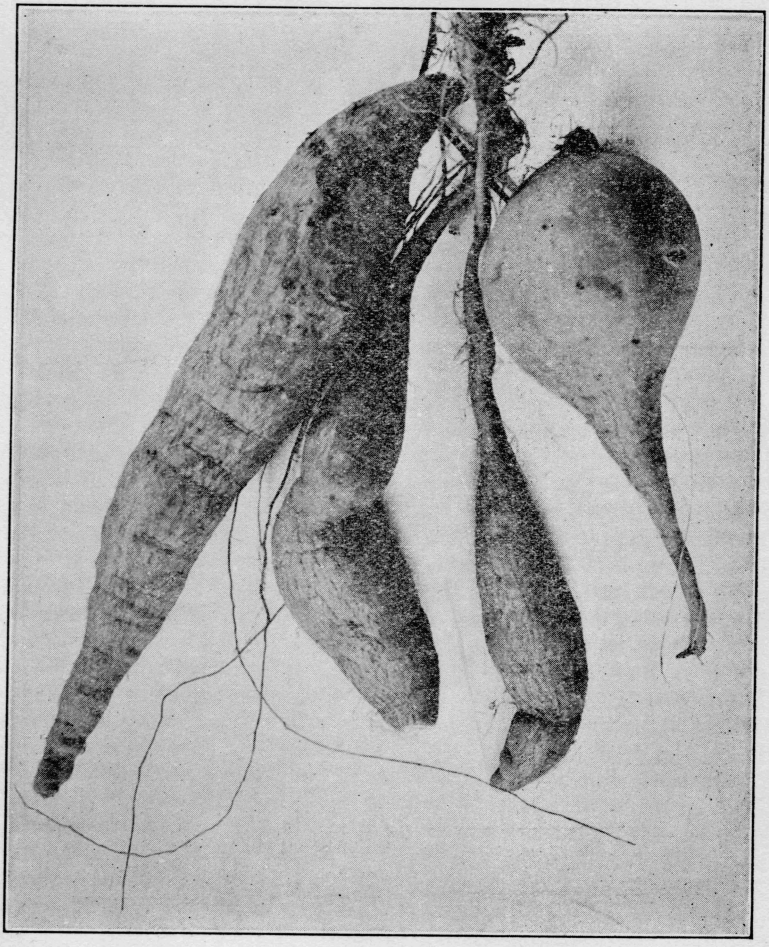
TEXAS AGRICULTURAL EXPERIMENT STATIONS.

BULLETIN NO. 93.

# THE SWEET POTATO BORER

BY

ALBERT F. CONRADI
Entomologist



A Hill of Sweet Potatoes Infested by the Borer.
(Photo by E. C. Green)

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# THE SWEET POTATO ROOT BORER

A. F. CONRADI

SUMMARY

From the investigations of this Department, as well as the letters received from prominent sweet pototo growers, it is apparent that the sweet potato industry of Texas is seriously threatened by the sweet potato root borer, also known as sweet potato weevil.

Ever since the middle of last century Texas has been one of the most important States growing the sweet potato.

The insect being of a tropical origin is most destructive in South Texas, less so in Central Texas, while sporadic outbreaks are possible during the growing season in any section of North Texas.

The insect has been on record since 1798. It was reported on sweet potato as early as 1857. It was probably introduced from the West Indies. It was first reported in the United States from New Orleans in 1875, the first report from Texas being 1890. It is present in South Texas west as far as Comal and Cameron counties, and north as far as Milam county.

Early varieties as well as potatoes planted early are more seriously injured than late varieties and those planted late.

Shallow planted tubers are more infested than those planted deep.

The weevils reach the tubers chiefly by burrowing along the vines.

The full grown insect is an elongated glossy snout beetle with a black head, middle part of body and legs red, hind part dark steel blue, and about 1-4 inch long. It lays its eggs on tubers and vines. The larva, which is a white foot-less grub about 1-5 inch long, tunnels in the tuber. It pupates at the end of its tunnel. The entire life cycle is completed in the potato in about 35 days.

The beetles can subsist on other plants besides sweet potatoes, principally on those plants that are closely related to the sweet potato vines, such as morning glory plants.

The insect has never been observed in flight in this country. It has well developed wings which makes it appear that migration on the wing is possible.

Rotation of sweet potato fields, combined with other methods, is of value not only from an insect standpoint but from an agricultural point of view as well. Plant as remote from last field as possible.

We have not found any variety of sweet potato that is immune.

Raw tubers should never be thrown out nor fed to stock without having been boiled.

Harrow the ground after the crop has been gathered. In spring by means of volunteer plants the over-wintering weevils may be destroyed on them.

As a rule stock will eat the tubers with the exception of those badly riddled and dried up. Remnants left by stock should always be gathered and destroyed by burning.

Burying infested tubers is discouraged.

A totally infested crop should be gathered clean, and vines and all thrown into a hot fire and burned.

Tuber traps may be used to advantage if carefully manipulated.

Gathering volunteer slips from tubers left in the ground from the last crop as well as selecting home grown seed from infested farms is dangerous.

Adults can be easily killed when exposed to the fumes of carbon bisulphide (high life) at the rate of 1 pound to 1000 cu. feet of space for 24 hours.

To kill the stages in the tubers carbon bisulphide should be used at the rate of 3 pounds to 100 bushels or 1000 cu. feet of space for thirty hours. The bin should be tightly closed.

All seed should be imported from non-infected sections, carefully packed to avoid danger of infestation en route.

Tie vines, such as morning glories, should be kept down by grazing or otherwise, as much as possible. When this is impossible they might be poisoned in and about a potato field.

Farmers should co-operate in controlling the pest.

## THE SWEET POTATO WEEVIL.

(Cylas formicarius, Fab.)

The Sweet Potato Borer, the worst of all sweet potato pests, is spreading over South Texas. The apprehension it is causing in the minds of sweet potato growers is well founded. The insect is terribly destructive and difficult to control. The following extracts from a few of the letters written to us by prominent growers will serve to illustrate the seriousness of the problem.

"People in this locality have already abandoned raising the sweet potato for the last two or three years on account of the weevil. About one-half or more of my crop was ruined by them last year. They are moving northward 10 or 15 miles a year. I intend to get new seed which is not infested and plant a large crop again next year so that if you discover a certain remedy, please let me hear from you."

"We find the potato weevil in nearly every field in the western part of the country. On some farms they have completely eaten up the crop, in most cases while they were in the ground before digging. There are about 200 farms infested with them. I think they will be about as hard to exterminate as the boll weevil."

"I send you under separate cover some kind of a bug that is eating up our sweet potatoes. They go into the ground and eat them before they are dug. What can we do?"

"Has there been any insecticide discovered that will control the sweet potato beetle? They are doing very serious damage here."

"By today's mail I am sending you some sweet potatoes that are full of some insects which have ruined the crop in this vicinity. As far as I know they attack only the sweet potato."

"I send you today by mail some sweet potatoes that are full of some kind of insect. The potato is not fit to eat, and in the lower part of the country near the head of the bay it is impossible to raise any sweet potatoes."

"Last year I had all my sweet potatoes destroyed by the weevil, and I would like to know how to prevent it. Would it be safe to use seed saved from this crop?"

## STATISTICAL.

With the exception of the Irish potato the sweet potato is probably the most extensively grown vegetable in the United States. In 1899 it was reported by over one-third as many farmers in the United States as the number growing Irish potatoes. While this vegetable can be grown over an extensive area of territory it is chiefly a southern crop. According to the Twelfth United States Census, the States of Georgia, Alabama, North Carolina, South Carolina, and Texas cultivated 52.6 per cent of the acreage of the crop of 1899. If to these States the acreages of Virginia, Mississippi, Tennessee, Louisiana, Florida, New Jersey, Kentucky, Arkansas, Missouri, and Illinois be added, we have an acreage of 93.1 per cent of the total in 1899.

Since the middle of the last centuary Texas has furnished her quota to the national production of this crop. In the Census report for 1850 we find Texas with 1,332,158 bushels, or 3.5 per cent of the National crop, ranking 9th in production. In 1860, 1,846,612 bushels or 4.4 per cent of the National crop, again ranking 9th in production. In 1870 the 2,000,000 mark was passed, producing 10.1 per cent of the total crop for the United States. In 1890 the Texas acreage was 52,206, ranking fourth in the United States, forming 10 per cent of the total acreage; it ranked third in production, its crop being 5,500,000 bushels, or 12.5 per cent of the national crop. In 1900 Texas ranked fifth in acreage, sixth in production, cultivating 8.1 per cent of the acreage and producing 7.8 per cent of the National crop. In 1900 her acreage was 43,561, yielding nearly 3,250,000 bushels. Of the 352,190 farms of Texas in 1899 they were raised on 63,209, or an average of 7-10 acres of sweet potatoes on every farm of Texas. The yield per acre in 1879 was 74.6 bushels; in 1889, 104.9 bushels; in 1899, 75.7 bushels. In 1899 the average market price was 51c per bushel, making an average value per acre of $38.77.

*Rank of States each with over 1,000,000 bushels of sweet potatoes, at census, 1850-1900. From bulletin 24, Division of Statistics, United States Department Agr.*

| RANK | 1850 | 1860 | 1870 | 1880 | 1890 | 1900 |
|---|---|---|---|---|---|---|
| 1 | Ga. | Ga. | N. C. | N. C. | N. C. | N. C. |
| 2 | Ala. | N. C. | Ga. | Ga. | Ga. | Ga. |
| 3 | N. C. | Ala. | Tex. | Miss. | Tex. | Va. |
| 4 | Miss | Miss | Ala. | Ala. | Ala. | Ala. |
| 5 | S. C. | S. C. | Miss | Tenn. | Miss | S. C. |
| 6 | Tenn. | Tenn. | N. J. | S. C. | S. C. | Tex. |
| 7 | Va. | La. | S. C. | N. J. | Va. | Miss. |
| 8 | La. | Va. | Tenn. | Va. | N. J. | N. J |
| 9 | Tex. | Tex. | La. | Fla. | Tenn. | Fla. |
| 10 | | Ark. | | Tex. | La. | La. |
| 11 | | Fla | | La. | Ark. | Tenn. |
| 12 | | Ky | | Ky. | Fla. | |
| 13 | | N. J. | | | | |

Since 1880 Texas increased its crop from 4.4 to 7.8 per cent. We

have no statistical data since 1900 with regard to the quantity of crop. Considering that the larger per cent of the sweet potato crop is grown for local consumption, the present annual crop of Texas, the vast expanse of unsettled territory in the State, the rapid development of new territory, the extension of railroads into every section, as well as the prominent place given the sweet potato in Southern gardens, it becomes at once apparent that we should give due attention to insect pests that threaten this industry with destruction.

## AREAS OF INFESTATION.

Upon examining the accompanying map we find that the sweet potato is grown over the greater area of Texas. Over one-third of the product is grown within the territory where the weevil survives the winter in all stages and which is the area in which the pest is most destructive.

In determining the area of present infestation as well as the area over which the pest will spread and become destructive in the future, we are guided by our studies of the distribution of the pest as well as the behavior of the insect under different climatic conditions. In the accompanying map the dotted line represents the boundary of the territory where the weevil is known to occur and is destructive. In studying the temperature of South Texas we find that the pest can spread as far north as line "A" before it is seriously handicapped by Texas winters. Over this territory we find that the temperature is rarely low enough to interfere with the successful survival of the winter by adult weevils, and at no time are tubers left in the soil during the winter sufficiently frozen to prevent larvae and pupae from developing into adults.

As the pest spreads northward above line "A," the temperature conditions become too severe for the adult weevils to survive, but the immature stages in tubers in the soil will pass the winter successfully. To determine approximately the northern limit of this territory a series of experiments was conducted for the purpose of ascertaining the minimum temperature the weevils and their larvae were able to stand. A large number of weevils in different stages were subjected to various temperatures during varying intervals, the experiments being repeated each time at a lower temperature until the minimum was reached that the weevils were able to survive. In a temperature of approximately 45 degrees F., they passed into a stupor that resembled hibernation. This stupor was not fatal except after they had been exposed to a temperature as shown in the following table:

| No. | STAGE OF INSECT | TIME EXPOSED. | DEGREES F. | EFFECT |
|---|---|---|---|---|
| 8 | Adults | 30 minutes | 23 degrees | Weevil recovered |
| 8 | Adults | 30 minutes | 20 degrees | Recovered |
| 8 | Adults | 1 hour | 20 degrees | 84% died |
| 8 | Adults | 2 hours | 10 degrees | All died |
| 2 | Larvae in tuber | 1 hour | 23 degrees | All died |
| 4 | Larvae in tuber | ½ hour | 23 degrees | 3 died |

The specimens used in the above experiments had recently emerged

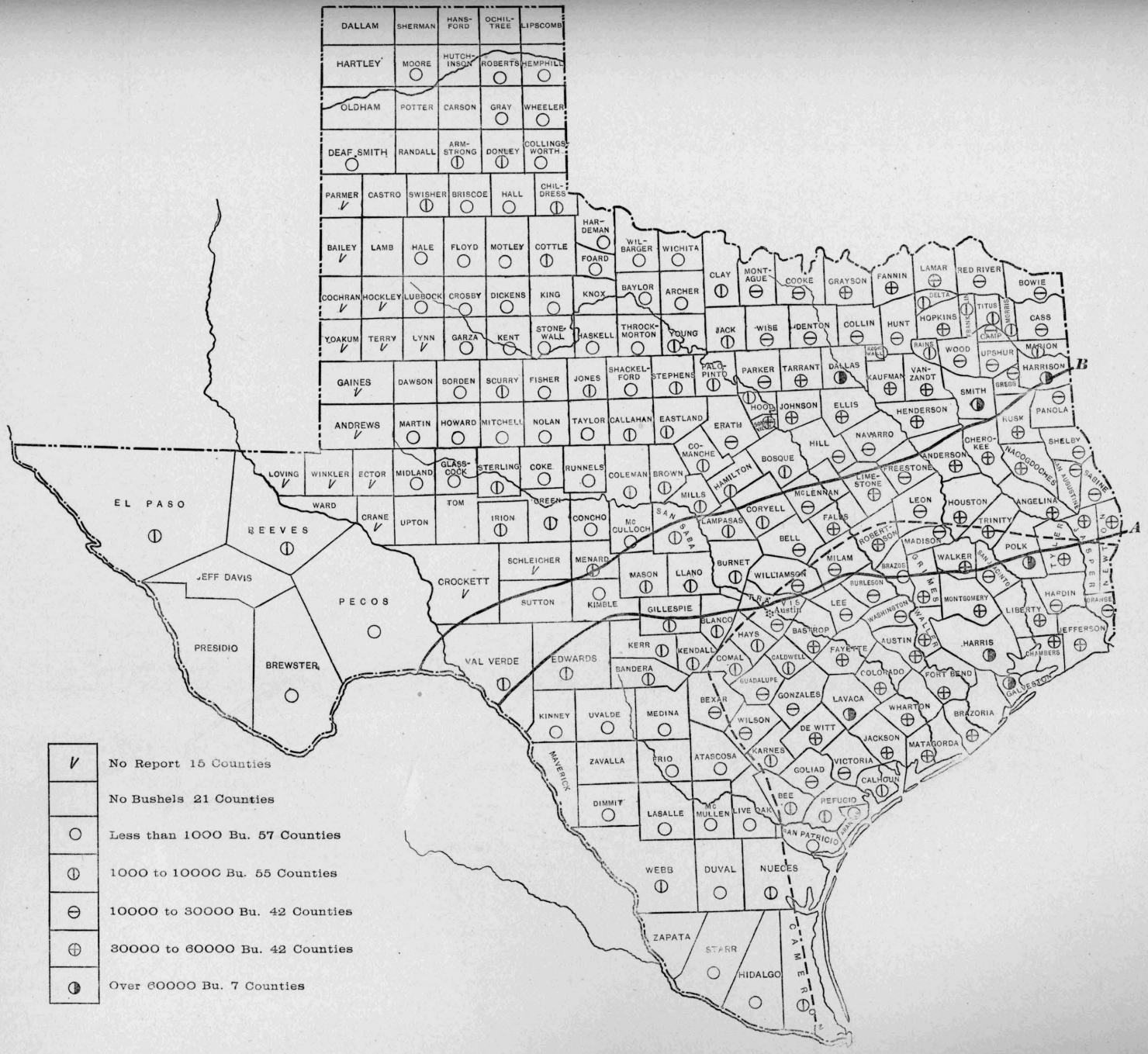



FIG. I Broken line shows the western and northern boundaries of the territory in which the borer now occurs. A, approximate northern limit of area in which all stages of the borer breed unchecked by weather conditions. B, approximate northern limit of the territory in which the immature stages in buried tubers survive the winter. (Prepared by Mrs. A. F. Conradi.)

and fed on tubers, consequently they were all in good condition. Where the cold is of longer duration the higher temperature would no doubt prove fatal, but such a condition is not represented by our Texas northers. These cold waves are of short duration, the minimum temperature continuing but a few hours. Although such a temperature may kill the adults, it is not severe enough to freeze the potato in the soil several inches; this would require a temperature that would freeze the soil several inches. As it requires freezing of the potatoes to kill the larvae,infested tubers left in the soil after harvest time would harbor the pest during the winter. This was illustrated at College Station during the winter of 1905, when the severe norther that swept over Texas on the morning of February 13th, the minimum temperature continued nearly two hours. It destroyed the adults in breeding cages at the surface, while the larvae in the tubers below the surface of the soil remained uninjured and matured the following spring.

Thus we see that north of the territory where no adult survives out-of-doors there is an area where "northers" are not of sufficient duration to freeze the ground to a depth that would be fatal to the larvae and pupae in buried tubers. Within this territory the pest is handicapped in the adult stage in winter, but the surviving larvae in the tubers cause infestations every season. While these two areas represent the territory where growers will suffer most severely from weevil injury, it should be remembered that sporadic outbreaks may occur over all the territory farther north during summer when infested tubers that have not previously been subjected to a freezing temperature are imported after the warm weather of spring has set in. Of course these areas represent an average and can be but an approximation. They will be changed according to different weather conditions each year; for example, during the winter of 1899-00 the upper line should have been shifted southward so as to cross the southern part of Travis county. Such "northers," however, are exceptional in the climate of Texas.

## HISTORICAL.

This insect was described as early as 1798 by Fabricius. We have no record of it as a sweet potato enemy until 1857 when Nietner recorded it as attacking sweet potatoes in the island of Ceylon in 1856. Among the earlier entomological writers, Fabricius refers to it from India and Tranquibar, Boheman from the East Indies and Java, and Dejean from the Isle of France. Among our American entomologists Le Conte gives the distribution as Cochin China, India, Madagascar, Cuba and Louisiana. Professor Townsend reported it from the island of Grand Cayman and other West Indies. Its original habitat is still unknown and will probably never be ascertained definitely, owing to the insect's mode of life as well as its ease of dissemination. Considering the early records and present distribution as well as its hibernation habits, the requirement of a constant source of food supply and its inability to resist cold, we conclude that the insect is of tropical origin.

## INTRODUCTION INTO THE UNITED STATES.

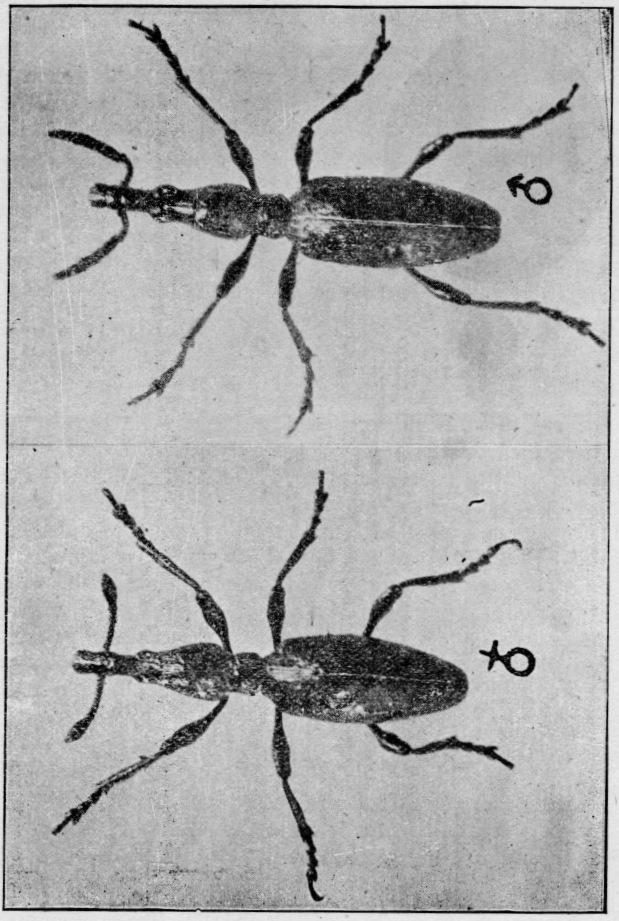
It is probable that the insect was introduced into this country from the West Indies. It was first reported in the United States from New Orleans in 1875, and about the same time it was reported from Florida as very destructive to sweet potatoes. In 1878 further reports from New Or-

leans stated that it had become very destructive in that section. It was then studied by Professor Comstock and the different stages were described by him in the Annual Report of the Commissioner of Agriculture for the year 1879. Since that time it was imported into Australia where its destructive work is increasing.

## OCCURRENCE IN TEXAS.

The first report of the occurrence of the weevil in Texas was in 1890 when T. H. Edwards, Bay View, Harris county, sent specimens to the U. S. Bureau of Entomology at Washington. In 1895 Professor R. H. Price of the Texas Experiment Station recorded it as being found on the Station grounds.

During the last few years, correspondence regarding the pest has rapidly increased, showing that the insect is generally spreading over Texas, and at present is generally distributed as far north as Milam county.



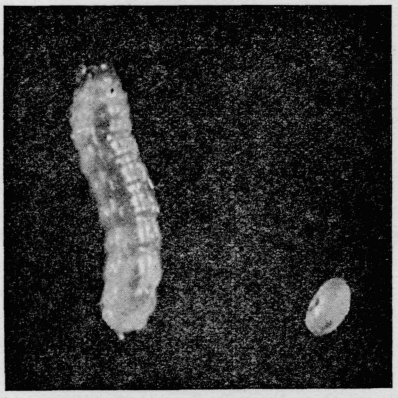
Adult Weevils. Male and Female.

## DESCRIPTION OF THE INSECT.

On account of the characteristic work and general appearance of the insect, it is so easily recognized that a detailed description would be almost superfluous. The full grown insect is a smooth, glossy snout beetle, of an elongated shape, having the head black, thorax and legs red, and the hind body dark steel-blue; length about 1-4 inch. In general shape and appearance it reminds one of an an ant, and, no doubt, it is from this resesemblance that it received the specific name of formicarius (Lat. formica, ant).

### EGG.

The egg is a minute object, of a yellowish-white color, oval in shape, about 1-46 of an inch in diameter, and owing to its somewhat dull surface it is difficult to discover. It is laid in cavities made by the insect, either on the lower portion of the vine or in the tuber. The attached end is frequently somewhat narrowed.



Larva and Egg

### LARVA.

The larva is a white, footless grub with a pale-brown head. When full grown it is about 1-5 inch long and rounded at the end. The head, though prominent, is narrower than the body.

### PUPA.

The pupa is of the same color as the larva, but somewhat smaller, and with pale-brown eyes. It can be readily distinguished from the larva by the presence, in a folded-up condition, of the snout, feelers, and legs, while the wings are represented by oblong pads. It is the dormant stage in the life history of the insect during which period no food is taken.

# Life-History.

### EGG LAYING.

In from 2 to 12 days after emerging the adults mate and begin egg-laying. Oviposition may continue for 3 weeks during which time from 12 to 20 eggs are laid. The eggs are normally placed in food cavities into which the female inserts the hind end of the abdomen for that purpose. The egg is fastened by its adhesive coat. The tuber is preferred to the plant for egg-laying.

### LARVA AND PUPA.

In from 5 to 6 days the egg hatches into the grub. If this occurs on the plant, the larva gnaws to the pith and downward towards the tuber. On young plants without tuber we have observed them develop success

fully in the stem, eventually killing the plant. If hatching occurs on the tuber the grub soon ramifies it with tunnels which makes it unfit for market and offensive for table use. In about 15 days the larvae become full grown under normal climatic conditions. This period may be prolonged over a week in cool weather. In its own tunnel it transforms to the pupa in a cell formed by closing the tunnel behind it with excrement. In about 8 days the adult emerges and eats its way to the outside. Under ordinary conditions it requires about 35 days for the completion of a generation from egg to egg. In winter the time may be prolonged nearly 15 days.

## BROODS.

Taking 35 days for a life cycle, theoretically 10 broods could develop in a single year under favorable weather conditions. In nature the weevil is handicapped by climatic changes as well as by the condition of the soil, depth of planting and cultivation. We have no evidence in our work that mating occurs underground, although in one or two instances burrows met in the tubers, indicating such a possibility. As the adults come to the surface for mating it follows that during the early part of the season when rhe potatoes are young and cultivation is thorough, their burrows are constantly interfered with.

Furthermore, breeding is retarded during the winter months. During our three years of observation at College Station we have no records of the insects breeding during December. January and February. Under normal conditions occasional egg-laying occurred as early as April 2nd, but the greatest breeding activity is from April 27 to May 6. In the bins, however, breeding is at its best, and during warm winters where no treatment is applied no doubt the generations are but little retarded in southern Texas during the winter months. Taking these facts into consideration we find there are upwards of 4 broods along the northern limit of the area of continuous breeding owing to a semi-hibernation period during winter; while upwards of 7 broods may develop during a single year in South Texas when the weather conditions are normally uniform and the activity of the weevils not retarded by "northers."

## FOOD PLANTS.

The adults belong to that group of beetles known as "general feeders." In the absence of early records of this insect as being tnjurious to sweet potatoes as well at the ready acceptance for food of other species of the sweet potato family, we are led to believe that the sweet potato is an acquired food plant. Experiments made in this department, show that in the absence of sweet potatoes the insect can live on the common species of Ipomoea. Any green succulent plant will be accepted as food for the adults. Experiments also showed that the average length a weevil is capable of living without food is 7 days in summer and 13 days in winter. On buckwheat the average of a number of weevils lived 55 days, on clover 20 days, on melons the experiment met with an accident after the weevils had lived 28 days. We have not been able to propagate the insect on the roots of buckwheat or melons. It seems possible, however, that they could develop successfully in the large succulent roots of Ipomoea or morning glory vines.

## PREVENTIVE AND REMEDIAL MEASURES.

Owing to its well protected habits the sweet potato weevil is one of the most difficult insects to combat. It is impossible to control it with one method alone; various methods must be employed during the year under different conditions. This Department has not been able to prosecute field experiments owing to the insufficient appropriations for the work. A thorough study, however, has been made of the pest in the locality of the Agricultural and Mechanical College, and although College Station is far from being a typical locality for the study of this pest, the results thus far obtained are here recorded and will be at least suggestive to many growers in other localities in their attempts to control the insect.

## PLANTING SWEET POTATOES REMOTE FROM INFESTED FIELDS.

This department has recommended to growers that sweet potatoes be planted as far from infested territory as possible. This recommendation was based on the fact that there are no records of the beetles having been observed in flight in this country. Professor Henry Tyron of Australia stated that the beetle was capable of flight of from 1-4 to 1-3 mile. We have observed them when spreading their wings as though attempting to fly. As well developed wings are present it appears that migration on the wing would be possible, but owing to the secluded habits, "playing 'possum," as well as its slow and protected movements, it is easy to see how this possible habit of the insects may have been overlooked. Were its only migration on foot dissemination would naturally have to be slow. In order to ascertain the weevil's inclination to flight, the following experiments were made by Mr. E. Scholl of this office: On May 6th, 6 weevils were put in a shallow dish which was placed on a block surrounded by water. Another dish containing a fresh sweet potato was placed about 6 inches away. The surface of the water was coated with flour to compel any insect when crawling to leave a trail. On May 8th all weevils had drowned. On April 1st, 4 weevils were placed in a dish surrounded by water; in another dish sweet potatoes were placed. April 2nd and 3rd weevils were found in the water and one was in the uppermost part of the cage. April 4th one weevil on another dish containing small pieces of potato evidently swam across. Two in the water drowned. On April 1st 4 weevils were placed in a dish surrounded by water. About 8 inches from it another dish containing a sweet potato was placed. On April 2nd 3 weevils were found kicking around in the water and one outside of cage. April 4th one weevil outside and one on potato. On May 16th the experiment was repeated with twelve weevils. About two hours later one weevil was on potato, another on wall of cage, and one was drowned in the water. May 6th, 4 weevils on potato and 3 drowned. On May 7th, the weevils were taken out, the surface of the water again covered with flour and 12 new, healthy specimens introduced. May 8th, one weevil succeed in crossing while the rest drowned; the legs got tangled up in the water and on account of the flour could not move. Thus we have no record of the weevil in flight.

## ROTATION.

A careful grower in South Texas who has practiced rotation of crops

for several years writes under date of Nov. 8th, 1906: "In planting sweet potatoes we always change the land each year. Whether this does any good or not I am doubtful; some years they seem worse than others. Last year we planted only a small patch and are now plowing them out. There are some weevils, but not nearly so many as last year."

The changing of land would not be sufficient by itself to control the weevil, but if it were supplemented by other practical means for checking the spread as well as rigid quarantine on the seed, it should have considerable value. Aside from weevil extermination, rotation has an important agricultural value and should always receive due consideration in combating insect pests.

## IMMUNE VARIETIES.

A thorough test for weevil-resistant features that may be possessed by different varieties has never been undertaken. In our investigations in this State we have as yet not found any variety that is immune. Prof. Tyron of New South Wales, Australia, states that of some 5 or 6 varieties of sweet potatoes produced in British Guinea and grown in Queensland not one escaped attacks when grown in weevil-infested fields. We have letters from well-known growers who claim that early varieties are more seriously injured than later ones. Early varieties furnish a much more favorable breeding ground for early broods than the late varieties, which may account for the fact that early varieties suffer greater damage to the tubers.

## DEEP AND SHALLOW PLANTING.

There is considerable controversy regarding the value of deep and shallow planting. In order to throw some light on this subject a series of experiments were performed with tubers buried at different depths in order to determine how deep the weevil is capable of burrowing to reach the underground tubers.

On April 20th infested tubers were planted at the following depths respectively: 4 inches, 5 inches, and 6 inches. From those buried 4 inches 100 per cent emerged successfully between the 3rd and 13th of May. From those planted 5 inches 100 per cent emerged from May 8th to May 20th. From those planted 6 inches deep, 100 per cent emerged May 1st to May 12. The experiment was repeated on May 20th with the same result, namely, that all weevils from infested tubers planted 6 inches deep reached the surface successfully.

The following experiment was performed in order to determine the depth to which weevils will burrow to the tubers. On June 12th 6 weevils were introduced after the sweet potato vines had started and tubers are formed. On June 14th 2 weevils had disappeared below the surface of the soil; June 15th, 2; June 16th, 1; and June 17th, all had disappeared. Seven days later an examination of the tuber was made when it was found that 100 per cent of the weevils had successfully reached the tubers. Simultaneously with these experiments another was performed in which the tubers were buried 8 inches with the result that the weevils reached the tubers successfully burrowing down through the soil close to the vine.

These experiments were repeated, except that tubers were buried without vines attached. One was buried 7 inches in firm soil; another in 8 inches firm soil, and three in 10 inches of loose soil. Into each cage 15

weevils were introduced. The result was that only one weevil reached the tuber that was buried 10 inches.

To determine the relative value of deep and shallow planting in the same garden, vines with tubers were dug up and replanted at various depths in firmly packed soil in the same cage and 30 weevils introduced. The following table shows the number of weevils that reached the tuber in each case:

| DATE | DEPTH OF PLANTING | NUMBER WEEVILS REACHING TUBER |
|---|---|---|
| May 12, 1904 | 1 inch | 12 |
| " 12, 1904 | 2 inches | 8 |
| " 12, 1904 | 4 inches | 5 |
| " 12, 1904 | 6 inches | 3 |

On May 22nd, 1906, a potato was buried 1½ inches below the surface of the soil in a breeding cage, another was placed on the surface and 4 beetles introduced. They remained on the exposed tuber.

The results of these experiments in connection with field observations show that there are several conditions governing the depth the weevils will burrow. A shallow planted tuber is infested more easily than those planted deep, provided such variation exists on the same land. Where all potatoes are planted deep weevils will burrow to them, even at a depth of 8 or 10 inches, but in such cases, and especially in very firm land, they will often prefer the vine. A loose, sandy soil will offer less resistance to their burrowing, and this is an advantage to early broods of the season, especially where broods are formed early as in the case of early varieties. This advantage is less marked later in the season after one or two broods have emerged. The channels left by specimens previously emerged will be used by entering weevils. Such channels do more toward facilitating breeding than loose soil. We know of one instance where in a plot of 28 plants only one hill was injured, and the tubers of that hill were partly exposed above the ground. In view of these conditions it is recommended that the seed bed be prepared on the level where conditions warrant it, as this will enable the grower to close all cracks and channels by cultivation. It is well to cultivate toward the plants in order to bury the tubers as deeply as possible. This will induce the weevils to depend on the vines to a greater extent for subsistence, in which case other methods, described later, may be applied. It furthermore limits their breeding area and consequently will retard propagafion. The work may furthermore be supplemented with trap rows of shallow planted potatoes, or by planting of an occasional shallow hill in each row from which enough soil has been removed as to partly uncover the tuber. When potatoes are planted in ridges, deep planting should be practiced with occasional shallow hills to attract the weevils.

## FUMIGATION IN THE BINS.

No method of fumigation can ever be made a remedy for potatoes that are already infested. Such tubers are ruined. No conscientious far-

mer would knowingly placed infested tubers on the market; they are unfit for human consumption. They should never be fed to stock in a raw condition. Fumigation experiments with carbon bisulphide were made in this department and where the tubers were treated at the rate of 3 pounds of the high life to every 100 bushels of tubers in an air tight room for 30 hours, all stages of the insect were killed. The carbon bisulphide was poured in several shallow dishes and these placed on top of the tubers in the bin. The result of these experiments should not warrant the statement that all the insects can be destroyed in a bin by a system of fumigation under practical conditions, and we do not at present recommend that any grower place such reliance on the use of carbon bisulphide. Fumigation alone will never control the pest. The adults that have escaped from the tubers in the bin can be easily killed by carbon bisulphide and fumigation may therefore be employed to advantage in assisting the grower to safeguard a bin against weevils escaping to the open. It should be remembered that carbon bisulphide is highly inflammable and explosive and fires of all kinds should be kept away from it.

## THE STORAGE BIN.

The first requisite of a storage bin is that it is weevil-proof. The bin should be tight, or screened in such a manner that no weevil that emerges from the tubers can escape into the open. If this precaution is not observed the storage bin will become the center of infestation for nearby fields every season.

## HANDLING OF INFESTED TUBERS.

When the crop is harvested the potatoes should be carefully assorted in a weevil-proof room. All tubers that show no signs of infestation should be transferred to the storage bin, making sure that no weevils are transferred with them. When the potatoes are gathered the field should be harrowed several times and every tuber exposed in this manner should be gathered and destroyed. They should likewise be assorted and all infested tubers destroyed Where the conditions warrant, hogs should be given the range of the field for a week or so after the potatoes are gathered in. In spring the field sbould be carefully obsetved, and as soon as volunteer vines from potatoes left undiscovered from the previous crop appear above ground, vine and tuber should be dug up and destroyed. Although it is impossible in all cases to determine whether a tuber is infested, after a little observation the marks on the surface of the potato will always enable the grower to assort those infested

A Hill of Sweet Potatoes Infested by Borer in the Bin.

## DESTROYING TUBERS.

1. Feeding Infested Tubers to Stock:

A number of our correspondents claim that stock refused to eat infested tubers. At this department we have fed them to hogs, cattle and horses. We find that in our experiments stock did not refuse infested tubers, except such as had been badly infested for a long tfme so that the potato had become dry and hard. Furthermore the castings in the burrows as well as the solidified walls of the same have a bitter flavor which may be objectionable to stock.

2. Boiling Infested Potatoes.

Infested tubers should never be fed raw. Frequently animals will not eat them up clean and many larvae as well as pupae will develop successfully even if left exposed on the ground. All tubers should therefore be thoroughly boiled before feeding. Remnants left after stock should be gathered and burned.

3. Throwing Tubers in Waste Places.

Where infested potatoes cannot be fed to stock they should not be thrown with the compost for their fertilizing value, even after they have been boiled,as they would supply a means of subsistence for weevils out-of-doors. In that case it would be safer to burn them in a hot fire previously built for that purpose.

Cross Section of Infested Tubor

4. Burying Infested Tubers.

It is not safe to bury infested tubers unless very deep, and in a place remote from the potato field. This would be practicable only where a few potatoes are grown.

5. Burning a Crop in the Field:

Where an entire crop is infested it is recommended that it be gathered, vines and all, and burned in a hot fire.

## TUBER TRAPS IN FIELDS.

As the weevils apparently do not migrate far on their own account, most of them that are not carried to the bins likely hibernate in or near the potato field. As they prefer tubers to vines it is recommended that in spring before the crop is planted a few potatoes be placed in sheltered spots in different parts of the old potato field to attract the weevils. The places where such potatoes are deposited should be carefully marked. They should be frequently examined and a week after the first weevils are found on them they should be destroyed by some safe methods and another lot put in their places. It should be repeated as long as the weevils are attracted, even after the crop has been planted. If these potatoes and the weevils on them are not regularly destroyed, this method is not only worthless but dangerous to the prospective crop.

## POISONS AND REPELLANTS.

In our experiments at the A. & M. College we found that weevils ate the vines in the absence of tubers. They gnawed cavities in the stems and branches and irregularly shaped holes in the leaves. A number of sprays were experimented with in the insectary, some of which are given below. In each experiment an equal number of weevils were placed in a cage without poison, called a "check" experiment.

No. 1. Nov. 18. '04. Placed 12 weevils on a potato vine under a lantern globe, and sprayed with Paris green. About 25 gallons of water and 1-4 lb. Paris green were the proportions used.

Nov. 20; 9 dead, 2 alive, and 1 lost.

Nov. 21; all dead. This was three days after spraying. In the "check" experiment none had died.

No. II. Nov. 18, 1904. Placed 12 weevils under lantern globe in laboratory on sweet potato vine and sprayed with arsenate of lead, 1 lb. arsenate of lead to 26 gallons of water.

Nov. 20; one dead.

Nov. 22; 9 dead and 2 alive.

Nov. 23; all dead. Five days after spraying all weevils were dead. None had died in check experiment.

No. III. May 22, 1905. Planted 2 vines, 1 sprayed with whale oil soap. Introduced 5 weevils to see which they would attack. May 24; weevils on unsprayed vine. Whale oil keeps them off for a time, but 4 days after, when the other vine had been devoured, they attacked the sprayed vine.

## SELECTING SEED.

The most rapid way of disseminating the pest is through infested seed. The habit of procuring home grown seed from an infested farm should be entirely abandoned and all seed potatoes should be imported from non-infested localities. The habit of gathering volunteer sets from potatoes left in the field from the previous crop is dangerous and for that reason should be discontinued. When seed is imported the shipper should be cautious to pack them so they cannot be reached by weevils enroute. Such shipments are sometimes unavoidably delayed at railway stations and if such stations are in infested territory the potatoes may become infested before reaching their destination. If not securely packed infestation may take place from infested shipments on the article of conveyance.

## DESTROYING TIE VINES.

Wild morning glories and similar weeds furnish food, if not a breeding place as well, for these insects, in the absence of sweet potatoes. Such vines should be kept down, if possible. In certain cases this might be accomplished by cattle. Where it is impossibles to keep such vines down they should be poisoned in early spring in and around the potato field, Poisoning may be done with a powder gun or by the stick and bag method, with which latter method all Texas growers are familiar.

## CO-OPERATION.

People in Texas believe in the effectiveness of organization, which, in a case like this, cannot be over-emphasized. The growers of a community should co-operate with one another in combating the sweet potato borer on their respective farms.