Georgia State Board of Entomology

E. LEE WORSHAM, State Entomologist

BULLETIN No. 49

JANUARY, 1918

PECAN INSECTS

WILLIAM F. TURNER.

PECAN SCAB

C. S. SPOONER.

PECAN DISEASES OTHER THAN SCAB

C. G. CRITTENDEN.

Atlanta,

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Monograph

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FOREWORD.

Pecan growing is rapidly becoming one of the most important industries of south Georgia and in recent years more and more plantings have been made in the central and even northern portions of the state. At present thousands of acres have been set out to pecans through south Georgia and these plantings are being increased yearly. (Frontispiece.) As a result the growers are already deeply interested in the insects and diseases which attack the pecan, and these pests are of continually increasing importance as the capital which is invested in the business increases.

The present bulletin is not intended to give exhaustive reports on the life histories of the various insects and diseases which attack the pecan. In fact, workers have been engaged in the study of the insects for such a short time that there are very few of them whose life histories are thoroughly known yet. This is also true, though perhaps in less degree, of the diseases.

In view of the numerous requests which are constantly being received for information concerning these matters, it was felt that the situation could best be met by a publication giving a general survey of the field. In the present bulletin, therefore, an attempt has been made to furnish the pecan growers with a guide by which they may become familiar with the insects and diseases which are now injurious, or which may become so, and may further become familiar with the principal methods of control.

It should be borne in mind that, altho many insects are dealt with in this bulletin, probably only a few of them will ultimately be looked upon as serious pests of the pecan. In this connection it is well to call to mind that many fruits, for instance apples, have as many or even more species of insects attacking them. Yet under ordinary conditions the grower has to contend with not more than three or four. Without doubt this will ultimately be found to be the case with the pecan, also. Those insects which are most injurious at the present time have been indicated, as have those which seem to possess habits and characteristics which may cause them to become of serious importance later.

With regard to some insects, at least, it has already been proven that successful, commercial pecan culture must include the spraying

of the trees. At first this seems a big item—something special which must be done. If the grower, however, will simply include spraying in his list of the year's operations, expecting to spray his trees at a certain time, just as he expects to plow at given periods, he will soon find that the matter adjusts itself naturally, and quickly becomes as little of a bug-bear as is planting or cultivating.

All dates given in this bulletin are for Thomasville, Ga.

PECAN INSECTS.*

PECAN LEAF CASE-BEARER.

(*Acrobasis nebulella* Riley.)

This insect is, at the present time, one of the most serious enemies of the pecan, probably causing more damage, in Georgia, than all other insects together. Fortunately, the species is, thus far, confined to south Georgia. It is present in injurious numbers about Thomasville, Cairo, Valdosta, Fitzgerald, Blackshear and Nashville. It has not been found in any numbers in the Albany district, however, and we have no reports of it from central Georgia. Since it has already been present in Florida and south Georgia for several years we have abundant grounds for hope that it will not become of serious importance in regions north of those in which it occurs at the present time, yet so many other insects have demonstrated their ability to adjust themselves to unfavorable conditions, particularly of climate, that it is possible the Pecan Case-bearer may do so eventually, and become a pest in portions of the pecan belt where it does not occur at present.

The principal damage is caused in the spring. The insects become active at the time when the buds begin to burst. The caterpillars or "worms" feed voraciously on the opening buds and tender shoots, frequently boring into and killing them. Young trees are often stripped entirely and, in bad outbreaks, trees as old as 12 and 13 years may be defoliated. This defoliation checks the growth of the trees and destroys the crop for the year. Since the larvae also attack the stems which bear nuts the crop is frequently destroyed even when the damage to the trees is not particularly severe.† Later, when the trees are well leafed out and the larvae can no longer feed on buds and young shoots, they attack the bases of the main leaf stalks and the leaflets themselves. This feeding is not as serious as that done earlier in the season.

*As indicated in footnotes, the portions on three or four of the insects were written by Mr. C. S. Spooner, formerly with the State Board of Entomology.

†Still a third type of injury was noted on one variety of trees, the Young, in the spring of 1916. Two trees about 30 ft. in height were under observation. Particular notes were made on April 22nd. On these two trees practically all the catkins, or male blooms, were destroyed by the worms, which fed at the base of these catkins. Very little injury of any other sort was noticed on these two trees. On trees of other varieties, near the two trees in question, little or no injury to the catkins was observed but the larvae were feeding, as is their usual habit, at the bases of the main leaf stalk and on the leaves themselves. The crop of these two trees was a failure.

LIFE HISTORY AND HABITS.

The adult insect is a mottled grey moth which, when its wings are spread, measures about five-eighths of an inch across. (Plate I, fig. 1.) When at rest it has a habit of sitting on a small twig with its head raised, the body forming an angle of about 30° with the twig and this position, together with the coloring, makes it very difficult to see. (See cover.) It seldom flies during the day time, but is very active at night.

Egg laying commences about the first of June and a few moths may lay as late as the first of August. The majority of the eggs are laid from about the middle of June to about the end of the first week in July. These eggs are small, soft, semi-transparent objects and are laid, almost invariably, along the main rib, on the under side of the leaf. In rare cases they are laid in angles between the side veins and one of the largest of the veins which branch off from these. We have never found eggs anywhere except on the under surface of the leaves.

The eggs hatch in a few days. This hatching commences, at Thomasville, about the middle of June and continues into early August. Most of the eggs hatch, however, during the first three weeks in July.

The young larvae, or "worms," are very small and usually reddish brown in color. They immediately commence feeding, eating only the lower surface of the leaf. From the frass and excrement they form a little tube, spinning silk with which to bind the particles together and line the case. This case is attached quite firmly to the leaf and runs along on the under surface of it. Commencing at the spot where the egg was laid the larva feeds outward, working back and forth so that the spot is fan shaped. The upper surface of the leaf turns brown. As the larva feeds it builds its case outward. The case itself is very firmly and tightly made, but at the outer end the larva builds a loose fan-shaped tent, under which it feeds. As soon as it eats all the green which it can reach from this tent it draws the back portion of it together, prolonging the case, or tube, and extends the outer portion in such a manner as to cover more green leaf. Since it also moves back and forth across the edge of the spot on which it has fed the case is curved, S-fashion, and

finally, by fall, becomes very serpentine in form. (Plate II, fig. 2.)

From one to twenty or more eggs may be laid on a single leaf. Each larva consumes only a small portion of the surface, usually remaining between the side rib near which the egg was laid, and the next one toward the tip. A larva may cross one of these side ribs, however, and while it usually feeds outward toward the tip, an occasional worm will turn back toward the base of the leaf. The feeding spots are very noticeable from both the upper and lower surfaces and in cases of severe outbreaks infested trees can be picked out from a considerable distance. Some of the larvae die during the summer, especially when there are several eggs laid on one leaf. Such larvae can always be located during the late summer and early fall, from the fact that the feeding spot is small and the end of the case does not reach to the edge of the brown spot. The tent usually is missing or the case may have been broken off entirely.

This summer feeding of the larvae is not particularly serious, in itself, except in the case of very severe outbreaks on young trees, when the growth of the trees is checked somewhat. As has been said, each worm does not eat very much and since the leaves are hard and do not furnish much nourishment, especially toward the end of the summer, the larva grows very slowly indeed, being only about one-twentieth of an inch long when it is obliged to cease feeding in the fall. The importance of this period lies in the fact that, up to the present, we have found it the best time to control the insect, as will be shown later.

In the fall, shortly before the leaves drop, the little worms leave their cases and crawl down to the buds. Here they form tiny, round, flattened cases, called hibernacula, and in these they spend the winter. (Plate II, fig. 1.) The hibernacula are most frequently located in the little groove where the bud touches the twig. When abundant, however, they may be anywhere about the bud, or even on it. As has been intimated, there is a close connection between the time of this migration and the time when the leaves drop. At Thomasville, in 1916, the migration began late in September and continued till frost, on November 16th. On October 24th, observations showed that about 50% of the insects had left the leaves. The migration commenced earlier on Mobiles than on any

FRONTISPIECE.

Map showing the distribution of pecans, by counties. Each dot represents 100 trees. The actual distribution of the trees in each county is not shown. (Figures from the 19th Ann. Rept. of the State Entomologist.)

PLATE I.

Fig. 1. Leaf Case-Bearer.

Fig. 2. Nut Case-Bearer.

Fig. 3. Cossid moth.

Fig. 4. Bud worm.

Fig. 5. Fall web-worm.

Adults of some Pecan Insects. (Slightly enlarged.)

PLATE II.

Fig. 1. Pecan Case-Bearer. Winter cases on bud. (Enlarged.)

Fig. 2. Pecan Case-Bearer. Summer cases. (July 15.) (Enlarged.)

Fig. 3. Pecan Case-Bearer. Spring cases on main leaf stalk. (Natural size.)

PLATE III.

Fig. 1. Pecan Leaf Case-Bearer. Late spring feeding.

Fig. 2. Pecan Leaf Case-Bearer. Early spring feeding on opening buds.

other variety, Mobiles shedding their leaves before the other common varieties do. Thus, on October 1, 1916, many hibernacula were found about the buds of the Mobiles, while none were found on other varieties.

The little larvae spend the winter in the cases on the buds, only leaving them in the spring at about the time the buds begin to burst. They then commence feeding on the opening buds and tender shoots, often boring into them. (Plate III, fig. 2.) A new type of case is now formed, this being the case most commonly noticed by the growers. It is cylindrical, open at both ends, and is carried about by the worm, as it moves from place to place, always standing out from the surface on which the worm is feeding. The young larva sometimes leaves one case entirely, building a new one in another location. When the larva bores into a shoot it usually fastens the case at the entrance of its burrow with silk, sometimes feeding with part of its body in the case and part in the burrow, at other times with its body entirely inside the burrow. At first the color of the case is a dirty grey, most of the outside being composed of frass. Later, when the larva is nearly full grown, more silk is used on the outside till finally the case is a light, silvery grey in color. It is always lined with silk. These mature cases are nearly always found out on the leaf stalk or on the under side of one of the leaflets themselves. (Plate II, fig. 3.)

The worms grow very rapidly at this time, becoming, when full grown, about three-fourths of an inch in length, while the case is about one inch long. The larva varies from a reddish green to olive green, the color depending somewhat on the portion of the tree on which the worm has been feeding.

When the larva is full grown and ready to pupate, it almost invariably fastens its case on the main stalk of a leaf, between two leaflets. These it draws together, fastening them loosely to the case and to each other with silk. It then builds two silken flaps, or lips, at the outer end of the case. These press together in such a manner that they cannot easily be opened from the outside, since any pressure simply closes them more tightly. On the other hand a very slight pressure from within will open them easily.

The larva now rests in its case for a few days and then pupates, with its head toward the outer end of the case. This pupal stage,

the period during which it transforms from a worm to a moth, lasts on the average for about 16 or 17 days. In 1914, the period lasted, in two cases, only 14 days, while one insect required as much as 20. This pupal period commences about the middle of May, a few insects probably pupating even earlier. It continues as late as the first of July. At the end of this period the moths emerge and are soon ready to lay the eggs for another generation.

CONTROL.

Up to the present time the only successful method which has been discovered for controlling this pest is to spray the trees with arsenate of lead between the middle of August and the last of September. All attempts to control with arsenate of lead in the spring have failed. This is also true of efforts to kill the worms in the winter cases by spraying during the winter with lime-sulphur.

The formula which we would now recommend is as follows:

Arsenate of lead (powdered)*	1 lb.
Lime	2 lbs.
Fish oil soap	2 lbs.
Water	50 gals.

The lime is added to this mixture in order to prevent the arsenate from burning the foliage. When it is not used the trees may be quite seriously injured. The soap is not absolutely necessary but its presence makes the spray mixture spread much more readily and evenly and, during the season of 1916, it was found that mixtures which contained the soap adhered to the foliage somewhat better than did those without it.

In groves of young trees, up to five or six years of age, an ordinary barrel pump may be used. In the older groves, however, the most satisfactory results can only be obtained by the use of a power sprayer. (Plate IV, figs. 1 and 2.)

The most important point to remember is that the trees must be thoroughly sprayed. While it requires only a very minute quantity of the poison to kill the tiny worm it is absolutely essential that that poison shall be placed where the worm will reach it. Therefore, for good results, care must be taken that, in so far as is possible, the

*If arsenate of lead paste is used, the amount must be doubled; that is, 2 lbs. to 50 gals. of water.

under side of every leaf is covered with the material. If this is done the grower will have no trouble in controlling this pest.

WINTER SPRAY.

Growers frequently ask why winter spraying cannot be employed against this pest. Several experiments have been conducted in which the trees were sprayed with lime-sulphur, and during the winter of 1916-17 we made extensive tests, using lime-sulphur, miscible oils and home-made oil emulsions. These sprays were absolute failures. The same was true of sprays containing nicotine sulphate and soap, applied in the spring just at the time the larvae were leaving their winter cases to commence feeding on the buds. Apparently the hibernacula are so tightly woven that the spray materials do not penetrate them thoroughly. The failure of the spring treatment to produce any appreciable effect seems to be due to the fact that no one time can be selected when a large enough percentage of the "worms" are exposed to the poison.

NATURAL ENEMIES.

There are several natural enemies which aid in controlling the Leaf Case-bearer. These consist of parasites, including several species of minute wasps,* and at least one fly;† predaceous enemies, including two or three species of bugs which attack the larvae and suck out the juices; and birds, as blue jays, which tear open the cases and pick out the "worms."

Rather limited examinations in one grove, during the season of 1916, gave the following results: 8.7% of the larvae in the cases collected were destroyed by parasites; 12% had been killed by birds, while 14.2% were "sick." Some of these "sick" larvae may have contained parasites but this point was not definitely settled.

In 1917, several lots of cases were collected from five groves at various intervals between May 18th and July 27th. These were examined carefully and the results are recorded in the following table:

**Habrobracon variabilis* Cush., *Macrocentrus* sp., *Exochus apicalis* Cr. Several other species were reared in 1917, but these have not yet been determined.

†*Exorista pyste* Wlk.

Table 1—Percentage of Worms Killed by Natural Causes.

Grove	Total Cases	Parasites		Killed by Birds		Dead & Dried		Total Dead	
		No.	%	No.	%	No.	%	No.	%
I	304	27	8.8	5	1.6	9	2.9	41	13.4
II	365	24	6.5	8	2.2	15	4.1	47	12.9
III	614	18	2.9	12	1.9	27	4.4	57	9.2
IV	90	15	16.6	4	4.4	4	4.4	23	25.5
V	50	7	14.0	2	4.0	1	2.0	10	20.0
Ttl.	1423	91		31		56		178	
Avg.			6.4		2.1		3.9		12.5

In view of the fact that extensive examinations, including several thousand individuals, have shown that there may be a total annual mortality of nearly 95% of this species, due mainly to the fact that large numbers never form cases on the buds, while many also die during the winter, and that in spite of this the species caused severe injury to the very groves in which the data was obtained, it is evident that little can be hoped for in the way of control by either parasites or birds.

Some very interesting data were obtained during the past season on the value of a predaceous bug, *Arilus cristatus*, in the control of the Leaf Case-bearer. Three bugs ate a total of 76 "worms" between May 11th and June 5th. At this latter date other food had to be provided since no more Case-bearer larvae were available. The larvae were removed from their cases before being fed to the bugs, so these figures must be considerably in excess of those actually obtaining in the field, where the bugs are obliged to search for the "worms" and to attack them in their cases. They indicate, however, that this species may be of considerable benefit wherever it occurs in any numbers. As with the parasites and birds, however, predaceous bugs cannot be relied on to control the pest and wherever Case-bearers are abundant artificial means of control must be employed.

VARIETIES OF PECANS ATTACKED.

C. S. SPOONER.

There is another most interesting point in connection with this insect and that is the freedom from attack enjoyed by many varieties of pecans. This is very evident and easily observed. In the same grove with trees of different varieties planted next each other, the one will be heavily infested and the other almost free from attack.

It was first noticed that the large leaved varieties were most subject to attack, while the small leaved varieties were, to a large extent, free from the insects. Further examinations showed the probable reason for this. It will be remembered that the eggs of this insect are laid in the angles made by the secondary veins with the midrib. Now in the large leaved varieties the veins are also large and form a deep pocket at this angle. In many cases the entrance to this pocket is hidden by hairs. This forms an ideal place for the eggs of the Case-bearer. They are hidden and protected from weather. The small leaved varieties lack these pockets and the egg must be laid directly on the surface of the leaf. There is little doubt but that the presence of this pocket favors the attack of these insects. The moths would search for them in preference to depositing their eggs on the small leaved varieties.

Notes were taken on the numbers of Case-bearers found on the different varieties. Trees in the same groves were compared and the insects were there in sufficient numbers to seriously infest all the trees, had they not selected the varieties most suitable to them.

The following varieties were severely infested:

Capitol,	Frotscher,
Van Deman,	Taylor,
Schley,	Alley,
Nelson,	Appomattox,
Stuart,	Delmas.

The following list had very few of the Case-bearers on them:

Money-maker,	Mantura,
Hassen,	Hican (none),
Georgia,	Teche,
Curtis,	Young.
Russell,	

The following varieties seemed to be intermediate between the above two groups:

Mobile,	Senator,
Creole,	Teddy,
Success,	Bacon,
President,	Hadley.
Pabst,	

These lists do not by any means include all the varieties, but are simply those which have been under observation.

The question may arise as to whether freedom from the attack of this insect should be considered in selecting varieties for planting. In cases where the varieties are about equal in other desirable points it would be well to let this point influence your choice. This insect is, however, so readily controlled that the freedom from attack would not outweigh any serious faults in a variety.

PECAN NUT CASE-BEARER.

(*Acrobasis hebesella* Hulst.)

The Pecan Nut Case-bearer is a comparatively recent comer to Georgia, having been here for probably only four years, or five at the most. It has been in Florida for a somewhat longer period and is of quite common occurrence west of the Mississippi, where it appears to be native. As far as we know, in Georgia the species is now confined to groves about Thomasville and Cairo, though it may occur elsewhere along the southern edge of the state. This insect, as its name indicates, is particularly an enemy of the nuts, themselves, altho in certain stages it attacks the shoots and swollen bases of the leaf petioles.

While the Nut Case-bearer is not of great economic importance in Georgia at present, because of its very limited occurrence, it seems very possible that it may eventually become our most serious pecan enemy. In one grove near Thomasville, during 1916, the worms destroyed 50% of the crop on the Frottscher trees and over 35% of the Teche before June 20th. The species always causes most of its damage early in the season, as will be explained later, but the total damage to the grove for the year was undoubtedly as much as 50%, including both varieties.

LIFE HISTORY AND HABITS.

Unlike the Leaf Case-bearer, this species has three generations during a single year. It spends the winter as larvae in hibernacula attached to the buds, just as does the Leaf Case-bearer. The larvae, or "worms," leave these winter cases as soon as the tree commences growth in the spring, and complete their growth by boring into the new shoots and feeding within them. The larvae look very much like those of the Leaf Case-bearer, varying in color from a yellowish brown through various shades of greenish brown and greenish grey to a pinkish olive green. The head and thoracic shield are dark brown. These larvae become full grown and pupate about the first of May and the moths begin to emerge and lay eggs about the middle of the month, at Thomasville.

The moths are about the size of the Leaf Case-bearer moths. Their fore wings are darker in color with a ridge of black scales at the base of each wing. When the wings are folded these ridges give the moth a hump-backed appearance. The hind wings are lighter grey. The abdomen is grey while the head and thorax have a more brownish cast. (Plate I, fig. 2.)

The eggs, which are very small and greenish or pinkish white in color, are laid at the blossom end of the newly formed nutlets, which at this time are about one-fourth to one-half of an inch in length, depending on the variety. These eggs hatch in a very few days and the tiny "worms" crawl down to the bases of the nutlets and bore into them, usually close to the line where the nut is attached to the stem, although occasionally entrance holes are found elsewhere on the nuts.

The young worm usually hollows out the nutlet in which it is feeding, eating out the portion which would later become the nut and leaving the portion which would eventually become the husk. Having finished one nutlet it leaves it and attacks another in the same cluster. Occasionally the larva migrates to a second nut before it has eaten very much in the first. One larva may feed on as many as four or five nuts before reaching its full size and it is for this reason that the damage is so severe at this time of the year. The hollowed nutlets soon turn brown and dry and may be seen hanging from the stems by threads of silk used by the worms in

making their cases. These empty nuts frequently hang on the trees throughout the season.

After becoming half grown, or even sooner, the larva usually builds a short tube or case, perhaps one-sixteenth to one-eighth of an inch in length, about its entrance hole. (Plate V, fig. 1.) This is formed of silk and frass. Frequently a worm will also build a tube from the base of the nut on which it has been feeding to the base of the next one which it attacks and these tubes may be one-half an inch or more in length. This habit, together with its feeding habits, suggested the name of Pecan Nut Case-bearer.*

In the laboratory the first larva reached full size, in 1916, about June 6th, and one had pupated by June 9th. The great majority of the insects had pupated by June 24th. The larva when preparing for this stage faces with its head towards the entrance burrow and transforms within the little nut which is just about large enough to hold the pupa. The moth emerges through the entrance burrow, which is of good size. This is due to the fact that the insect pupates, of course, in the last nut attacked and that the "worm" was nearly grown when it entered this nut.

The first adult emerged, in the breeding cage, on June 18th in 1916. In 1917 moths appeared as early as June 10th. Emergence continued till July 9th, 1916, and to July 12th, 1917.

These moths, in turn, lay eggs at the blossom ends of the nuts, which are much larger now, being fully half or more than half grown. Each "worm" feeds only in one nut, and does not clean that one out. As a result each larva of this generation destroys only about one-fourth as many nuts as does a larva of the first generation. (Plate V, fig. 2.)

The entrance burrow is still made near the base of the nut. Since it is made by the worm just after it has hatched it is usually very small and in many instances there is no case about it. Also the adult frequently cannot emerge through it and consequently in such cases another method for emergence is provided. Before it pupates, the larva eats a hole almost through the husk of the nut, leaving just a thin layer of the surface, to cover it. This hole is usually in the side of the nut near the base. The larva then forms

*This name was suggested by Mr. A. C. Gill, of the U. S. Bureau of Entomology.

Fig. 1. Spraying for Case-Bearer. Using a Bordeaux Nozzle on one line, so that the tower is not needed.

Fig. 2. Filling tank from a well, by means of a barrel.

PLATE V.

Fig. 1. Work of first generation on small nuts.
(Much enlarged.)

Fig. 2. Work of second generation on nearly
grown nuts. (Slightly enlarged.)

Fig. 1. Summer case
(much enlarged).

Fig. 2. Winter case
near bud.

Fig. 3. Summer case on leaf; note dark
area, where insect has fed.

Cigar Case-Bearer.

PLATE VII.

Fig. 1. Web-worm moth covering eggs.

Fig. 2. Same egg batch with moth removed.

Fig. 3. Egg batch of walnut, or pecan, caterpillar.

a cocoon of silk and frass, with the head end open and attached about the exit hole. It pupates in this cocoon and later transforms into a moth. This moth simply pushes out the flap and escapes.

The nuts attacked by the second generation seldom hang on the trees as do the nuts attacked by the first, since they are much heavier and are not held by silk. They frequently drop before the moths have emerged, and the worms complete their feeding and transform to adults in these nuts on the ground.

The second generation pupated between August 3rd and 20th, 1916, mostly about August 16th. Moths began emerging about August 15th and apparently all had emerged by about September 1st. In 1917 one moth emerged as early as August 10th.

The larvae of the third generation feed little, if at all, on the nuts. Instead they attack the swollen bases of the leaf stems, feeding in these until it is time for them to form their winter cases on the buds. It will be noticed that the "worms" of this generation feed on leaf and stem tissue throughout their entire life (both in the fall and spring), while those of the other two generations feed on nuts.

CONTROL.

We have not conducted any experiments, as yet, for the particular control of this species, for this reason. During 1916 one grove, rather severely infested with Leaf Case-bearers, was sprayed as recommended, with arsenate of lead, between August 22nd and 25th. In 1916 fully 50% of the nuts in this grove were destroyed by the Nut Case-bearer. In 1917 this species destroyed only 5.8% of the nuts on the worst infested tree in the grove. These results seem to indicate that the spray used for the Leaf Case-bearer, if applied at the proper season, will also control the Nut Case-bearer. However, this cannot be definitely stated, since another factor, to be mentioned below, complicates the situation and may be sufficient of itself to account for these results. This decrease in infestation further precluded the possibility of control experiments in 1917, as no groves were found in which the insects were present in sufficient numbers to furnish reliable data.

As previously noted, winter spraying with various materials

has not yet proven efficient against the Leaf Case-bearer, and cannot be expected to be any more so against this insect.

NATURAL ENEMIES.

The natural enemies of this species appear to control it more efficiently than is the case with any other important insect attacking pecans. To return once more to the grove already mentioned as losing half of its crop through the work of the Nut Case-bearer, during 1916, it was found that 50% of the first generation was destroyed by parasites. Of these there were reared two species of Hymenoptera,* which together killed 23.5%, and one Dipteran,† or fly, which accounted for 26.5%. As will be seen, this is the most important of the enemies of the Nut Case-bearer as yet recorded. This fly also attacks the Leaf Case-bearer to some extent.

As a result of this parasitism the second generation was much less abundant than the first. The percentage of "worms" destroyed in this way was also less, in the second generation, but still about 10% to 12% were killed. This difference is probably due, for the most part, to the fact that the larvae of this generation live entirely in a sheltered position, while those of the first generation are frequently exposed, when migrating from one nut to another and before they are able to burrow within each new nut, thus giving the fly, which is the most important enemy, an opportunity to lay its eggs on them.

In 1917, as stated in the discussion on control, the infestation in this same grove was only nominal, one tree, the most severely infested, losing only 5.8% of its nuts, and the damage to the entire grove being about 1%, or less. Since this grove was sprayed, in 1916, at about the time the young larvae began to attack the bases of the leaf stems, many of them may have been killed by the spray. Nevertheless, the results for the early part of 1916 indicate that parasites exert an important influence on the abundance of Nut Case-bearers.

In 1917, of the insects handled in breeding cages, 17.3% of the first generation were destroyed, 13% by the fly and 4.3% by the

**Habrobracon varlabilis* Cush., *Microbracon* sp. Other species reared in 1917 have not been determined.

†*Exorista pyste* Wlk.

wasp parasites. As a result the second generation was not at all abundant, only an occasional infested nut being found.

Growers should bear in mind the fact that parasites are almost never entirely satisfactory as a means of control of injurious insects. They never absolutely destroy their host insect, as to do so would be to starve themselves to death. However, during years when the host insect is scarce, great numbers of the parasites cannot find food and consequently die. Thus they become scarce, in their turn, and the host insects being almost free from enemies begin to increase in numbers, rapidly, the parasites also becoming more numerous as their food insects become abundant, but never quite catching them. Finally there is a climax year when the pest is extremely abundant and injurious, at first, while the parasites are also abundant, and finally destroy a large percentage of the injurious form. As a result the pest will be scarce the next year and the parasite, abundant at first, will themselves become more and more scarce as their food becomes harder and harder to find, till they too are rare, and the whole cycle begins over again.

It is for this reason that insects having important insect enemies, such as is the case with army worms, are abundant only periodically. This will undoubtedly prove true with the Nut Case-bearer and consequently it will probably be necessary to supplement the work of parasites by artificial control during some seasons.

VARIETIES OF PECANS ATTACKED.

Very little has been noted on this phase of the problem. In the spring of 1917, however, in a grove containing Frotscher, Teche and Alley, it was observed that a few infested nuts were to be found on almost every Frotscher before any could be located on Alley or Teche. Later, however, the two latter varieties were attacked slightly.

THE CIGAR CASE-BEARER.

(*Coleophora caryaefoliella* Clem.)

This insect is a leaf feeder like the Leaf Case-bearer. It is a much smaller insect than the latter, the adult being a small, shiny

brown moth, which, with its wings spread, measures something under half an inch across. The wings are very narrow with a thick fringe of long hairs on the hind margins. The case is entirely different from that constructed by the two case-bearers which have already been discussed, in that the latter construct a case, bit by bit, from particles of frass bound together with silk, while the Cigar Case-bearer makes its case of pieces of leaf, fastened and lined with silk. (Plate VI, fig. 1.)

While this insect is widely spread throughout the pecan belt of Georgia it has not been found, as yet, in sufficient numbers to cause serious damage. Infestations have been observed in Florida, however, where the damage was very severe.

The life history of the insect is very similar to that of the Pecan Case-bearer. The young larvae spend the winter in small cases around the buds, usually in the angle between the bud and the twig. (Plate VI, fig. 2.) In the spring, when the buds swell, they leave their nesting place and feed upon the buds, destroying them. Later they feed on the leaves. When feeding on the leaves the larva mines into the leaf, eating out the interior, but leaving the upper and under surface intact. In doing this it fastens its case at a right angle to the leaf and makes a small hole through the surface, directly under the mouth of the case. It then eats out the interior of the leaf in every direction, as far as it can reach. Having exhausted one spot it moves its case to a new place and repeats the operation. (Plate VI, fig. 3.)

The insects pupate during the first part of May and the adults emerge the last of May and the first of June. The eggs are laid on the leaves, during the middle and latter part of June. Upon hatching the larvae mine into the leaves and spend some time there, entirely between the two surfaces. They then cut out the dry brown portions of the leaf, tie them together into a case and move about, feeding as previously described. In the fall they migrate from the leaves to the buds where they attach themselves for the winter.

This insect seldom does sufficient damage to warrant control measures. In case of local severe outbreaks we would recommend spraying the trees with arsenate of lead, in the spring, using the formula given for the control of the Leaf Case-bearer.

THE PECAN BUDWORM.

(Proteopteryx bolliana Sling.)

Altho it attacks trees of all ages to some extent, the budworm is particularly a pest of nursery trees and of trees newly set in groves. Like many other pests, while it occurs throughout the pecan growing region of Georgia, it very seldom is present in sufficient numbers to cause serious injury.

This species spends the winter in the adult, or moth stage, hiding under loose bark or elsewhere about the fields. The moth is about the size of the Leaf Case-bearer moth, measuring about five-eighths of an inch with the wings spread. The general color of the front wings is grey mottled in a very pretty pattern with black, while the hind wings are dark grey without markings. (Plate I, fig. 4.) These moths are very abundant in the fall, especially during November, when they may be found resting on the trunks and larger branches of the trees. If disturbed they fly only a short distance, perhaps four or five feet, returning immediately to the same tree.

The larvae are greenish white in color, with black head and thoracic shield when young—these becoming dark brown in the older larvae. The full grown worm is about five-eighths of an inch long. These grown larvae of the first generation usually leave the bud and migrate to the trunks, where they pupate under loose bark. This habit seems to be very strongly ingrained, since in at least one instance under observation the larvae were forced to travel more than thirty feet from foliage to trunk, which they did in large numbers.

There are at least five generations of this species in South Georgia. The later generations, not having the new and tender shoots to feed on, pick out the youngest foliage present on the trees. This is particularly noticeable during the late summer when the trees put on their second growth. At this time the work of these worms, which has been scarcely noticeable for two or three months, becomes very evident again. In feeding on the foliage the larva folds over the edge of the leaf, fastens this loosely with silk and feeds within, or at the ends of this fold. These larvae do not migrate to the trunk for pupation, as do those of the first generation, but transform within the folded leaflet.

CONTROL.

Under ordinary conditions no control measures are required against this pest. In severe local outbreaks, however, it would be well to spray the trees with arsenate of lead in the spring.

PECAN SHUCKWORM.

(*Laspeyresia* (*Enarmonia*) *caryana* Fitch.)

This insect occurs throughout the pecan belt of Georgia. While it is not found in injurious numbers in all localities, practically no grove in the state is entirely free from it, and it may become serious, during some seasons, wherever it occurs.

The young, or larvae, burrow in the outer shucks, or husks, of the pecan nuts. The damage is of two sorts. If the insects attack the young nuts these fail to develop. If they attack the larger nuts they may fail to fill out, so that when gathered they contain merely a shriveled kernel. The principal injury to the large nuts, however, consists in staining the shell with dark blotches. This materially reduces the market value of nuts. Considerable trouble is caused also by the fact that the infested husks often stick to the nuts and must be removed by force.

The life history of this species is not completely known, at present, but enough is known to suggest a sure method for suppressing the pest, as will be shown later. The larvae spend the winter in the shucks, on the ground. Toward spring, that is in the latter part of February and through March, they pupate, or go into the resting stage during which they change from the worm to the adult moth. This stage, also, occurs in the husk of the nut. The insects become adult and emerge from the husks early in the spring. A few have been reared as early as March 22d (1914) and emergence may continue at least as late as April 28th (1916). The time of greatest emergence was from April 7th to 14th in 1914, and from April 3d to 10th in 1916. The adult is a small moth about one-half to five-eighths of an inch across, when the wings are spread. The color is mottled brown and bronze.

In the early spring, when the moths of the overwintered generation appear, the nutlets have not yet been formed and the activ-

ities of this species during the weeks intervening between the emergence of the moths and the appearance of larvae in the young nuts have not been definitely determined. It had been thought that the larvae might attack the young shoots, but whether or not such is the case we have not been able to determine as yet.*

Beginning in late June the larvae of this species are found attacking the nuts. These larvae are creamy white in color, with light brown heads. They feed on the husk, or shuck, of the nuts and during the early part of the season, before the nut shell is hardened, they frequently eat into the nut itself. Moths again appear in August. These lay eggs on the nuts or leaves and from these hatch out the worms found in the shucks at gathering time. These worms are not full grown when winter arrives but continue their feeding in the shucks on the ground till about midwinter or even later, when they pupate, as noted previously.

CONTROL.

The best method of control is to gather and burn the shucks when the nuts are harvested in the fall. This is an economical and very effective method of reducing the numbers of the pest. If the nuts are beaten from the trees on to large sheets, laid on the ground, the nuts can then be picked out and the shucks gathered and put into racks and carried off to be burned. In this way a very large per cent of the insects will be destroyed.

Late fall plowing will also prove effective. Experiments have shown that 75 to 80% of the insects buried to a depth of three inches will be killed and over 95% of them killed when covered to a depth of six inches. Pasturing hogs in the groves during fall and winter will undoubtedly be beneficial, also.

NATURAL ENEMIES.

Parasites have been reared in considerable numbers from this insect.† The percentage of parasitism is often very high, altho there is no present indication that natural enemies will control the pest sufficiently to warrant stopping the artificial measures mentioned above.

*Gill states, in a recent bulletin, that these first generation larvae probably attack pig nuts and hickory nuts, for the most part, only a small percentage of the latest moths to emerge, waiting for pecan nuts. (Gill, J. B., Farmer's Bulletin 843, U. S. D. A., 1917.)

†*Calllephialtes grapholithas* (Cres.), *Phanerctoma tibialis* Hald., *Microbracon* sp.

THE FALL WEBWORM.

(*Hyphantria cunea* Drury.)

This insect is well known to all pecan growers. It forms the familiar webs enclosing the tips of the branches. The adult moth is about an inch across when the wings are spread. These moths are usually pure white in color, although sometimes they are marked with black spots on the wings. (Plate I, fig. 5.) The eggs are laid in clusters of several hundred on the under side of the leaves. The moth usually covers the egg batch with her body and wings, remaining in this position until she dies. (Plate VII, figs. 1 and 2.)

Upon hatching the young caterpillars commence feeding upon the surface of the leaves and as they feed they enclose the foliage in a web. When they exhaust the food within the web they enlarge it, including more and more leaves until the entire tip of the branch is covered, forming the unsightly nest with its enclosed brown and dead leaves which is such a familiar sight on many kinds of trees. The caterpillars are usually yellow and are clothed with long black and yellow hairs. Occasionally they are very dark, almost black in color.

When fully grown the larvae leave the nests and crawl to some secluded spot, under loose bark, under boards and sometimes just below the surface of the soil. Here they pupate and later the moths emerge to lay eggs for the next generation.

In southern Georgia there are two broods a year and a partial third brood. That is, some of the late caterpillars of the second brood do not mature the first season. The insect spends the winter in the pupal stage, the moths emerging in the spring. The first nests appear about the middle of May, the second brood nests appearing in August and September, and the partial third brood also appearing late in September and into October.

Aside from the unsightly appearance which the nests give the trees, this insect is not of serious importance during most years and in most localities, though its feeding is bound to check the growth of the trees to some extent. This is especially true in the case of the young groves and nursery stock. Occasionally, however, the damage is very serious, as in 1916, around Thomasville. During that year the species was abundant throughout the summer and by

the middle of September several groves were almost defoliated. (Plate VIII, fig. 1.) Most of these groves were young ones, but one, composed of nine year old trees, was so severely attacked that by the end of September somewhat over 40% of the foliage of the entire grove had been eaten by the caterpillars. Of course this work was not evenly distributed, so that while a very few trees were not attacked, many were entirely defoliated. In addition to eating the foliage the caterpillars fed on the shucks of the nuts. As a result the shells were badly stained and it was practically impossible to remove the uneaten portion of the shucks from the nuts, so that the crop on these trees was almost worthless. (Plate VIII, fig. 2.)

CONTROL.

Such outbreaks are entirely unnecessary if care is taken to destroy the caterpillars early in the season. This may be done by systematically destroying the webs with the worms in them. They can be burned with a torch, or cut off and burned later. Many people simply twist the nests out of the branch by means of a stick with a nail driven partly through one end, and then crush the larvae on the ground. With a little care in this matter the grower will have no trouble in controlling the pest.

WALNUT OR PECAN CATERPILLAR.

(*Datana integerrima* G. & R.)

This is another leaf-eating insect which feeds upon the pecan. The larvae are dark with two white stripes on each side of the body, and are clothed with a few short hairs. The adult moths are yellow brown with four white stripes across each front wing.

The eggs are laid in masses of several hundred on the under side of the leaves. (Plate VII, fig. 3.) The caterpillars feed on the foliage. Unlike the Fall Webworm these insects do not spin webs but move freely about the trees. When nearly grown the larvae all gather together on the trunk of the tree on which they are feeding and shed their skins for the last time. They then go back to the branches and feed for a short period after which they leave the tree and enter the ground to pupate.

These insects may be easily killed while they are in the bunch on the trunk of the tree. They can be scraped off and crushed. This will greatly reduce the numbers of future generations. In cases where the insect is very numerous the trees should be sprayed with arsenate of lead, $1\frac{1}{2}$ pounds of powder or 3 pounds of paste to 50 gallons of water.

THE PECAN CATOCALAS.

(*Catocala* spp.)

At least two species of Catocalas feed on pecan. The adults are large moths, with greyish or dark brown front wings. The hind wings of one species are yellow with two transverse black lines, while those of the other are dark brown with a narrow band of white.

The caterpillars, when full grown, are large, one measuring over two inches in length and the other three inches. Both are dark grey with various markings. The hide is tough and leathery in appearance, and the caterpillars are sometimes known as "alligator worms."

These insects, because of their coloring and their habit of hiding in crevices in the bark during the day time, are seldom noticed. Ordinarily they are not particularly injurious but they may become so, occasionally. The larvae are usually present only in April and May. They may be controlled by hand picking or by an arsenical spray. They will also gather, at night, under bands of burlap, if these be tied loosely about the trunks, and can be collected and destroyed the following morning.

TWIG GIRDLEERS.

(*Oncideres cingulata* Say.)

The twig girdlers are probably the most widely known of all the pecan pests and they occur throughout the pecan belt. There are two species, but the only one observed thus far, injuring the trees in this state, is *cingulata*. Both apparently work in the same manner.

The female beetles girdle the small branches of the trees and lay their eggs in these. The cut branches eventually break and fall to the ground. It is this pruning work which is known to the growers, the beetles themselves seldom being seen. As has been said this girdling is done by the female, which lays its eggs in these cut twigs. The work starts about the middle of September and continues until December. The female, after girdling a twig, proceeds to lay eggs in the cut-off portion, from one to several eggs being deposited in a single twig. The beetle cuts a slit just below a bud, then thrusts her ovipositor through this slit between the wood and the bark and deposits a single long slender white egg. (Plate IX, fig. 2.) She usually scars the bark with transverse shallow grooves, below the point where the egg is deposited. (Plate IX, fig. 1.) The purpose of this scarring is not certainly known. It probably aids in protecting the egg in some manner. There can be no doubt, on the other hand, that the girdling of the twig is for the purpose of killing it, since its continued growth would crush the eggs. Also, the young are probably unable to feed on live wood.

The eggs hatch in a little less than a month and the white borers immediately commence feeding. This feeding continues through the winter and on till the next fall, the borers becoming full size and pupating in late August or early September. In some cases it appears that the adults do not emerge the first year, but the pupae, or perhaps the larvae live over till the next year.

Under ordinary circumstances the injury caused by these insects is not of serious importance. When very abundant, however, especially in young groves, the girdlers may cause very material damage.

In order to control this species all the fallen twigs should be gathered during the fall and winter and burned. It is not possible to destroy the insects entirely as they also attack hickories and persimmons, in the woods, where it is practically impossible to employ this method. If followed faithfully, however, the grower will have no difficulty in keeping the girdlers well in hand.

FLAT HEADED BORERS.

The flat headed borers are the most abundant and most destructive of the borers attacking the pecan. The adults of these

borers are flat, hard beetles usually shiny and with metallic lustre. The larvae are whitish grubs with broad flat heads, the body cylindrical and much narrower than the head. Three species have been taken from pecan, thus far.* Of these the most important seems to be the Apple Tree Flat Headed Borer.

The larvae bore into the bark and feed between the bark and the wood. As is well known this is the part of the tree which is alive and growing. So wherever these insects bore, that portion of the tree is killed. On small trees or where the number of borers is large these tunnels may extend entirely around the tree, thus girdling and killing it outright.

The adult beetles emerge principally during May and deposit eggs in crevices in the bark. As soon as these eggs hatch the larvae tunnel into the bark. When fully grown these larvae enclose themselves in cells composed of borings and frass and there pupate. The following spring the adults emerge and lay eggs for the next generation.

Judging by evidence recently obtained there may either be two broods a year or it may sometimes require two years for the insects to mature. The fact that larvae of two sizes have been found in the fall leads to one of these conclusions.†

The most satisfactory method of combating these insects so far known, is to dig them out. Their presence is usually indicated by cracks in the bark along a depressed or sunken area. The tunnels should be opened and then painted with a good quality of white lead paint to prevent further decay.

THE COSSID BORER.

(*Cossula magnifica* Strecker.)

This is the insect whose larval stage and work are referred to by growers as "round heads" and "round head work." These are not round headed borers, however, the adult of the round head being a hard-shelled beetle, with long antennae or "horns," much like the adult of the twig-girdler, while the adult of the cossid borer is a moth. (Plate I, fig. 3.)

**Chrysobothris femorata* Fab. (The Apple Tree Flat Headed Borer), *C. scitula* and *Agrillius anxius*.

†Gill states that this difference is due to the fact that the adults emerge at any time from March to November, that is, that there is no definite period of a few weeks when they appear and lay eggs. U. S. D. A. Farmer's Bulletin, 843, p. 39 (1917).

This insect works within the wood of the tree, attacking the trunk and the larger branches. It attacks trees which are apparently sound in every way. In ordinary infestations the damage done is not particularly serious, but the borers may eat out so much of the wood, in a young tree, as to cause it to break in a high wind.

This species always leaves a hole through the bark at the beginning of its burrow. (Plate IX, fig. 3.) Through this hole it pushes out castings, rather large pellets of a yellowish, or frequently reddish color. These are very noticeable, at the foot of an infested tree, and through them attacks by this insect can always be located.

The moths appear in the spring. The work of the larvae hatching from their eggs is not apparent until the next fall, when the castings can be found under infested trees. The larvae feed till spring, then, after enlarging the entrance hole to their burrow, they pupate within it. When the moth emerges it leaves its empty pupal skin protruding from the burrow. It seems certain, at least in south Georgia, that there is one generation a year.

CONTROL.

This borer is easily controlled by injecting a little carbon bisulphide into the burrow and then plugging it with wax or even chewing gum. Some growers use a little medicine dropper for injecting the liquid, but one man who has had good success in controlling this insect uses a different method. He has his men carry with them a little vial of bi-sulphide, a small wad of cotton lint and a little ball of wax. This wax is made by melting together equal parts of beeswax and tallow. When thoroughly melted this is dropped into cold water and, as quickly as possible, is worked up into balls as big through as a quarter. Whenever a man sees evidences of borer work, he takes a bit of cotton, dips it into the bi-sulphide and pushes it into the burrow, after which he plugs the burrow with wax.

This method has been mentioned at some length because of the fact that it shows the constant care and watchfulness exercised by this grower. With both cossids and flat-heads the most important point in control is watchfulness. Every time that evidences of their

presence are seen steps should be taken, *immediately*, to eradicate them. If this is done the grower will have little difficulty in controlling these pests.

SHOT HOLE AND PIN HOLE BORERS.

This group, following the general classification as made by growers, really includes several groups of insects which are quite widely separated in their characters, habits, etc. For all practical purposes, however, the grouping is perfectly sound. The presence of all these insects is evidenced by the smooth round holes which they leave in the bark of infested trees, these holes varying in size as indicated by the name of the group. Moreover, all these insects attack only such trees or portions of trees as are dead, dying or considerably weakened by other causes. They seldom do any actual damage to a grove, being dangerous only through the fact that they may attack and kill a tree, which though in weakened condition might otherwise recover.

The principal shot hole borer is known as the Red Shouldered Shot Hole Borer.* This insect caused considerable anxiety throughout south Georgia during the spring of 1917. The adult bores into a branch or even the trunk of a young tree, usually through, or just above a leaf scar. It then forms a circular tunnel running partly, or entirely around the limb just within the woody portion. In this tunnel it lays its eggs, the young burrowing up the limb. (Plate IX, fig. 4.) These limbs are very easily snapped off at the location of the circular tunnel.

As stated above, the work of this species was very abundant in 1917, and at the time of its discovery the trees appeared to be in perfectly normal condition. Examination soon showed, however, that the infested trees suffered, invariably, from winter injury of so serious a nature that they must have died eventually from that cause alone, though at the time they had every outward appearance of perfect health.

Another species of general occurrence during the same spring was the Pecan Ambrosia Beetle,† a little beetle which makes a hole less than one-thirty-second of an inch in diameter. This insect at-

**Xylebiops (Sinoxylon) basillare* Say.
†*Xyleborinus (Xyleborus) pecanalis* Hopk.

tacks the trunk or branches, boring straight into them for a short distance and then turning up or down and following the general direction of the grain. It lays its eggs in a small chamber and the young borers, upon hatching, feed together in the egg chamber. This insect causes a greenish discoloration of the wood, especially about the egg chamber where the young larvae feed. As was the case with the shot hole borer, mentioned previously, the trees appeared to be perfectly sound, except for the work of these borers. Further examination, however, showed that they, too, were suffering from winter injury.

While an attack by any of the various species forming this group is a certain sign that the host is in an unhealthy condition, such trees or portions of trees should always be removed and burned, for the general good of the grove. In addition to this all cut surfaces, of any size, should be treated with a mixture of coal tar and creosote to prevent decay which will attract these beetles. This should be borne in mind particularly when top working trees.

THE LESSER PECAN TREE BORER.

(*Synanthedon (Sesia) geliformis* Walker.)

Two different species of clear winged moths, both related to each other and to the peach tree borers, occur on pecan. One species has been recorded by Herrick* as attacking the pecan in Mississippi and this species appears to be the one attacking it in North Carolina. The moth is deep steel blue in color with yellow bands on abdomen and legs. Gossard† found a species attacking pecan in Florida and, not finding the adult, judged it to be the same insect. We have never taken this insect in Georgia, our form producing a moth which is dark brown in color, with a bright red hind body, or abdomen. It also seems probable that this is the species occurring in Florida. Since this form is related more closely to the Lesser Peach-tree Borer, and since moreover, the name Pecan Tree-borer has already been applied to the other species, it has seemed best to call our insect the Lesser Pecan-tree Borer.

*(*Sesia scitula* Harris). Herrick, Glenn W., Miss. Agr. Exp. Sta., Bull. 86 (1904), p. 11.

†Gossard, H. A., Fla. Agr. Exp. Sta., Bull. 79 (1905), p. 299.

The life history of this species has not yet been thoroughly worked out. Moths appear over a period of at least three months in the spring, from the first of March to the last of May. They lay their eggs on the bark, and the young larvae, upon hatching, burrow inward and commence feeding in the inner layer of bark. (Plate X, fig. 1.) The insects attack trees of all sizes and may be found anywhere from a foot above ground to 15 or 20 ft. above, in the branches. They spend the winter in the larval, or borer stage, pupating during the late winter or early spring. On emerging the moth leaves its empty pupal case protruding somewhat, usually from beneath a scale of the bark. We have not been able to determine whether there are two generations a year or not.

Since the lesser pecan-tree borers eat out only a small area, especially when compared to the size of the trees, they usually do not cause any material injury. Owing to the fact, however, that they appear to congregate mainly in a few trees they may sometimes become so numerous as not only to seriously injure a tree but to girdle it, thus killing it outright. (Plate X, fig. 2.)

CONTROL.

No particular method of control can be recommended. The borers are worse on trees with rough scaly bark than on those whose bark is smooth. An occasional examination, through the winter, by removing rough pieces of bark, will usually reveal the work of these insects, if they are present, and the larva can be located and killed.

Repellant white washes have been tried to some extent but nothing of this nature has proven satisfactory thus far.

A PECAN NUT CURCULIO.*

Probably the Walnut Curculio.

(*Conotrachelus juglandis* Lec.)

For several years reports reached this office of a weevil working in pecan nuts and occasionally specimens of nuts with the characteristic weevil holes in them were sent in. These came from Putney, Ga., Thomasville and one or two places in north Georgia.

*By C. S. Spooner.

Fig. 1. Young tree, four years old, defoliated by web-worms.

Fig. 2. Nearly mature nuts attacked
by web-worms.

PLATE IX.

Fig. 1. Twig girdler; egg puncture and scarring.

Fig. 2. Twig girdler; egg. (Bark has been removed.)

Fig. 3. Cossid Borer. Entrance to burrow. (Much reduced.)

Fig. 4. Red shouldered Shot-Hole Borer. Entrance hole of adult, above bud, and channel made by young.

Fig. 1. Lesser Pecan Tree Borer and work on tree
(almost natural size).

Fig. 2. Nine year old tree practically dead from work
of Lesser Pecan Tree Borer.

PLATE XI.

Pecan Phylloxera Galls on leaves.

Not until 1915, however, were these insects observed in any numbers.

In the spring of 1915 attention was called to a Hican tree at DeWitt, Ga., well loaded with nuts which were attacked by a curculio. They showed the characteristic egg puncture with the crescent shaped slit below. Fully 90% of the nuts of this tree were attacked and fell. At the same time in other localities the same insect was observed working in the tender new shoots of pecan trees. In these cases the larvae were tunneling out the center of the shoot and caused its death. The probable reason for this difference in habit is that the Hican nuts are much earlier and larger than the pecans. They were large enough to support the young weevil larvae while the pecan nuts were not. Therefore on the pecans the insects had to deposit their eggs in the new sprouts.

The full life history of this insect has not been worked out. According to Mr. W. D. Pierce, of the U. S. Bureau of Entomology, an authority on this group, the insect probably has three broods a year in Georgia. Thus this insect can become a serious menace to the pecan industry.

The larva of this insect when attacking the nuts eats out the inner part of the nut which soon falls to the ground. The grub then bores its way out and enters the ground where it forms a cell in the earth and pupates.

Control measures have not been worked out yet, but shallow plowing at the time the weevils are in the ground in the pupal state is indicated.

THE HICKORY AND PECAN WEEVIL.

(*Balaninus caryae* Horn.)

This insect has been reported as destructive to pecans, in Georgia, only during single widely separated seasons and from very limited areas. As it might become of serious importance, however, it is well for the grower to know about it and to watch for it.

The adult is a dark brown weevil, having a very long, slender snout. The young is a white grub, like that found in chestnuts. In fact this insect is very closely related to the chestnut weevil. The adult lays her egg in the nut, the grub hatching out and feed-

ing in the nut until fall, when it bores a round hole out through the shell, goes into the ground and pupates. The adults emerge during the spring or early summer. As will be seen, it is practically impossible to tell whether an unopened nut has been attacked or not, unless the grub has left it. The egg puncture is so small that one can hardly find it.

CONTROL.

Probably the best method for controlling this pest is to fumigate the nuts with carbon bi-sulphide, using about 10 pounds to 1,000 cubic feet. It is also reported that the grub may be killed by heating the nuts to 125°-150° Fahrenheit. With either method it is necessary to gather and treat all the nuts from trees which are found to be infested. They must also be gathered early, before the grubs have entered the ground.

One severe outbreak near Thomasville, Ga., was apparently controlled by turning hogs into the grove as early as possible in the fall. At least, no other control methods were tried and the insects did not cause any injury in the grove the following year.

A LEAF FEEDING BEETLE.*

(*Diplotaxis excavata* Leconte.)

On April 16th, 1912, at DeWitt, Ga., a large number of leaves and young growing tips of pecans were found on the ground. These had been cut off by insects. For some time the cause of this trouble could not be located, but finally numbers of small holes were noticed in the ground. On examination these were found to contain a species of beetle known as *Diplotaxis excavata*. They are cylindrical black beetles a little less than half an inch long. They resemble somewhat the well known May beetles. The larvae live under ground on the roots of various plants and only the adult attacks the pecan. The injury was quite severe and had a decided pruning effect on the trees. The attack lasted about two weeks, when the beetles disappeared.

If the beetles occur in sufficient numbers to seriously affect the

*By C. S. Spooner.

trees they can be controlled by spraying at their first appearance with arsenate of lead at the rate of 3 pounds of paste, or 1½ pounds of powder, to 50 gallons of water.*

LEAF HOPPER.†

(*Empoasca* sp.)

Occasionally one notices that the leaves of pecans, especially the new tender ones, are very much curled and distorted. This is caused by small green sucking insects known as leaf-hoppers. They are very much like the apple leaf-hopper, bright green in color and about one-fourth of an inch in length.

These insects feed on the under side of the leaf. They have mouth parts fitted for sucking and pierce the surface of the leaf with their beaks, sucking the juices of the plants. This causes the leaves to curl and when the insects are numerous seriously affects the nutrition of the tree, especially young trees with few leaves.

These insects can be readily controlled by a spray of whale oil soap, one pound to two gallons of water. As this insecticide kills by contact and not by being eaten care must be taken to hit the under side of the leaves where the insects stay.

PECAN PHYLLOXERA.

(*Phylloxera* sp.)

The pecan phylloxera is a small plant louse which causes the formation of galls on the leaves and leaf stems. (Plate XI, fig. 1.) It is seldom found on old trees, but occurs quite frequently on young ones and is very common on nursery stock. It apparently does no damage in particular and up to the present no measures of control have been needed against it.

*At least one species of the true May beetle may cause serious injury of a somewhat similar nature. Such an attack was observed near Augusta, in 1917, the trees being almost entirely defoliated. (W. F. T.)

†By C. S. Spooner.

THE PECAN APHIS.

(*Monellia costalis* F.)

This is the small yellow species with the front margins of the fore wings bordered with dark brown or black, which occurs on pecans throughout south Georgia. It is accompanied by a second, somewhat smaller species* of much less common occurrence which lacks the broad, dark wing margin. This second species carries its wings over itself like a roof while the commoner species holds them flat over its back.

The aphids may first be found, in the spring, about the last of March, at Thomasville. When full grown these insects are winged and only females occur. From then on, throughout the summer and early fall, generation follows generation, all adults being females and bearing living young (parthenogenetic and viviparous). Also they are all winged. There may be as many as twenty-one such generations during a season, each female producing about thirty to forty young on the average. We have a record of one which bore 239 young.

About the middle of October young aphids are found which differ somewhat in color and markings and in general appearance from the others. These eventually grow into egg laying (oviparous) females and males. These females are without wings (apterous) even when fully grown. The males are winged but are somewhat smaller than the summer form and bear black markings on the thorax, by which they may easily be determined.

These males and females mate and the latter lay small eggs, depositing them on the trunk and main branches, under loose bark. This egg stage carries the insects over winter, the eggs hatching the following March to start another year's cycle.

Both species feed on the under surface of the leaves, apparently preferring rather old foliage to the newer and more tender growth. The insects with flat wings, and their young, are found well scattered about over the leaves, while adults of the other species are usually to be found surrounded by several young, all rather close together. This seems to be due to the fact that the flat winged species is more "nervous" than the other, not remaining in one

* *Monellia* sp.

place as long and being much more prone to jump when disturbed in any way.

These species do not appear to cause any serious damage, at present. For one thing, although they reproduce so rapidly, quantities of them are destroyed by lady beetles and their young, which swarm over the infested trees. In case of a severe outbreak the trees should be sprayed with a nicotine solution and soap.

SPITTLE INSECT.

During 1917 this insect, whose young live within small accumulations of a froth-like material, was very abundant on pecans in some localities, especially about Thomasville and Valdosta, and was the cause of many inquiries from growers in these districts.

In the spring the young feed mainly on the swollen bases of the leaf stems. Later they attack the young nuts and it is on these that they are usually to be found during the summer and early fall. It is this habit which caused anxiety among the nut growers.

Numerous observations and experiments have failed, thus far, to show any particular evidence of injury by this species. In our experiments, nuts fed on by the insects were no more liable to fall than were those which were free from attack. Consequently, the presence of this species need not cause any uneasiness and no control measures are needed.

PECAN SCAB.

(*Fusicladium effusum*.)

BY C. S. SPOONER.

Pecan scab is the most serious disease affecting the pecan. It is caused by a fungus which enters the tissues of the leaves and nuts and seriously affects their development. Its presence may be recognized by small black pustules on the surface of both leaves and nuts. The pustules are about 1-18 of an inch in diameter and may be so numerous as to practically cover the entire surface. The pustules contain the spores of the fungus and it is by means of these spores that the disease is spread. They escape from the pustules and lodge upon fresh surfaces where, in the presence of moisture they germinate, enter the tissue and develop into the fungus which in turn develops new pustules and spores.

When the disease is confined to the leaves it does not seriously affect the health of the tree, but when it attacks the nuts it does affect the development of the nut. It causes the nut to drop off or reduces its size according to the abundance of the fungus.

Susceptible and Immune Varieties.

There is a great difference in the susceptibility of the different varieties of pecans to scab. Some are apparently entirely immune, others are attacked very slightly, showing scab spots on a few nuts which are growing close to the trunk or heavily shaded by the branches, while others are very severely attacked so that few if any nuts escape injury. This is strikingly shown by trees of different varieties growing next one another. On one the whole crop will be diseased, while on the other no trace of the disease will be found. There is also apparently a sectional difference in the degree of susceptibility to scab. For example, in the Thomasville district the Delmas scabs badly; while in the Albany district it is quite free from disease. In Florida the Van Deman is reported as scabbing badly, while with us it is only slightly affected.

The varieties which are most subject to scab with us are, Georgia, San Saba and other Texas varieties, Capitol, Delmas and many seedlings. Seedlings are usually very severely injured by scab.

Van Deman, Schley, Alley, Halkert, Mobile scab to a slight degree, but not enough to warrant uneasiness. Scab has also been recorded as occurring on Stuart and Jewett to a slight extent.

Present indications show that Money-maker, Russell, Stuart, Schley and Alley are among the better known varieties which are safe to plant from the standpoint of scab.

Seasonal Difference.

There is a great seasonal difference in the severity of scab. Very wet seasons promote the growth of the fungus to a great degree. One season has been observed by the writer in which practically every Georgia nut in one grove was destroyed by scab before the season was half over.

On the other hand in very dry seasons the loss is hardly noticeable, when the nuts are so lightly attacked that the greatest injury is shown by the presence of many under-sized nuts. Between these two extremes the amount of damage will vary according to the season.

Remedial Measures.

The aim in spraying for Fungus Diseases.

In discussing control measures, the underlying principle of spraying for fungus diseases of plants should be remembered. The fungus is spread through the air by means of very minute spores. These lodge on leaves and nuts and there remain dormant until they come in contact with moisture. Thus after a rain, when the leaves are still wet the spores germinate and send a small thread into the tissue of the plant. The fungus then develops rapidly.

The object of the spraying is to have the poison on the leaves when the moisture comes so that the presence of the poison in the water will kill the spore before it has time to germinate. Therefore a spray applied before a rain is infinitely more effective than one applied afterwards.

The Choice of a Fungicide.

A fungicide is a chemical combination applied to a plant for the purpose of controlling or destroying fungi which attack the

plant. There are several fungicides which give excellent results in combating other fungus diseases and several of these were tried on pecans to determine which was the most effective against the scab.

Atomic sulphur was applied on one block of trees at the rate of seven pounds to fifty gallons of water and to another block at the rate of five pounds to fifty gallons of water. No beneficial results whatever were observed.

Lime sulphur (Commercial) was used at the strength of one gallon to thirty gallons of water and one gallon to fifty gallons of water. Both of these strengths burned the foliage quite severely and did not control the disease. Some slight benefit was noticed, but because of the severe burning this fungicide was abandoned.

A winter spray of lime sulphur at the strength of one gallon to ten of water, was applied January 22nd. No benefit was seen from this treatment. The trees which had received this treatment together with some which had not received it were later sprayed with Bordeaux Mixture. No difference in the results was obtained on the two blocks.

Bordeaux Mixture was used at strengths of 3-3-50 and 5-5-50. The results with the two strengths did not differ so that the 3-3-50 formula was used. This fungicide was used in many experiments. A differing number of sprays was applied and in many cases good results were obtained. Following is a summary of the experiments:

In 1912 Bordeaux was used on only one tree. Most of the work of this year was confined to atomic sulphur and lime sulphur. As shown above, these two fungicides were unsatisfactory and were abandoned. The one tree sprayed with Bordeaux gave some evidence in favor of this fungicide and it was tried extensively in 1913-1914.

The experiments in 1913 were carried out with Bordeaux Mixture at the strength of 3-3-50. The trees were divided into five blocks and treated as follows: Block C was left unsprayed as a check on the other blocks. Block A was sprayed April 18th and June 3rd. Plot D sprayed March 17th, April 18th and July 16th. Plot E sprayed March 17th, April 18th, June 3rd and July 16th. Plot F sprayed April 18th, June 3rd, July 16th.

In getting the following percentage the drops which showed

PLATE XII.

Fig. 1. Eight year old tree suffering from a severe attack of Rosette.

Fig. 2. Healthy eight year old tree in same grove. Tree shown in Fig. 1 is indicated by arrow.

PLATE XIII.

Fig. 1. Diseased kernels, showing appearance of Kernel Spot.

Fig. 2. Brown Leaf Spot. Moderately severe infestation.

Pecan scab (*Fusicladium effusum*).

PLATE XV.

Spraying pecan trees with gasoline sprayer (using tower).

scab supposedly would have matured if it had not been for the scab, so that these together with the matured nuts were taken as the normal crop. A careful count was kept of all drops and those showing scab were counted separately. The number of the drops showing scab divided by the total crop would give the percentage of the crop affected by scab.

In Plot C, unsprayed, 72% of the crop dropped because of the scab.

Plot A, two sprayings April 18th and June 3rd, lost 15% of the crop.

Plot D, sprayed March 17th, April 18th, July 16th, lost 29% of the crop.

Plot E, sprayed March 17th, April 18th, June 3rd, July 16th, lost 20% of the crop.

Plot F, sprayed April 18th, June 3rd, July 16th, lost 24% of the crop.

It will be seen that all of the sprayed plots showed a distinct improvement over the unsprayed. The plots varied somewhat in unexpected ways, as is shown by Plot A having a better percentage than Plot E, although the latter had two more sprayings. This was caused partly by the variations in the size of the crop on different trees and other factors which could not be controlled. It also shows that the two sprays, applied April 18th and June 3rd, were the most essential ones in the control of the scab. There can be no question but what it paid to spray these trees.

The year 1914 was very dry and while extensive spraying experiments were carried on the results are very hard, if not impossible, to tabulate. The scab showed up very late in the season, July 11th being the date when it was first observed and then very little of it was found. For this reason the damage to nuts, sprayed or unsprayed, was very slight. No difference could be found in the number of drops caused by scab because there were so few of them either on the sprayed or unsprayed trees.

A very decided difference could be observed while the nuts were on the trees, however. On the sprayed trees the nuts showed much less scab than those on the unsprayed trees and they ran larger and better. While these experiments did not materially improve the crop they showed again that Bordeaux would control the scab to a great extent. They showed no material benefit because

the season was so dry that spraying for this disease was not necessary.

It will be seen from the above experiments that while no complete control was effected, a very considerable amount of good was accomplished by the spraying, especially in 1913, which was a fairly wet season. An increased number of sprayings in wet seasons would unquestionably give greater control.

No set rule can be given as to the dates of spraying. Each season will be different. The grower must be governed by the amount of rainfall each year. It is well to apply a coat of the spray soon after the nuts are formed. Subsequent sprayings can then be determined later. The trees need not be sprayed during a long, dry spell, but in wet weather spray every ten days or two weeks.

Too much emphasis cannot be laid on the necessity for thorough spraying. A careless, hit or miss application costs as much to apply and uses as much material as a good, thorough job and the results are widely different. In many cases where statements are made to the effect that spraying did not control the disease it can be shown that the spraying was not carefully done.

Be sure to hit every leaf. If necessary it will be worth the time of a reliable man to go with the spraying outfit to see that the spray is properly applied.

Preparation of Bordeaux Mixture.

Bordeaux Mixture must be properly made to be effective. It will therefore be well to give instructions for those who are unfamiliar with this Mixture. Bordeaux Mixture is made from copper sulphate, lime and water. The formula 3-3-50 means that three pounds of copper sulphate and three pounds of lime are used to fifty gallons of water. Each ingredient should be mixed separately with a little water and then each is poured in a separate barrel and enough more water added to make twenty-five gallons of each solution. These are then poured together into the spray tank. Barrels placed on a platform and connected up as shown in the figure make a most convenient outfit for mixing Bordeaux.

The lime should be unslacked. If old air slacked lime is used the resulting mixture is liable to seriously burn the foliage. Hy-

drated lime, if readily obtainable, is the most convenient to use as it is more easily suspended in the water.

If much of the solution is to be used it will be found best to tie the required amount of copper sulphate in a sack and suspend the sack near the top of a barrel of water. This should be done the evening before spraying. It will have all dissolved by morning. The required amount can then be dipped out as needed.

Top Working to Immune Varieties.

The question is often asked if it would not be best to top work scabbing varieties with immune varieties. In young groves this is undoubtedly the best thing to do. Of course, it is not policy to plant scabbing varieties in groves. However, in large, bearing groves each grower must decide for himself, whether he would prefer to spray or to top work his trees with the resulting curtailment of his crop for several years. As to the expense concerned, it is a question which is better. Over a long term of years, the top-working, if successfully done, would be the cheaper.

PECAN DISEASES OTHER THAN SCAB.

BY C. G. CRITTENDEN.*

PECAN ROSETTE.

IMPORTANCE AND SYMPTOMS.

Pecan rosette is considered by growers of pecans, to be one of the most serious diseases with which they have to contend. It makes its first appearance in a tree through the putting out of mottled yellow leaves which are usually more or less wrinkled and undersized. It may appear over the whole tree at once, but often affects one branch long before it shows up in the rest of the tree. The affected branches are stunted and fail to grow the usual length. This shortens the distance between the leaves and thus forms a "rosette." A tree lightly affected one season may not show the disease the next season. However, trees badly affected seldom recover. If a tree is badly affected the branches usually die back from the tips, either the first season or later. In some cases, this dying back may go so far as to kill the tree. More often, however, it does not go that far. In the spring new branches come out at the base of the dead branch, and these in turn die back, so that the final result in the case of a tree badly rosetted for years, is a gnarled unsightly dwarf. (Plate XII, figs. 1 and 2.)

NATURE OF THE DISEASE.

Rosette is neither a fungus nor a bacterial disease, but is what is termed a physiological disease and is, probably, the result of some defect in nutrition. Orton and Rand† have shown that it is due to some unfavorable condition of the soil. When they transplanted trees into holes from which rosetted trees had been removed, a large proportion of these healthy trees became rosetted and if the transplant was reversed and rosetted trees were planted in places from which healthy ones had been removed, a large proportion of these diseased trees recovered. These investigators also found that budding or grafting healthy buds or scions on rosetted stocks gave rosette in the scion and conversely that working buds or scions from rosetted trees onto healthy stocks produced healthy trees.

*Formerly pathologist with the Georgia State Board of Entomology.

†Orton, W. A., and Rand, F. V. Pecan Rosette. Jour. Agr. Res. vol. 3, No. 2: pp. 149-174, 1914.

The disease is non-parasitic and non infectious and is the result of some unfavorable condition in the soil.

CONTROL.

No method for curing rosetted trees can be recommended. Trees which are badly diseased should be removed and replaced by healthy trees. Many of these healthy trees are likely to become rosetted, but some can be depended upon to remain healthy, others will not be as badly affected as those removed, while some, probably, will be as bad as the old trees.

All rosetted nursery stock should be discarded and only thoroughly sound stocks used for budding or grafting.

In selecting a location for a grove, choose a good fertile soil with a clay subsoil. Avoid a sandy subsoil and do not plant a pecan tree where no other crop will succeed.

BROWN LEAF SPOT.

(*Cercospora fusca* Rand.)

The brown leaf spot is the most prevalent and most conspicuous leaf disease of the pecan. It probably occurs wherever the pecan is grown. The loss occasioned by the disease is difficult to estimate, as only the leaves are affected. In severe cases there may be considerable defoliation of the trees.

Different varieties of pecan show little or no difference in susceptibility to the disease.

SYMPTOMS.

The disease first makes its appearance on a leaf as a small dark brown irregular spot with an indefinite outline, which extends through the leaf and is visible on both surfaces. There may be many of these on one leaf. The spot increases in size and often reaches a half inch in diameter, and the larger ones sometimes become light brown in the center. (Plate XIII, fig. 2.)

CAUSE OF THE DISEASE.

Brown leaf spot is caused by a fungus, the threads of which penetrate the leaf. When the spots are from five to six weeks

old, club-shaped spores of the fungus are produced, usually on their upper surface. These spores may be carried by wind to other leaves where they produce new spots. First infections appear in early summer and the disease continues to spread throughout the summer and till fall.

CONTROL.

The disease is usually not severe enough to make it profitable to attempt to control it. It may be prevented by thoroughly spraying the trees three times with Bordeaux mixture. The first spray should be applied soon after the trees are fully leaved out. The second and third should follow at intervals of three to four weeks.

KERNEL SPOT.

(*Coniothyrium caryogenum* Rãnd.)

Up to the present time this disease has been given little consideration, either by pecan growers or by workers on pecan diseases. The loss occasioned by the disease has hitherto been small, only occasionally on a single tree or in small groves here and there has it been reported serious. However, the disease appears to be spreading and the damage increasing. During the season of 1916, serious loss was inflicted on some growers in the vicinity of Thomasville and Cairo. One Thomasville grower sold his crop of Schleys, which were damaged by kernel spot, for 25 cents per pound when prices for good Schleys ranged from 50 to 60 cents.

SYMPTOMS.

As the name implies, the disease affects only the kernel. It can be detected only after the shell is removed. The spot on the kernel is irregular in outline, dark brown or black and usually somewhat sunken. It is about $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. (Plate XIII. fig. 1.)

When the kernel is cut the brown diseased area is found to extend into the meat to a depth of perhaps $\frac{1}{8}$ of an inch. The diseased spot is bitter and imparts a bitter flavor to the rest of the meat.

CAUSE OF THE DISEASE.*

Kernel spot is caused by a fungus. This has been proven by Rand, of the U. S. Department of Agriculture. The life history of the fungus is not very well known. As far as is at present known it affects only the kernel. When an affected kernel is placed under moist conditions pycnidia or spore bearing bodies are formed by the fungus. Inside the pycnidia are produced the spores which are the means of reproducing the disease. At what time or just how infection of the kernel takes place is not known.

CONTROL OF THE DISEASE.

No efforts have thus far been made to control the disease and no specific method can be given at this time. However, there are certain measures which can be recommended as giving promise. - As previously stated, so far as is known, the disease affects only the kernel of the nut. If this is true then removal from the orchard or destruction of all nuts in the fall should reduce the amount of disease the following year.

Some varieties seem to be more susceptible to the disease than others. The Schley appears to be most seriously affected and Success and Curtis are probably more susceptible than others.

OTHER DISEASES OF PECAN.

NURSERY BLIGHT.

(*Phyllosticta caryae* Peck.)

This is a fungus disease which is confined almost entirely to the nursery, where it often does considerable damage. Only the leaves are affected. "Generally the first indications of infection appear in the form of minute roundish spots which are dark reddish brown on the upper surface and blackish on the lower. These slowly increase in size until a diameter of 2 to 5 mm. ($\frac{1}{4}$ - $\frac{1}{2}$ in.) is often reached in the individual spots. With increase in size the center of the spot on the upper surface assumes an ashen gray color,

*Investigations conducted during the season of 1917 seem to indicate that the Green Soldier Bug (*Nezara harris*) is a very important factor in the production of this disease. We have not been able to determine, absolutely, whether the spot is caused by a fungus which is carried by the bug, or whether the spot is directly due to the feeding of the bug. This bug is the insect frequently called a "pumpkin bug" which occurs very commonly on cow peas. (William F. Turner.)

which is usually bordered with reddish brown, while the lower surface remains black throughout or with an occasional tiny ashen-gray spot in the center of this dark colored area.'''*

CONTROL.

Spray with Bordeaux mixture four times. Begin spraying as soon as the trees are fully leaved out and repeat at intervals of three to four weeks.

ANTHRACNOSE.

(*Glomerella cingulata* (stonem) S. V. & S.)

This disease affects both the leaves and the nuts. The affected spots on the leaves are irregular in outline and grayish brown. They vary in size and sometimes cover a whole leaf. Leaves badly affected usually fall to the ground. On the nuts the disease produces black sunken spots which are irregular in outline and sometimes causes a heavy drop of half grown nuts. The disease is caused by a fungus. No method of control can be given at the present time.

CROWN GALL.

(*Bacterium tumefaciens* (S. M. & Town.)

This disease is rare on the pecan. When present it produces swellings or galls on the tree trunk below the surface of the ground. It is produced by the same bacteria which causes crown gall of the peach, apple, etc.

CONTROL.

All nursery trees found to be affected with crown gall should be discarded and destroyed.

MILDEW.

(*Microspheera alni* (Wallr) Wint.)

Mildew is more or less common on the leaves and nuts of the pecan, occurring most often on the lower shaded branches of the tree. It produces a white powdery covering often involving the whole surface of a nut. The mildew produces little or no damage and can be ignored.

*Rand, F. V. Some diseases of pecans. Jour. Agr. Res. 11, No. 4: pp. 303-337, 1914.

**LIST OF AVAILABLE PUBLICATIONS,
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