to an experimental cage at Audubon Park and destroyed a number of adults in the experiment. An earwig was taken in another cage from which a number of weevils mysteriously disappeared, leaving several wing-covers behind. A mite was found infesting adults near New Orleans, but it had little or no effect on the life of the insect.

The Argentine ant was frequently observed attacking adults, but these adults were not injured as a result. At no time was this ant found attacking the immature stages of the weevil in their natural habitat, though it would readily kill any placed within easy reach.

The chinch bug fungus, *(Beauveria globulifera* (Speg.) Pic.)† kills considerable numbers of adults when favorable conditions for its development prevail. This disease interfered greatly with cage experiments that were conducted at Audubon Park in 1919. The insectary and surrounding grounds became so thoroughly contaminated that beetles brought in hardly lived a week. Artificial inoculation experiments were made in Petri dishes, in cages placed on hedges in the field, and in the open field. Pure cultures of the fungus and natural cultures from infected beetles were used; the fungus being placed on sweet potatoes to which the beetles had access. No beetles were killed when the pure cultures were used, but from 50 to 100 per cent

* Determined by Dr. F. H. Chittenden.
† Determined by Dr. A. T. Spears, formerly of the Bureau of Entomology, U. S. Dept. of Agric.
in the cages and from 70 to 100 per cent of those in the Petri dishes were killed by the natural culture. Very few beetles were apparently killed, however, by such cultures in the open field. The minimum length of time from the date beetles were placed with the fungus until their death was six days.

**WILD FOOD PLANT EXTERMINATION.**

It was decided soon after the survey was started that it would be impossible to exterminate, or even satisfactorily control, the sweet-potato weevil near infested wild food plants. On the McIlhenny estate on Avery Island, for instance, the large rooted perennial morning-glory, (*Ipomoea pandurata*), was found to be well established and severely infested by the weevil. It was found growing on ditch banks, hedges, and fence rows over a large part of the cultivated land. The inspector was informed that sweet potatoes were grown quite extensively for canning purposes until about 1910, when the crop had to be abandoned for this purpose because such a large proportion was rendered unfit for use by the weevil. Since that time, however, a few sweet potatoes were grown each year for table use and the loss to these crops caused by the weevil ranged from 20 to 90 per cent every year. Arrangements were made with E. A. McIlhenny, manager of the Estate, to use these plants for experiments with herbicides and other methods of extermination.

The digging out and burning of the entire root system was first tried, but this was found to be very unsatisfactory and expensive. The larger roots were found to penetrate the soil from three to five feet and it was practically impossible to remove all parts capable of sending out sprouts. This method was found practicable only in the case of young plants whose roots reached a diameter of about one inch and a length of about a foot.

A number of different chemicals were tested as possible herbicides for this large rooted morning-glory. Among those used that proved valueless were acetic acid, acetic acid and bi-chloride of mercury, crude oil, powdered white arsenic, and iron sulphate (liquid and powered). Gasoline, carbon bisulphide and formalin (20%) gave fair penetrations, but insufficient to kill the entire root system.

A commercial preparation gave the best results of any compound tried. This contained, according to an analysis made by
the Bureau of Chemistry, United States Department of Agriculture, the following ingredients:

- Sodium Arsenite (NaAsO₂) .................................. 10.40%
- Sodium Carbonate (Na₂CO₃) .................................. 6.19%
- Fatty Anhydride ................................................. 1.68%
- Water ................................................................... 81.51%
- Sodium Oxide combining Fatty Anhyd (Diff) ........... .22%

Thirty cubic centimeters applied in an excavation made in the top of tuberous root was found to be sufficient to kill the largest of them.

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Fig. 5.—Known distribution of the sweet-potato weevil in the southern United States to May 9, 1923. (From a map furnished by Dr. F. H. Chittenden, Bureau of Entomology, U. S. D. A.)

Several strengths of commercial sodium arsenite containing 44.15% water soluble As₂O₃* and a preparation† made by boiling until clear (in an iron or granite kettle) 2 pounds sal soda, 1 pound powdered white arsenic, and 1 gallon water, were applied as sprays to the vines. All strengths used killed the vines down to the ground. Some of the stronger ones completely killed the plant down to the large root and in a few cases several inches of penetration were noted in the large root, but new sprouts were always sent up soon after the treatments were made.

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* Analysis made by Mr. A. P. Kerr, Chief Chemist, Louisiana Experiment Station.
BAITS.

Upward of eighty different combinations of the materials named below were tested in cages at Audubon Park in 1919 as possible baits that might prove of value as an aid in controlling the sweet-potato weevil. Powdered white arsenic was the killing substance used in the mashes, which contained the following substances alone or in combination, with and without honey and inverted sugar:—wheat bran, corn meal, a filtrate, a steam distillate and a residue from grated sweet potato, ground or grated sweet potato, ground sweet potato vines, and the vines of the seaside morning-glory. Mashes with a small amount of peach, rose, strawberry, orange, lemon, raspberry, almond and vanilla flavoring extracts added were also used. The adults fed but slightly on any of these mashes, none of them being as attractive as the whole sweet potato.

Dehydrated and raw sweet potato tubers dipped in solutions of bichloride of mercury (.002%) and sodium arsenite (.02%) were used. The adults did not feed on the dehydrated tubers. Soon after the raw tubers were treated no preference was shown between the treated and untreated, but all the live weevils had collected on the untreated tubers within 24 hours. This was probably due to the action of the chemicals on the tuber. Forty per cent of the weevils were dead at the end of 24 hours and 20 per cent were practically so.

Powdered white arsenic applied to gashes made in whole tubers gave promising results as a poisoned bait when used in cages. Two diverging gashes made lengthwise the tuber, and pulled slightly open if they did not gape naturally, seemed the best method of preparing the tuber for the poison. In putting out the treated tubers, the gashes were placed next to the ground.

The arsenical did not appear the least bit offensive to the beetle, while the freshly cut root was much more attractive than uncut ones. Within a few hours from 80 to 100 per cent of all the beetles in the cage would be collected and feeding in the gashes. This experiment was repeated a number of times and the mortality ranged from 75 to 80 per cent in each case. Sodium arsenite was substituted for white arsenic but it soon acted on the tubers, rendering them unattractive to the beetles. Whole sweet potatoes were always placed in the cages as checks.
Sweet potato tubers were used in trapping adult sweet-potato weevils in the field at Audubon Park in 1919 and 1920. The tubers were placed along ditch banks, hedges, and elsewhere, and covered with any rubbish that was handy. The tubers were visited twice a week and the beetles collected. Each year the majority of the weevils were caught between March 15 and April 1. All potatoes bearing weevil punctures were collected and destroyed every three weeks in order to prevent breeding in the traps. In 1919, 321 tubers were put out and from them 81 adult beetles were collected. All vines and refuse of the crop were allowed to remain in the field the fall before, as is the practice on many farms. In 1920, 74 tubers were put out and from these 330 beetles were collected. Of these, 281 were females. The 1919 field was quite thoroughly cleaned of all refuse from the crop.

Indications are that traps can be used effectively to rid a field of wintered-over beetles when no food materials are allowed to remain in the field after the preceding crop is harvested. Traps would doubtless be worthless in the presence of infested wild host plants and uncleaned potato patches. Tubers treated with white arsenic, as discussed under "Baits", could be used as traps where no livestock of any description is allowed in the field and the grower did not have time, or want to take the time, to collect the beetles. These poisoned sweet potatoes would also aid in ridding a field of field mice and rats.

CULTURAL CONTROL EXPERIMENT.

That the sweet-potato weevil can be satisfactorily controlled, and possibly eradicated, by the use of certain cultural methods, was indicated by an incompletely experiment underway in St. Tammany Parish when the Government was forced to discontinue its investigations of the weevil in Louisiana on June 30, 1920. The writer inspected the farms included in the project the first of the following December and checked up the results. The pest had apparently been eradicated on several properties and greatly reduced on others. On farms where losses occurred the plan of control was, almost invariably, not carried out in every respect. The importance of every step included in the plan of control was well demonstrated in the results. A loss of practically 100 per cent occurred on a farm where no effort was made.
to control the pest, whereas, on a nearby farm where the plan was followed, the pest was apparently eradicated. The control plan consisted mainly of the following operations, in which Government inspectors aided the growers:

1. The destruction of vines before harvesting the 1919 crop by grazing, pulling them up and feeding them to stock, or burning them after they were dry enough.

2. The sorting out and destruction of all infested tubers at digging time by feeding them to stock or burning; none but apparently sound roots being stored.

3. Tubers to be used for planting stored separately from the remainder of the crop.

4. Old field thoroughly cleaned by hogging off.

5. All storage bins and banks thoroughly cleaned immediately after the crop was used up or disposed of and the refuse burned.

6. Seed resorted at bedding time. Potatoes bedded as late as possible.

7. Seed bed located as far as possible from where any infested material existed the year before, and the same precautions used in selecting the locations for the slip and vine fields.

8. Seed bed destroyed immediately after it had served its purpose.

The control of the sweet-potato weevil is a comparatively simple matter; especially in the absence of preferred wild host plants and on farms with considerable acreage under cultivation. The insect has well developed wings, but seldom, if ever, infests new farms or localities by flight. The weevil will only make its own way from one farm to another when sweet potatoes are grown in fields near each other or when wild host plants inhabit the land lying between. A number of growers were encountered, while the survey was underway, who claimed to have rid their properties of the pest by discontinuing the growing of sweet potatoes for one year. This "skip-a-crop" method would probably only be effective when the farm was well separated from other infested properties, when wild host plants were absent, and when no volunteer sweet potatoes were permitted to grow on the place during the year when sweet potatoes were not grown.

In some sections of Louisiana, as in some sections of St.
Tammany Parish, the farms of many growers of sweet potatoes are too small to practice crop rotation, but these farms are located some distance apart in many cases. Under such conditions, the "skip-a-crop" method is probably the best way to eradicate the pest. In other parts of the State, the farms are close together, have narrow fronts but extend some distance back. Under this condition, the strictest co-operation of all growers of the settlement is necessary to even control the pest. Under both of these conditions, the loss can be greatly lessened by following as closely as possible the measures given below. Little relief can be expected from the employment of control measures on lands infested with preferred wild host plants, unless these plants are first exterminated.

The best time to start applying measures for the control or eradication of the sweet-potato weevil is at harvest time. No vines should be buried in the furrows or allowed to remain in piles on headlands, but should be grazed off with cattle, pulled and fed to livestock, or pulled and burned when dry. At harvest time, all infested tubers should be sorted out and immediately disposed of by feeding them to livestock or by burning. All tubers severely infested should be burned or boiled, if to be offered to livestock. Neither hogs nor cattle will eat very badly infested roots, but will brush them aside and, because of this, adult weevils will often escape. Immediately after the crop is harvested a sufficient number of hogs should be placed on the field to clean up all refuse from the crop.

Best results can be expected when the entire crop is disposed of and the premises thoroughly cleaned some time before it is time to make the seed bed or plant the crop, and the longer the place is kept free of any tubers, slips, and other material that may be infested with the weevil, the better. The following methods are recommended in order of preference for propagating the next crop.

Use vine cuttings from weevil-free locality, making planting in July.

Use slips from weevil-free locality.

Obtain seed potatoes from weevil-free locality.

When home grown seed is used it should be carefully selected at harvest time, stored separate and resorted at bedding time.

Much care should be exercised in selecting locations for the
seed bed, slip and vine fields. Each should be located as far as possible from the others and from other possible infestations. As soon as the slip bed has served its purpose, it should be hogged off, or tubers rooted out and fed to livestock. A few trap potatoes should be placed on or near the old slip bed location immediately after it is destroyed to catch any adult weevils that might have emerged, thus preventing their possible migration to the nearest patch of sweet potatoes.

The mother-row method of propagation is not recommended, but if it is used, the planting should be located similarly to the seed bed, and destroyed likewise when no longer needed. Nothing but tips of vines cut not closer than ten inches of the base of the vine, should be used for cutting.

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The Louisiana project was organized by W. R. Perkins, Director of Extension, and J. E. Graf and Thos. H. Jones of the U. S. Bureau of Entomology. Professor Perkins and Mr. Jones selected and recommended the appointment of the inspectors, the latter giving the men the necessary training and directing the work as State Leader until the writer was transferred to the State and placed in charge. The corps of inspectors consisted of J. P. Landry, M. Hull, M. J. Kerr, W. T. Dillard, T. H. Cutrer, C. F. Moreland, O. W. Rosewall, and Felix Dabadie.

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