THE LOCUST BORER

(Cyllene robiniae)

AND OTHER INSECT ENEMIES OF THE BLACK LOCUST

BY

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Agricultural Experiment Station

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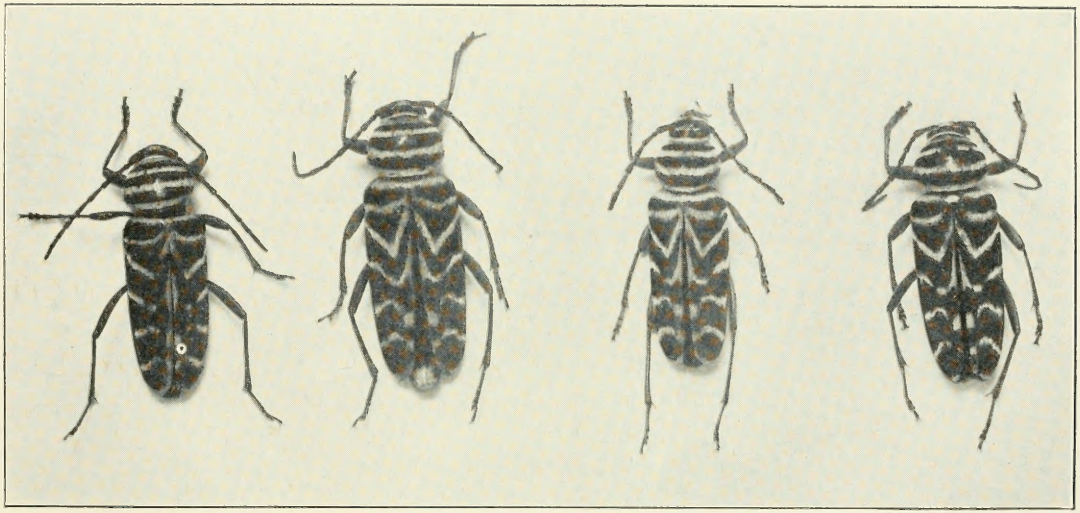

Fig. 1. Adult locust borers (X 2).

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By H. Garman,

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The most serious handicap to the successful growing of black locust is the attacks of an insect belonging to the family commonly known as long-horned wood borers and in entomological writings as Cerambycidae. Its family contains many troublesome pests, mostly attacking trees of different sorts by boring in their trunks. The round-headed apple tree borer *(Saperda candida)* is a similar insect; the elm borer *(Saperda tridentata)* is another; the basswood borer *(Saperda vestita)*, still another. The cane borer of blackberry and the twig girdler, together with numerous other species, all represent the same family of insects as the one here treated. They are among the most difficult of insects to deal with, and represent to the forester what the chinch-bug, Hessian fly, cutworm and army worm do to the grower of field crops. Few of our native trees are entirely exempt from the attacks of one or another of these borers. But the black locust borer is in this State perhaps the most numerous beetle of its family. In the fall of the year the adults become common on certain flowers. None of the other wood borers in any situation is quite so numerous, although a red and black one is often seen about the flowers of milkweed and is an exception to the rule in the family as to its habits, attacking the stems and roots of milkweed instead of those of woody plants.

The adult locust borer is an active, slender, black beetle about 0.60 inch long, which may be found in September and October on the flowers of the common goldenrods, upon which it feeds. It is black, with a number of cross bands of yellow, one of those on the middle of the back being W-shaped. There is only one other beetle likely to be mistaken for it and this is the Hickory Borer (*Cyllene pictus*), which does not however frequent goldenrod, and comes out as an adult in the spring of the year. My figure, together with these statements, will enable any one to recognize the locust borer, and a more detailed description may be left for another section of this account. The beetles themselves do no harm to locust trees, and are not often observed about the trees unless one looks for them during the period of egg laying. The mischief is done by their young, legless, white grubs, with brown heads and strong jaws, which bore into the trunks of the trees.

Nature and Extent of the Injury.

The burrows made by the grubs occur anywhere on the trunks of the trees from the ground up to the branches, and, contrary to my impression when I began to study their habits, extend out on the branches to where these are an inch and a half or thereabouts in diameter. It thus proves that no part of the tree above ground is free from attack except the new growth and the more slender branches. Trees may show dozens of the burrows, made at different seasons, so that neglected ones finally become riddled with burrows, though those of individual grubs remain independent commonly. The direct damage is severe enough to render trees worthless for posts, but if it were not followed by decay, might not result in the destruction of the trees. As a matter of fact, but few trees are killed outright, though they lose their branches, become knotted and stunted and simply remain breeding places for the beetles. Many trees kept about premises for shade are now in this condition. The locust is a very hardy tree, and even with its heart wood largely gone as a result of water admitted by the borers, it will stand for years, giving rise each season to a score or more of the beetles. The seriousness of the damage done becomes

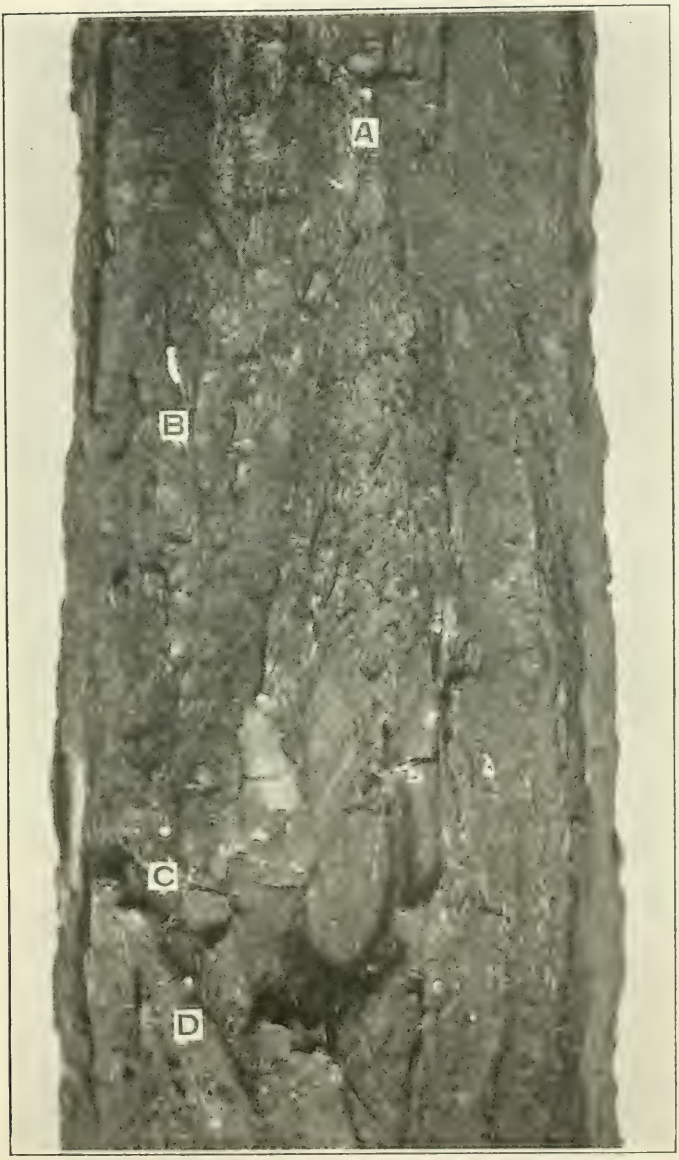

Fig. 2. A, B, C, and D, eggs of the locust borer, as they appear after being thrust by the beetles into crevices in the bark (X 2).

more apparent to the man who tries to raise locusts for posts, or who buys posts and wants sound ones. With several burrows reaching in toward the center of a post in every foot or two of length, the life of a post is bound to be greatly shortened by decay, and the grower finds his profits cut down because of his inability to furnish sound posts.

There is no part of Kentucky, apparently, in which the borers are not present, and their numbers are in proportion to the abundance of locust trees. In Bluegrass Kentucky they are exceedingly common, and this statement applies to all that territory about Lexington, Paris, Covington, Frankfort, Shelbyville, Louisville, and westward to the Mississippi River, with locust in some southern counties, for some unexplained reason, less injured than they are along the Ohio River. Eastward the injury becomes somewhat less also, and the adult borers are less often seen on the goldenrod. I have visited no part of the State, however, where the adult beetles were not found if the visit was made during the time when they are abroad, and my search for them this fall in mountain counties, where they are least common, showed them to be present in small numbers there.

Their local scarcity thus appears to be a matter of scarcity of the trees, and seems to be the condition that prevailed when the locust was only found growing wild in the forests. The planting of trees for shade about premises and along roadsides has doubtless been followed by a great increase in their numbers. Any general tendency to grow trees in a commercial way for posts is thus likely to be followed by a still further increase in the number of beetles unless we can find a means of lessening their numbers. The outlook appears unpromising, but I am stating the facts, since these are the only basis upon which success in producing locust posts can be based. If we cannot get rid of this injury, it is useless to talk of growing sound posts for the market.

Injury to Locust Plantings Made for the Production of Posts.

Already a few enterprising men in the State have started plantings with the object of producing posts, and part of these trees have now been examined by us to

learn if possible the conditions under which injury is most severe. The trees will grow almost anywhere, a peculiarity which gives them an advantage over catalpa and other forest trees which might otherwise compete with them for favor. The poorest clayey hill will produce locust very well, whereas the planting there of catalpa would be a waste of time and money. As a matter of fact, black locust gathers nitrogen from the air and thus improves poor soils where other trees would deplete them. But poor land in which some of the Kentucky plantings have been made, is also likely to be surrounded by neglected land, and on neglected land the rank growths of Solidago (goldenrod) in the fall of the year furnish forage for the beetles. The injury is thus sometimes severe on such land, not because the trees are less well adapted to it, but because the other conditions favor the beetles. On good land with the surrounding region in close cultivation *the beetles are at a disadvantage in getting food during the period when they are out of the trees.* The fact here stated I consider one of the important ones learned by a study of the insect. It will be dwelt on later in discussing the food habits of the beetle.

The Owenton Planting.

One of the largest plantings known to me is located at Owenton in Owen County. The tres grow here naturally in perhaps as large numbers as anywhere in the State, and the conditions for growing trees in a commercial way are exceptionally good, excepting for the depredations of the beetles. Col. R. C. Ford has at his place perhaps a hundred acres planted in locusts. Some of the trees are now of a size suitable for fence posts, others are smaller, the range in age being from one to six years. The land is poor, badly washed and gullied in places, though the plantings have in part been made to stop this cutting up of the surface and the accompanying rapid washing away of the soil. Col. Ford thinks the trees have more than repaid the cost of planting in checking this removal of the surface.

Nearly all of the trees were found badly infested July 28-30, when examined by Mr. Jewett, of the Division, the older trees having suffered most. Isolated trees and

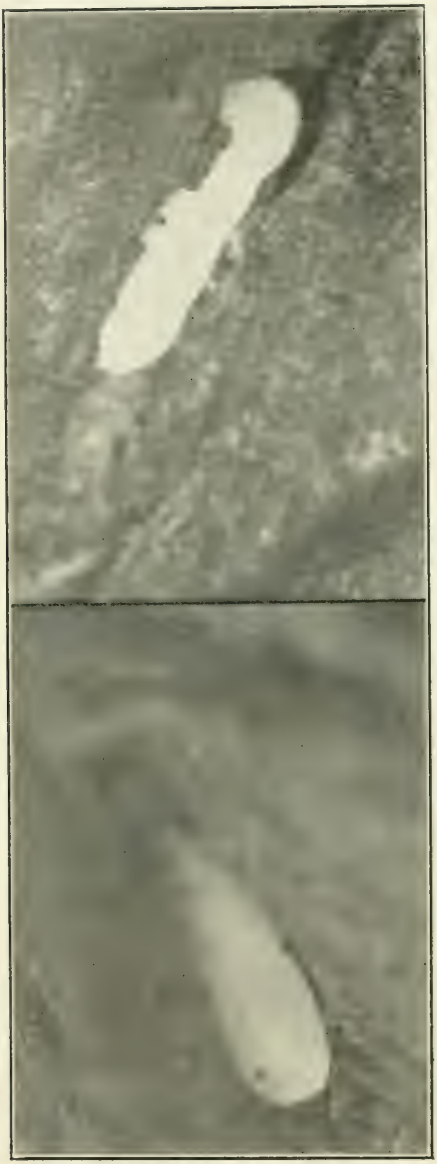

Fig. 3. Two eggs, greatly magnified (X 18), in crevices of bark.

clumps growing along roadsides had suffered with the rest, and it was evident that the beetles had concentrated in the vicinity as the trees became numerous. Some difference in favor of trees growing near the bottom of slopes was noted, due probably to the better soil, which kept the trees in a better condition to withstand attack.

Some dead trees were noted, the result of drought, borers, and poor soil combined, but probably few or none were actually killed by the borers, though many of the trees showed dead branches which had evidently been killed by the insects. Trees which had been cut for posts were badly damaged by the burrows.

Trees from three to five inches in diameter were in every case damaged by borers. Those from two to three inches in diameter of trunk were less injured, the percentage being about fifty per cent. The youngest trees, of a season's growth, showed no injury and were thrifty in appearance. The instinct of the beetles seems thus to warn them that the seedlings are too small to afford sustenance to the larvae.

The young cut out of the trees at Owenton were well advanced in development, and the condition of the burrows showed that they were approaching the period of pupation. The holes always cut by the larvae just previous to becoming pupae had in some cases been made, from which it appears that the condition was much like that at Lexington at this time.

Other insects were doing little injury to these trees. The bag worm (*Thyridopteryx ephemeraeformis*) was common. Some leaf hoppers were collected. Leaf miners had been working on the leaves, but had at the time left their mines.

The Shelbyville Planting.

On August 14, 1914, a planting occupying about twenty-five acres of ground, and another of five acres, were examined on the premises of Mr. Frazier. The larger planting was twenty-seven years old, the trees ranging from five to eight inches in diameter of trunk, while those of the younger planting averaged about four inches.

The land was very badly gullied when planted, but at the present time the gullies are largely obliterated

through the influence of the trees, and has undoubtedly been improved by their presence otherwise. The only other trees noted in the neighborhood were scattered trees along the roads.

These trees appeared to be in much better condition than those examined at Owenton. The foliage was of good color and no dead trees were seen, though dead branches were sometimes observed on trees by the roadsides. Very little evidence of the presence of borers was found and the damage done seems not to be very severe. Fence posts were cut from the planting in 1913 to the value of $1,200, and were only slightly damaged.

The reason for the immunity of these plantings as compared with others we have examined was not apparent and is yet to learn.

Young of the beetle taken from trees were changing to pupae or preparing to do so. The exit holes had been cut in the majority of cases, and the plug of shavings placed in the burrow above the insect.

Plantings at Morganfield, Union County, October, 2, 1914.

Mr. G. L. Drury at Morganfield has a planting occupying several acres which, with numerous trees growing in the vicinity, was examined October 2, 1914, by Mr. Niswonger. The region, like that at Owenton, seems exceptionally suited to black locust, and trees were found everywhere along roadsides, fence rows, creeks, etc. A small planting examined at this place appeared to have been completely killed by the insect, with the exception of the larger trees. On Mr. Drury's place the trees, averaging about three inches in diameter of trunk, were severely injured, some of them killed.

At Waverly, Kentucky, a planting of about seven acres was examined on the place of Mr. H. A. Roberts. The trees were planted in 1887 and ranged from six to eleven inches in diameter of trunk. The larger trees seemed to be little injured, but the young ones showed the exit holes made by beetles. Dead trees, of which a few were observed in this planting, appeared to have been injured by other agencies than the beetles. This planting had been grazed by sheep.

The adult beetles were found to be common on goldenrod in the locality, sometimes at a distance from trees, in one instance a half mile from the nearest observed tree. All about the small two-acre planting on Mr. C. F. Morehead's place, noted above as very badly injured, goldenrod grew in profusion and some plants were scattered among the trees. In fields and along roadsides also goldenrod was excessively common, and everywhere harbored large numbers of beetles. On the trees the beetles were ovipositing, and eggs were found hatching, while others had already given up the young. This was at eleven o'clock in the forenoon. About Mr. Drury's place, also, the goldenrod grew everywhere in adjacent fields and along roadsides. At 2:30 p. m. the beetles were noted running up and down the trees looking for places to conceal their eggs. At the same time large numbers were about the flowers, many of them mated.

On Mr. H. A. Roberts' place at Waverly the injury appeared to be less than in other plantings, a condition explained perhaps by the fact that his land was kept clear of weedy growths and the locust planting itself had been grazed by sheep. Few beetles were observed here, and very few goldenrod plants, a condition the reverse of the others examined about Morganfield.

Small trees planted at one edge of his farm had, however, been badly injured and in their vicinity golden rod was common. Both trees and flowers bore numerous beetles at the time of Mr. Niswonger's visit.

St. Bernard Coal Company Plantings, at Central City, October 3 and 4, 1914.

At Central City several plantings, from a few acres to sixty in extent, were found to agree in general with those already mentioned. The beetles had done most mischief where goldenrod was most numerous and the injury diminished even on parts of one planting as the goldenrod became less common. A section near the railroad where goldenrod continues from year to year had been largely killed by the beetles and hundreds were observed on the flowers, twenty-five beetles being counted on one small clump of plants. The adults were observed

to be mating at eleven o'clock in the morning; eggs just hatching, others that had hatched were found, sometimes on dead trees.

A forty-acre planting at this place was found to correspond with those inspected elsewhere, in that where the open spaces occurred in which goldenrod was established the injury was always worst and in isolated sections where there was no goldenrod the trees were nearly perfect.

A LaGrange Planting.

October 6, 1914, a planting of two thousand black locusts at LaGrange was examined. It had been killed by fires. The trees were planted in 1903 and in some cases had a trunk diameter of four inches, though mostly less. The planting was badly infested with goldenrod, about half done blooming, upon which were found some beetles. A few mating beetles were noted (3-5 P. M.), and females were observed looking for places to deposit their eggs, on partly dead trees. The dead trees observed showed numerous marks of infestation.

Summary of Examinations Made in 1914.

While the beetles fly like bees when disturbed and travel some distance to find food, it is evident from the work thus far done that there is a relation between the abundance of goldenrod and the prevalence of injury. Wherever a planting adjoins land on which goldenrod is exceptionally common the injury is severe. Wherever the planting is away from growths of goldenrod the injury is proportionately less. The insects certainly do most harm where the food plant upon which the beetle depends is most numerous, and this suggests the possibility of controlling the injury to a great extent by destroying this plant whenever it is seen in the vicinity of locust trees.

The Food Plants of the Adult Borer.

The important relation sustained by the goldenrods to locust injury in Kentucky led me to observe these plants more closely in 1915, with a view to learning what

species was most resorted to by the beetles. From the examinations made in 1914 it began to appear that one species of plant *(Solidago altissima)* furnished most, or all of the food taken by the adult beetles while their eggs were maturing. This has proved true in great measure as a result of observations made in 1915. The period during which the insects are out of the trees corresponds with remarkable closeness with the period of blooming of this common species. The beetles may be said to depend upon it for food. But, contrary to my first impression, they are not restricted to it. We have a species *(S. canadensis)* bearing a close resemblance to *S. altissima,* but with smaller heads of flowers and an earlier period of blooming, upon which the beetles first to emerge were found. But they were few in number, and the plant evidently is not an important forage for the insects, excepting as it may tide over the early maturing beetles until the more acceptable plant is in bloom. Still another species besides *S. canadensis* was observed to have attracted a beetle at Corbin, Kentucky, this fall, and a cultivated species with broad leaves *(S. rigida?)* obtained from the Henry Dreer Seed Company of Philadelphia, and kept during the past season at the Conservatory of the Division, attracted a few beetles. So it is evident that they get some food from other species of goldenrod at times, and would probably resort to any of the species in the absence of their favorite. I had supposed they were restricted for food to the genus Solidago, but this also seems not to be true. On one occasion at Lexington, Mr. Jewett, of the Division, found a beetle on a native plant with white heads of flowers *(Eupatorium serotinum).* It grows in wet ground about ponds and is one of the Joe-Pye weeds and a member of the same botanical family (Compositae) as the goldenrods. I have myself several times taken the beetles during the season of 1915 from another species of the genus *(Eupatorium perfoliatum)* known as Thorowort or Boneset. It also has white flowers. These plants are, however, not as generally scattered about fields as are the goldenrods and are thus of much less importance as food for the beetles. Their time of blooming comes very close to the period of emergence of the beetles.

I have had it reported to me that the beetles visit the flowers of the Marigold, an old-fashioned flower of our gardens. The statement seemed so contrary to what we know of the insect that I wished to verify the observation and see to what extent this exotic attracted these native insects. With this in view I had planted a number of varieties, both African and French, dwarf and tall, in a plot of ground near the Conservatory. They made a fine growth and produced a great wealth of flowers. Several species of Solidago were planted near them and a short distance away were some young locust trees to which some beetles were attracted. Adult beetles were present on the goldenrods throughout most of the period when the insects were abroad. I examined the marigolds repeatedly and did not find a single beetle on the flowers. Such beetles as visit these plants must, I think, be strays that have alighted during their wanderings in search of locust trees or of goldenrod.

In brief, the important food plant of the adult locust borer is one species of goldenrod, the *Solidago altissima*, already mentioned. Wandering beetles may alight on the flowers of other plants at times, but with the exceptions noted above this appears to be only temporarily. Asters and other flowers which were common in the immediate neighborhood of goldenrod this season were visited by large numbers of other insects, but in not a single case was a locust borer noted about them. On the other hand, any isolated clump of *Solidago altissima* was likely when in full bloom to be visited. A small clump in my yard was generally frequented by several of the beetles, day and night, during September.

The Food and Feeding of the Adult Beetle.

The activity of the beetles about the flowers of goldenrod at once arouses one's curiosity as to what they get from the flowers, and why it should be necessary for them to feed so constantly after they emerge from the trees. They are as industrious as bees and almost as active, eating away steadily, but dropping to the ground, or taking wing quickly, when approached. An examination of the contents of the alimentary canal throws light on this subject: The part of the flower eaten is the pollen,

Fig. 4. A number of eggs deposited under the bark in an old excavation (X 3).

and they are thus rivals of the bees in collecting this nutritious food. The beetles mature but slowly after they cast the pupal skin in their burrows, and remain for a long period without food, the body white and soft, the colors gradually appearing and the crust becoming harder, until about the time the goldenrod begins to bloom, the first ones come out, the numbers rapidly increasing until in late September when they may be found wherever there are *locust trees and goldenrod.* Without the two, one to provide food for the larva, the other for the adult, this insect would probably not long continue abundant.

It seems to me, therefore, that the general destruction of goldenrod in the vicinity of locust plantings will lessen the injuries of the beetles, if it does not entirely prevent it. For it is evident that this plant furnishes the stimulating food necessary for the development of the eggs of the female; and as a matter of fact I find that beetles confined without food of this character soon die, while those provided with it live and place eggs on the bark of sections of locust trees furnished them.

Life-history of the Locust Borer.

After mating, the beetles begin to resort to the locust trees for the placing of their eggs. Eggs may be found on the bark of trees about the middle of September. In 1914, they were found in some numbers September 17. The females run up and down the trunks and larger branches, searching for suitable crevices in which to hide the eggs, generally placing them well under loose bark, but often leaving one end, or in some cases the larger part of the length exposed. They are scattered about indiscriminately anywhere on the trunk and larger branches, and may be found on some of the latter which are only an inch and a half in diameter. The greater smoothness of the bark on small branches seems to deter the placing of eggs to some extent, and the majority are ordinarily found on the trunk where they can be better concealed. Sometimes a half dozen or more eggs may be placed close together, as shown in one of my figures. By September 22, egg-laying is most

active, and in the middle of the day numerous beetles can be seen running about the trees engaged in this task.

Eggs were observed hatching on September 25, but the beetles were still numerous on goldenrod and continued so until the middle of October, and eggs were observed hatching as late as October 1. Many eggs are placed on trees subsequent to this date, however. On October 4, 1914, near Versailles in Woodford County, I found beetles still common on goldenrod, and from 11 A. M. until 1:30 P. M., observed them placing their eggs on the trunks of locust trees.

They were observed again October 22, 1915, near Frankfort, on goldenrod, but were less common at this date than in 1914, because of a couple of early frosts which had destroyed most of the goldenrod.

As soon as hatched the young grub bores into the outer bark, throwing out refuse as it burrows, so that the point of entrance can generally be detected. It does not go very deep in the fall of the year, simply penetrating the outer bark and making a small oval cavity next the wood where it ceases boring and lies torpid during the winter months. Some of the burrows at this stage are represented in one of my figures.

With reference to the condition in which the young borer passes the winter, the following entries in my notes on the life-history may be quoted:

Nov. 17, 1914. Our first really cold weather began last night. The adults and Solidago disappeared some time ago. A piece of young tree about 3½ inches in diameter examined today. The eggs on the bark were marked earlier in the fall. Young are few in number and have not penetrated as deeply as was expected. Three were discovered just beneath the outer corky layer of bark, the cavities in which they lay being scarcely larger than the bodies of their respective grubs. One cavity measures 4.3 millimeters (0.132 inch) in length and 2^{mm} (0.08 inch) in diameter. The grub measures 2.6^{mm} or about 0.10 inch in length. These little chambers are marked by a yellow stain outside each, due to the presence of the grub, probably to some secretion it produces, and which softens the wood, preparing it for more rapid appropriation by the weak mandibles and probably ren-

Fig. 5. Eggs, greatly magnified (X 18).

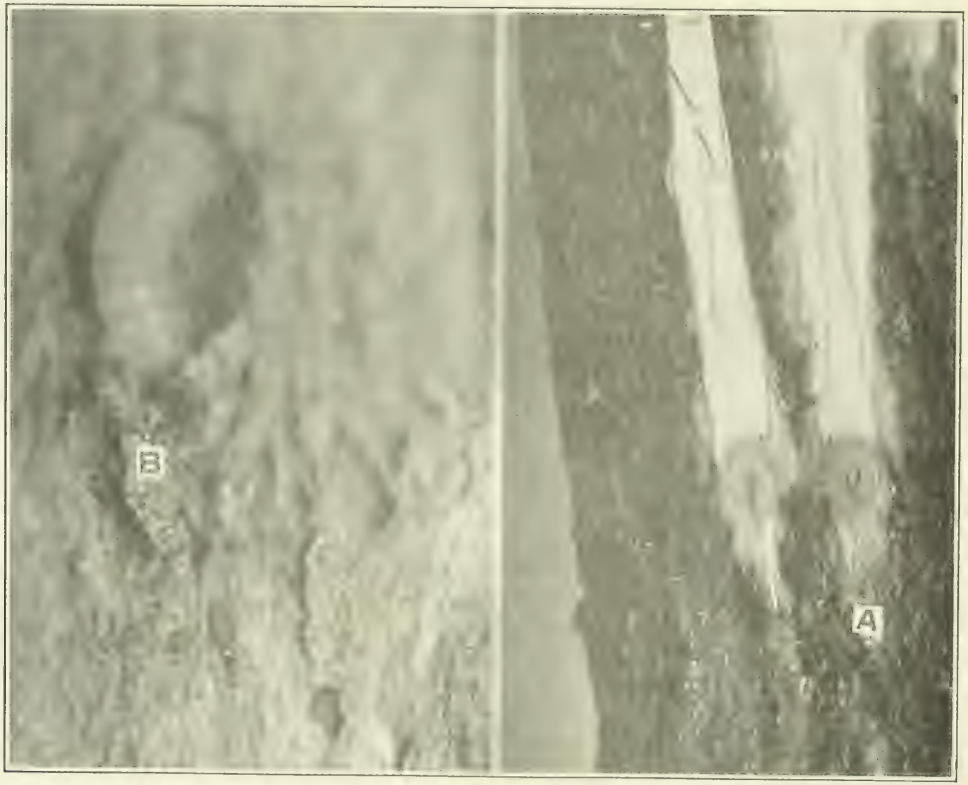

Fig. 6. A, a borer exposed in the fall of the year, the bark having been stripped off, turned over and pinned at one side; natural size; B, a young borer, soon after it has penetrated the bark; greatly magnified (X 12).

dering it more digestible. This yellowed wood extends about 3.4^{mm} outward in all directions from the cavity. The little grub lies not more than 3^{mm} (0.12 inch) from the outer surface of the bark.

Grubs torpid; move scarcely at all when the burrow is opened.

December 21, 1914. Numerous burrows were uncovered today in a section of a tree brought in from out-of-doors. All the grubs had stopped just under the rough bark and had only made cavities sufficient to accommodate their bodies. It is evident that they do not feed much as grubs in the fall.

When the Grubs Become Active in the Spring.

The real work of mining the tree and feeding begins, with the grub, in early spring, as soon as the trees themselves become active and the temperature rises. On April 29, 1915, larvae taken from the trees were found to have made but little headway since the preceding fall. They were becoming active, however, and an example in a branch about three-fourths inch in diameter had penetrated to an old burrow where it had grown much more rapidly than the rest. The great majority uncovered at this date were not much larger than they were in the fall. The stained region about the burrows has by this time extended somewhat and the discoloration is of a deeper brown color, so that burrows are quickly visible on stripping off the outer bark. A typical example measured to the outer limits of the stained region 20^{mm} (0.80 inch) by 8^{mm} (0.32 inch). These stained regions were elliptical or oval in shape, the stained wood beginning to break away at the edges from the living wood outside. The region has a peculiar sour odor at this time, due to some fermentative action set up either by the secretions of the grub or by bacterial organisms introduced by it from outside. As already stated the stain appears as soon as the recently hatched grubs reach the inner bark, and extends on all sides as the insect grows.

By June 15 the grubs have made shallow burrows beneath the corky layer of bark measuring from about 0.60 to 0.80 inch in diameter, with a depth of about 0.20

inch. Then at the upper end of this cavity it bores upward and inward toward the center of the trunk, in small trees reaching the center, then descending in the heart wood for a distance of about three inches. As refuse accumulates in the inner descending limb of the burrow it is pushed upward and over the bend to fall into the outer chamber made by the young larva. Ordinarily the grubs do not leave the descending limb of the burrow after it is made. The inner burrow is nearly uniform in diameter but may increase a little toward the lower end, where it measures in an example before me 0.40 inch. In large branches and in the trunks of trees the burrows do not reach the center, and in most of those examined the descending part runs downward parallel with the surface and just about an inch from the surface of the wood.

When sections of this wood were brought indoors from June 15 to June 20 the larvae continued active in them for some time, and as they lay on my table the slight noise made by their gnawing operations could be heard constantly, while a small heap of particles gradually accumulated on the table beneath each burrow. The drying out of these sections had the effect of hurrying the transformation of the grubs, however, and on June 29 in one instance a piece of branch about 18 inches long in which were several larvae, ceased to give forth refuse, and it became evident that the grubs were either dead or had begun to pupate. On cutting into the burrows July 11, it was found that in one was a pupa but it was dead. It was about 0.72 inch from the bottom of its burrow, and was protected from marauders from outside by a plug of loose chips made by the grub previously, and by another of dust-like particles filling the bend a half inch above. The whole burrow in this case was small, measuring 2.16 inches deep and 0.14 inch in diameter. In exposing this burrow I cut into the lower end of another above it, at one side of the first and not exactly in the center of the branch. The lower one followed the center. This upper burrow contained a larva preparing to pupate. Its burrow was closed above with chips and dust, but it had not yet molted. A plate glass was sealed over this second burrow so that it might

Fig. 7. Locust borers; natural size and enlarged.

Fig. 8. The pupae of the locust borer; natural size and enlarged.

be observed. It pupated in the night of July 2, and was found in this condition July 3.

A singular feature of the habits was observed at this time and has since proved to be constant for the insect. These grubs, it is to be remembered, have never been outside the tree since they hatched from the egg. They are not supposed to know anything of adult locust borers, having never seen or in any other way received knowledge of this stage of their development, yet each borer cuts through the wood at the highest point in the burrow straight to the outside, so that the future beetle into which it will later develop can easily get out of the tree, and without having to descend, even if the burrow were large enough for the purpose, into the small chamber made by the young grub during the fall and early spring. Here, as in many other insects, is an illustration of something like prevision, foresight, call it what you will; and it becomes the more remarkable when you refuse to ascribe to these animals a mind and capacity to think. What is it that tells these grubs that the adult beetle will be unable to escape from the burrow unless the way is prepared for it by the strong jaws of the grub?

On July 23, 1914, the insect over which the plate of glass was sealed, was found to have become adult, but its body was still soft and it was below the plug of chips. On July 25 it was still below the plug, but when examined August 2, had pulled the plug into the bottom of its burrow and was in the upper part. It was out August 5, and was a small individual, having evidently been dwarfed by the drying of the wood, and its development accelerated.

On August 1, 1914, larvae out-of-doors had begun to make plugs in their burrows preparatory to entering upon the quiescent pupa stage. On August 10 both larvae and pupae were found in the burrows of living trees, on cutting into them, but the pupae were not numerous, and it was evident from their numbers that this is the time when pupation normally takes place.

Adults were not observed in the trees until September 2, when examples were found in the burrows, still soft and pallid. They were not observed out of the bur-

rows and on Solidago until September 12, when both males and females were observed on the flowers.

This completes the round for a season; the egg-laying having already been mentioned as beginning about the middle of September, and continuing until cold weather approaches.

The Appearance of Infested Trees.

Old trees about the streets of cities are sometimes so badly riddled by the borers that the trunk becomes unsymmetrical and rough while many of the branches are reduced to stubs and the rest greatly reduced in size, so that the crown is small and out of proportion to the diameter of the trunk. When cut into, such trees are found to bear the marks of boring by generation after generation of beetles, beginning at the center where they were injured when young, and extending out to the bark. Quite often the center and large cavities elsewhere are eaten out by decay also, yet such trees persist, wrecks as they are, year after year, silent testimony to the wonderful vitality of the species and the surprising durability of its wood. In most of the more closely peopled sections of the State wherever locusts have been planted in any number this is the condition in which many of the trees exist. Examination of shade trees about Lexington shows that from 50 to 100 per cent. is infested, most of them badly so. A tree about six inches through at the base and about twenty-five years old (the center was decayed a little so as to prevent an exact determination of the age), growing on the Experiment Farm, was stripped of its bark, June 15-20, from the ground up to the branches and then out on the branches as far as injury could be detected. It was found to be injured by the borers from the ground to and upon the branches until the latter became less than about 1.33 inches in diameter, after which the burrows were no longer present. The injury was greater at the bases of the branches than on the trunk of the tree, and this accounted for the numerous dead branches, while the body still retained enough vitality to produce foliage on the small branches.

The position of burrows was always apparent at this time because of the refuse consisting of bits of wood

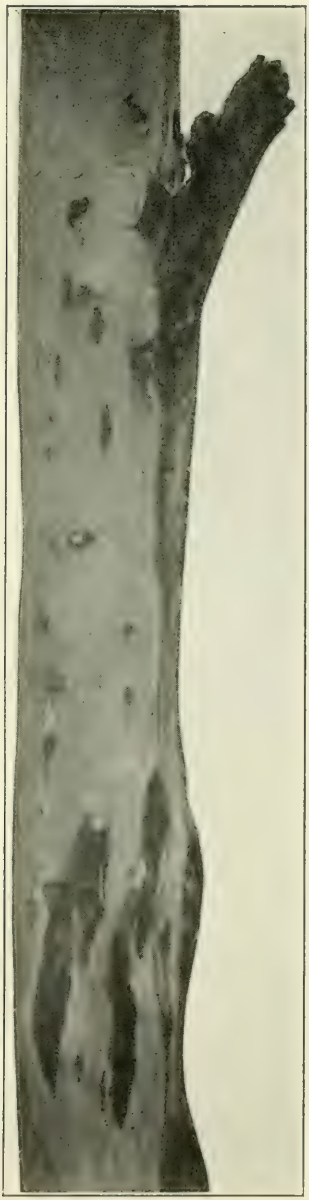

Fig. 9. A section of a badly injured young locust tree.

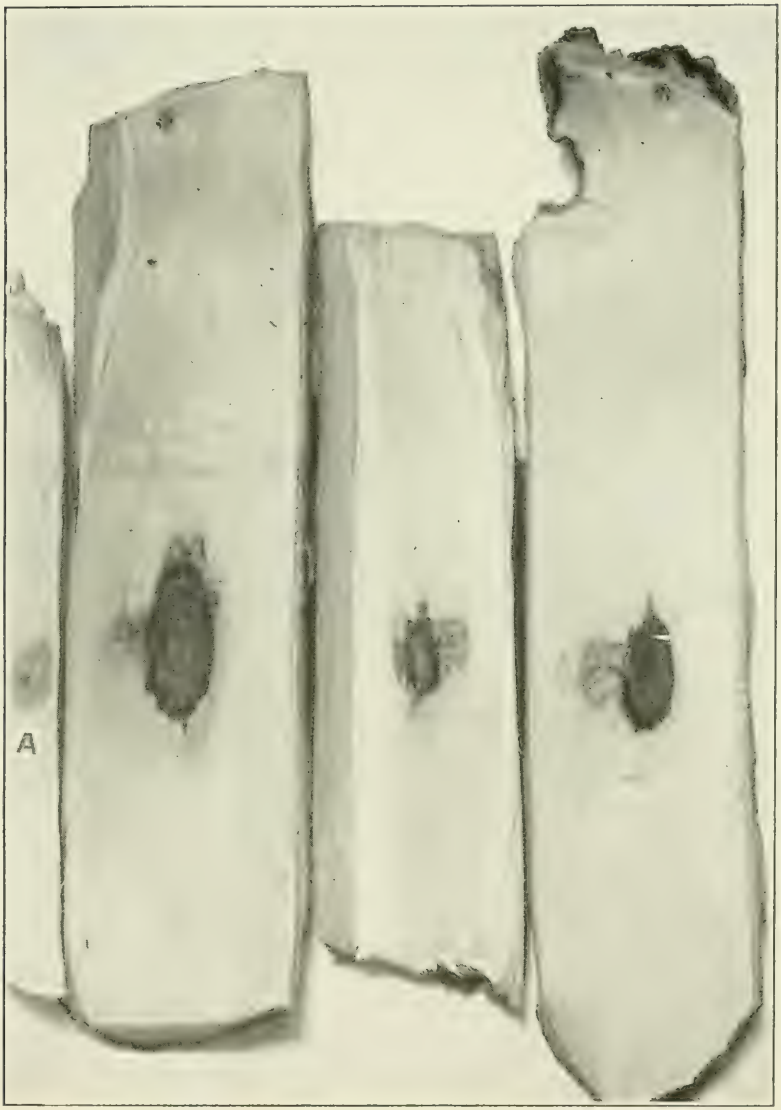

Fig. 10. Strips of locust bark removed to show cavities made by young borers; A, cavity as it appears in the fall; the rest as they appear in the spring (April).

and the like thrown from their entrances as well as by the sap which exudes at this season of the year. The apertures were always small, however, and quite often the bits seemed to have been thrown out by a small ant which takes up its domicile in the deserted burrows and was frequently observed in the shallow excavation made by the young borers just under the bark. Single burrows cause no serious injury to a tree. Trees with only a few would undoubtedly recover and present finally no outward signs of injury. It is the continued work of the insects year after year that finally shows its injurious effect, leaving the wood honeycombed with burrows and eaten away with the decay that follows them.

Descriptions of the Locust Borer.

Egg.—Elongate, cylindrical, rounded or slightly truncate at one end, more pointed at the other. Smooth, opaque, white. Length, .092 inch; diameter, .032 inch.

Larva.—Cylindrical in general shape, widest just behind the head, the divisions well marked, about six of them protuberant at the sides. Head medium in size, brown about the bases of the appendages, elsewhere largely white, but with dark sutures beneath and a median dot above at the hind margin. When ready to pupate, the head may be largely brown. Division of body following the head widest, the second and third small, the size gradually increasing backwards to the tenth, then suddenly diminishing, the last being smallest and only about half the diameter of the one preceding it. Nine brown spiracles along each side, the front largest and out of line with the rest. Everywhere with fine, brown, microscopic pubescence, except on certain prominences along the back and on the under side, which are smooth. Four obscure pale brown spots are more or less visible above on the division immediately behind the head. No legs. General color white. Length of a fresh example about ready to pupate, 1 inch; greatest diameter .26 inch. A larva recently hatched measured .09 inch in length and .04 inch in greatest diameter. In general shape they are much like older larvae. They are quite helpless when removed from the burrow.

Pupa.—Oval in general shape, the legs, wings, antennae and other parts of the adult being outlined, but folded against the body. On the back of the thorax and abdomen are small brown prickles, these being larger and more conspicuous behind. Color white, or yellowish, a faint line along the middle of the back. Length .97 inch.

Imago (Adult).—The beetle is a slender cylindrical insect with moderately long legs and antennae. Length from about .50 to .80 inch, the males averaging smallest. Black, with cross bands of bright yellow, of which the third on the wing covers is W-shaped.

The only other beetle likely to be mistaken for it is the hickory borer *(Cyllene pictus),* which is marked with yellow bands in the same pattern, but has longer legs, the reddish thighs, reaching to the tips of the wing covers, and the second division of the hind tarsi being smooth beneath, whereas the same division of the feet of the locust borer is pubescent. The adult hickory borer is found only in the spring, when it is attracted to the bleeding stumps of trees that have recently been cut down.

Enemies of the Locust Borer.

A common insect like this, living as an adult exposed in the bright sunlight, would naturally be expected to serve as food for birds and predatory insects. The number of enemies thus far observed by us is small. The adult beetles are pretty well concealed when on the flowers of goldenrod by their yellow and black colors, which harmonize with those of the flowers much better than would be expected from an examination of the insect alone. I have not observed birds molesting them at any time. A disagreeable odor which they emit when handled may be an additional protection. The hard bodies of the beetles probably saves them from the attacks of most predatory insects. The larvae and pupae living within the burrows are completely sheltered from most enemies. I suspect that the wood is too hard for the beaks of woodpeckers, the only birds at all calculated to reach them.

A single large puncturing insect, the wheel bug *(Prionidus cristatus)* has proved a very effective check on the adult beetles, and where it is sufficiently common destroys them in large numbers. This insect is one of

Fig. 11. The outer excavations made by borers under the bark before they penetrate the trunk. They bore into the tree at the upper edge of these shallow outer cavities; natural size.

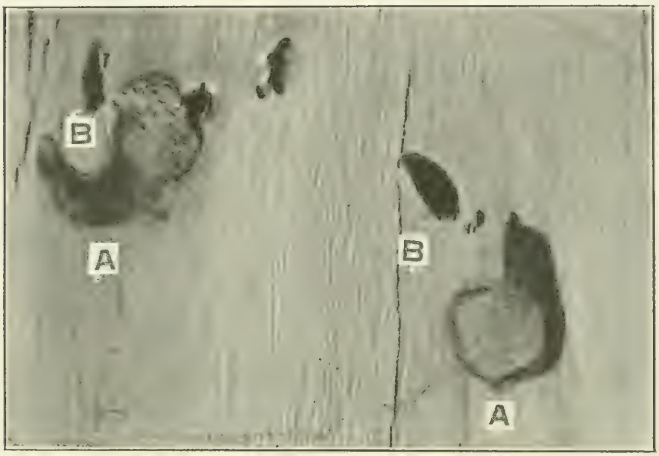

Fig. 12. A, A, two excavations of borers that are ready to pupate, the holes for the exit of the beetles being cut at B, B; natural size.

the most formidable of its kind. It is a member of the order Hemiptera, a group containing such pests as the notorious chinch-bug, the squash bug, the bed bug and the kissing bug. It reaches a length of 1.28 inch, is provided with a stout beak, and gets its common name wheel bug from a toothed and arched crest on the back just behind the head. Individuals have been observed on the flowers of goldenrod destroying the locust borer adults, and also on the trunks of locust trees, where they may be observed with the beetles impaled on their beaks. On one occasion near McKee in Woodford County, I found an example with a beetle still struggling on its beak. With the wound it inflicts the bug injects a clear fluid that probably has a paralyzing effect. On one occasion an example taken from a goldenrod, managed while I was occupied momentarily with something else, to prod my finger, causing a sharp pain and subsequent inflammation and swelling, the results being somewhat like that of a bee sting.

The females when captured sometimes emit at the hind end of the body a forked, orange-colored, glandular body with a pungent scent like that of the gland of a celery butterfly. It is probably protective. The bottle-shaped eggs of this bug are placed in clumps on the twigs, and remain in this condition over winter. They are laid in September.

These wheel bugs are doing a great deal of good in some localities, and should be recognized and protected where this is practicable by those interested in the growing of locusts.

Adult locust borers dying in confinement are sometimes partly covered by a white fungus which emerges at the articulations between the divisions of the body. It may prove to be one of the parasitic fungi such as destroy the chinch-bug and other insects, but has not been studied carefully. From the free life led by the adults they are not so much exposed to the attacks of such fungi as are insects living concealed in moist situations.

Other Insects Infesting the Wood of Locust Trees.

Several other insects are found in the burrows of the locust borer, some of them appearing to be pretty constant guests in the outer parts of burrows and especially

in the old cavities. The small ant has already been mentioned. The larva of a small beetle is also frequently seen, and seems to be the young of a sap-lover, and one of the Nitidulidae. The egg-cases of roaches are sometimes found in the refuse of old cavities communicating freely with the exterior. A small gray beetle of the same family as the locust borer (Cerambycidae) has been occasionally found in the old burrows, and sometimes on the bark of the trunk.

Some examples of the Carpenter Moth *(Prionoxystus robiniae)* have been encountered by me in opening up the burrows of the locust borer. One of them brought in July 6, measured two inches in length, with a diameter of 0.44 inch. These big worms are more formidable in appearance than the grubs of the borers. They are yellowish white, with a series of poorly defined brown spots along each side of the back, and another lower down on each side. The head is deep chestnut brown, becoming blackish about the mouth. It can quickly be distinguished from the borer by the presence of three pairs of jointed legs just behind the head, no trace of such appendages being visible on the locust borer grub. The adult of the carpenter worm is a moth, and it thus belongs to an entirely different insect order (Lepidoptera).

It would be possible to give a long list of insects that attack the wood, living or dead, but it would only cumber this paper and serve no useful purpose. There are, however, several species in Kentucky besides the Locust Borer *(Cyllene robiniae)* and the Carpenter Moth *(Prionoxystus robiniae)* already mentioned, that do some mischief at times and are of interest to the grower of young trees.

The Twig Miner *(Ecdytolopha insiticiana)*. Perhaps the most important enemy of nursery trees is a small moth whose young bores into and mines the twigs of young trees. It has been found this year on a planting made by the State Forester at Louisville, and is constantly injurious to young trees about Lexington. The injury may commonly be recognized by an elongate swelling of the twig, with an opening at the lower end, between two thorns, from which protrudes a mass of

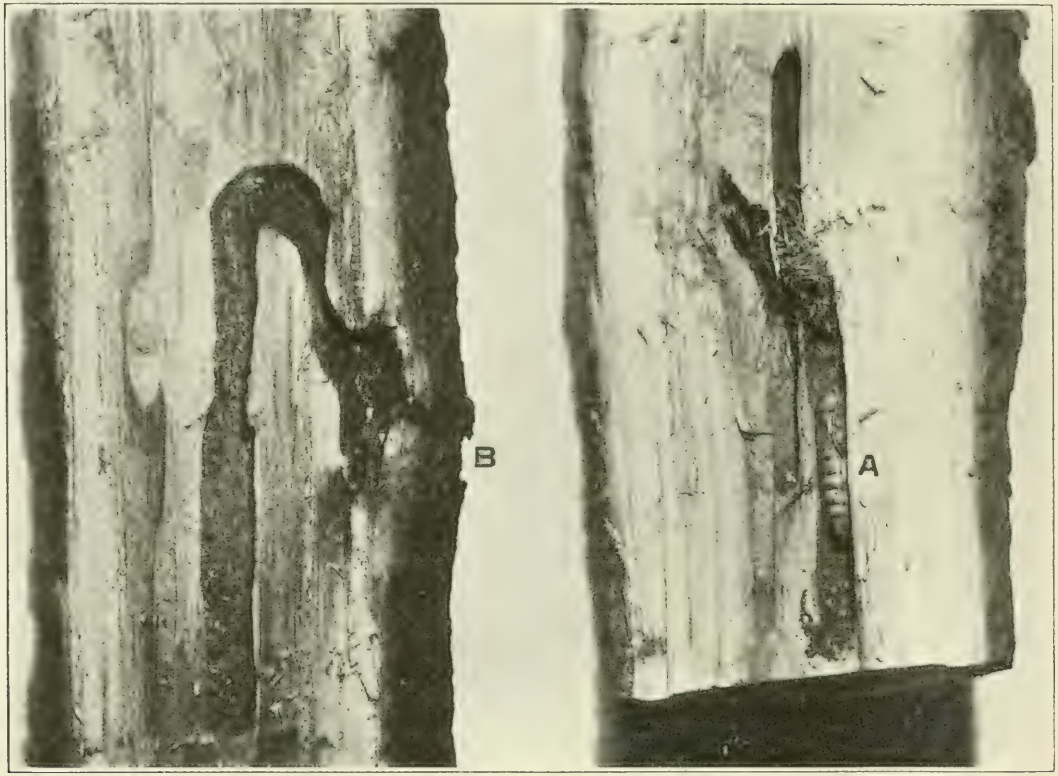

Fig. 13. Longitudinal sections of trees, showing burrows; A, the pupa beneath the plug of shavings; B, a complete burrow, the entrance opposite B; natural size.

Fig. 14. Back and side views of the wheel bug, male (upper), and female (lower); natural size.

refuse which has been thrown from the burrow by its occupant. Some of the mines show no swelling of the twig, but in such cases their location can be recognized by the mass of refuse. The interior of such twigs is mined lengthwise by a small yellow, or, finally, bright crimson larva, with a reddish brown head and a blackish brown neck-plate just behind it. It moves quickly, and when ready for the next change comes out of the mined twig and roams about looking for a place to form a cocoon in which to lie during the pupa stage. In confinement most of them made odd little oval cases by cutting out pieces of two leaves lying in contact, fastening them together with silk and undergoing the change within. They lie for a long time in these cases as larvae, however, assuming finally the bright crimson color mentioned above. Most of them failed to emerge, but in two cases adult moths appeared, one from the cocoons, the other from sand and rubbish in the bottom of the rearing jar. Some of the larvae which made cases for pupation in the latter part of August were still unchanged September 4. One of the adults secured came out September 8, leaving the pupa skin protruding from the case.

Several broods appear to develop during a season. At any rate, after the brood secured in August as larvae had all emerged for pupation, and I supposed the winter would be spent in the adult or egg stage, young larvae were again found in the trees. In October, near Duncan, in Franklin County, these young larvae were quite common. We have not yet had an opportunity to learn just where and in what condition this late brood passes the winter.

Treatment for this pest consists simply in cutting out and burning the infested twigs. They can be so readily seen that this procedure involves no great difficulty. Spraying early in the season with arsenate of lead may be suggested also, since it is as reasonable to suppose that this treatment will be as effective as it is for the codling moth of apple. It remains to be tested, however.

Agrilus egenus.—A second insect that attacks the wood is to be mentioned here because of its constant

presence and occasional abundance in locust trees. It is a small, slender-bodied, bronzy beetle of the same family as the flat-headed apple tree borer, and like the latter works under the bark. Its injury as a bark beetle is not often apparent, but the adults are common on the leaves, and have a very singular way of chewing the edges of the leaflets so as to give them a rough appearance. The roughness is so slight, however, as easily to be overlooked. The mischief is not of great importance, except when taken with that of numerous other leaf-gnawing insects of locust trees. It could doubtless be controlled by the use of a spray of arsenate of lead.

Insects Attacking the Young Twigs and Leaves.

The leaves of black locust harbor at all times a large number of insects representing a long list of species. They attack the leaves in various ways, some by gnawing, some by puncturing, some by mining them, etc.

Leaf Miner No. 1.—The Black and Yellow Locust Hispa (Chalepus dorsalis).—Among the leaf insects infesting the trees this is the worst. The adult is a small yellow and black, flattish beetle often found among the leaves, and sometimes in this condition doing a good deal of harm. Its eggs are laid in packets, each of about five flattened, somewhat triangular eggs. On hatching the young all bore into the leaf and make a mine between the two cuticles, upper and under, their food consisting of the green substance of the leaf. By gnawing this away the foliage is soon made to assume a brown hue, and as the little miners scatter and make new mines for themselves the whole foliage of a tree may be embrowned by the latter part of the summer, giving it the appearance of having been damaged by fire. The little grub in each mine ceases feeding after a while, becomes a quiescent pupa lying in the middle of the mine it has made, and finally emerges as a beetle to mate and lay eggs for a new brood. One brood becomes mature in July, and another, generally less numerous, matures in late summer and passes the winter among rubbish under the trees.

A second smaller brown beetle of the same genus *(Chalepus nervosa)* is common as an adult about locust

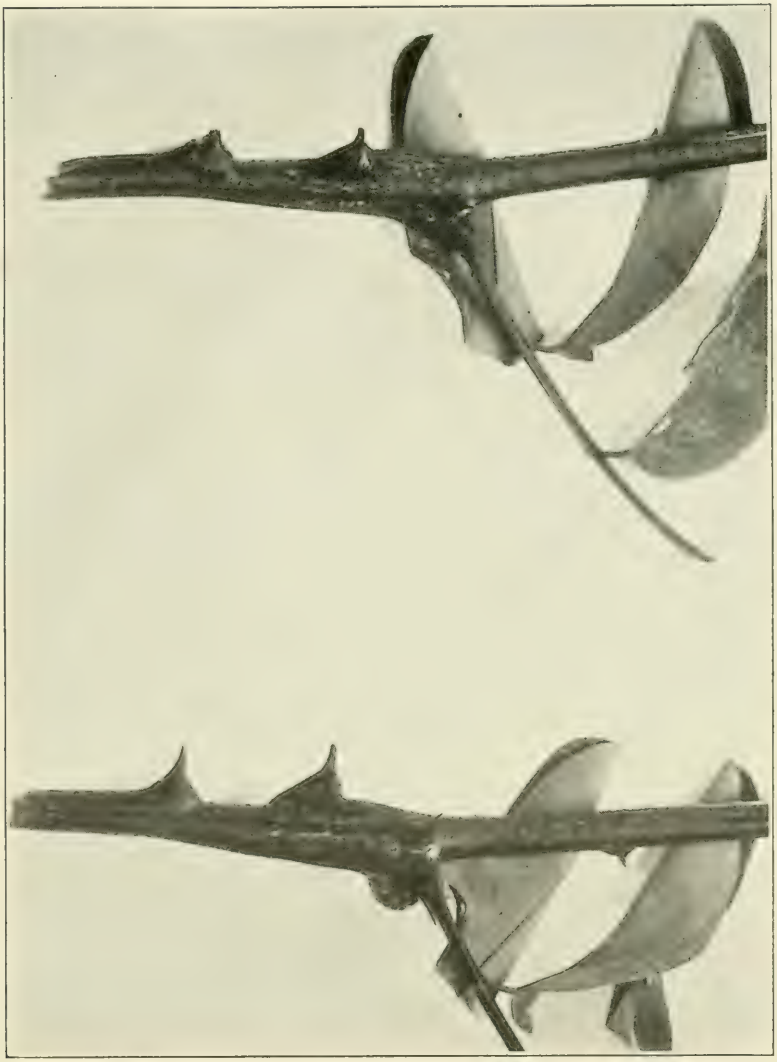

Fig. 15. Two views of a twig occupied by a twig miner, showing also the bug, Thelia bimaculata, and its striking resemblance to one of the thorns; natural size.

Fig. 16. The cases made by the locust twig miner by cutting out ovals from two leaves, when ready to pupate. The figure at the right, of natural size.

trees and feeds upon the leaves, but its early stages have not been secured by me from this tree.

In addition to these beetle leaf-miners the locust trees in Kentucky are infested by a small group of moths which in their larval stages mine, or skeletonize, the leaves. They were more common during the season of 1915 than the Locust Hispa. The following paragraphs are taken from an article of mine published a good many years ago, and not now accessible. They will give an idea of the nature of the injury and the character of the insects:

Leaf Miner No. 2 (Gracillaria lespedezifoliella).— Several other insects make blisters on the leaflets not very different in general from blisters made by the young Hispa. The casual observer is likely to mistake the latter for the ones already described. One of these is produced by the larva or grub of a moth, about the size of the common clothes moth so troublesome in dwellings. It is in fact a closely related insect. The blister when fully formed may be recognized by the fact that it lies along the midrib of the leaflet, and has processes or lobes extending out toward the margins. It is yellowish brown in color and is narrowly edged with reddish brown. To distinguish it from other blisters, I have named it in my notes the digitate blister. The grub is somewhat flattened like that of the Locust Hispa, but is more slender. The manner in which these blisters are formed is so curious that I must describe it for the benefit of those interested in insect architecture. About June 1, small whitish triangular blisters occur in the angles formed by the junction of the veins and midrib on the under side of leaflets. No one would suppose they had anything to do with the digitate mines of the upper surface, which appear somewhat later. But they are the beginnings of digitate mines. The little moth places a single lens-like egg at the edge of a vein about one-eighth inch from where it joins the midrib. The grub, hatching from the egg, bores into the leaf at once, and then makes a narrow mine along the vein until the midrib is reached, when it mines along the latter in the same way and for about the same distance, the mine being now V-shaped. Then it turns back on its course and mines alongside the

second arm of the V until the angle is reached again, when it goes out along the first-made arm, only to return when it reaches its extremity. And thus it continues until all the space included between the arms of the V is mined, and the little blister is triangular in shape. Instead of continuing on the under side of the leaf the grub now cuts through to the upper side of the midrib and makes a larger mine along it, at first linear in general shape, but gradually extended until finally it assumes the digitate character of the completed blister. While the grub is yet small it will, when its mine is laid open, retreat promptly into the triangular mine of the under side. At least two broods of this insect develop each season, the second lot of mines appearing in the latter part of August. The moths are so retiring in habit that they are not often seen. Just how it passes the winter I am unable to say positively, but it appears to leave the blister, and it is probable that it becomes a pupa among leaves on the ground beneath the trees. The adult moth is brown, the fore-wings marked with three oblique silvery lines shaded with dark brown, and with as many silvery dots on the inner margin.

Leaf Miner No. 3—Ostensacken's Leaf-miner (Lithocolletes ostensackenella).—A third very common blister on locust leaves is produced by the larva of another small moth, also much like the clothes moth in structure. It is one of the most beautiful midgets when it has acquired wings in the whole range of animated existence. The fore wings are of a rich brown color and shine as if made of burnished metal. Each wing is crossed by four silvery lines, edged in front with black, the two outermost broken at the middle. It is not more than an eighth of an inch long from the front of the head to the tips of the folded wings. This little moth places its flattened egg either on the upper or under surface of the leaflet, and is also indiscriminate as to the part of the leaf chosen. The recently hatched grub makes at first a tortuous mine, but soon abandons this style of construction and enlarges it into a more or less round blotch-mine of a yellowish brown color. The worms change to pupae in silken cases which they spin within the mines.

Fig. 17. The adult Locust Hispa (Chalepus dorsalis), greatly magnified (X 12).

Fig. 18. The Digitate leaf mine; natural size.

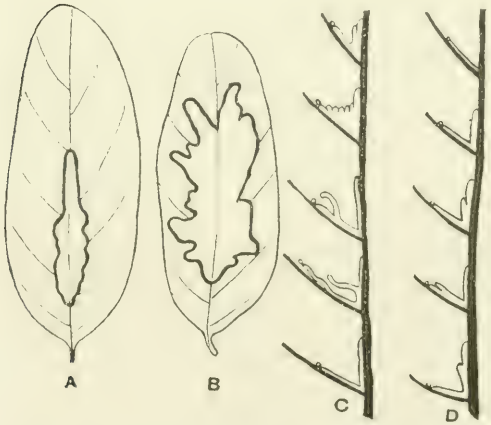

Fig. 19. A, the Digitate mine when first made on the upper side of a leaflet; B, the mine when completed; C and D, mines as first made in the angles of veins on the under sides of leaflets, in various stages, the two upper ones at the left being nearly complete.

Leaf Miner No. 4—The Autumnal Locust Leaf-miner (Lithocolletes robiniella).—About the first of August a pure white blister, generally elongate-oval in outline and restricted to one side of the midrib, appears, most often on the underside of the leaflets. It can be distinguished from the yellow blotch-mine by the fact that it is not linear and tortuous at first. The egg is placed by the moth at the edge of the prospective blister, and the young grub produces a blotch-mine at once, only making it gradually larger with its own increase in size. By the third week in August some of these blisters contain quiescent pupae in little white cocoons, and by the last of August the adult moths come out. They are very similar to the moth of No. 3, but the silvery lines do not extend entirely across the fore wings, and there is a distinct black spot at the free ends of the wings. In addition there are some golden lines alternating with the silver. The wings are closely folded about the body when at rest. Over the head projects a dense tuft of bristly hairs, the central black, the others white. It measures about an eighth inch from the tip of the frontal bristles to the ends of the folded wings.

The Locust Leaf-skeletonizer (Gelechia pseudacacicella).—Though not a leaf-miner, this insect is closely related with the three preceding species. It draws the leaflets together and lives between them, gnawing away the surfaces. It is very active in its movements and scurries back into its retreat when uncovered, and often when pursued further lets itself drop from the foliage by means of a silken thread which it emits from its lower lip. The fully grown worm is three-fourths of an inch long, pale green in general color, with brown head and six pale longitudinal stripes. The very young larvae are darker in hue. These skeletonizers are found among the leaves from June to October. Pupae are found in July, and adults emerge from them in August, placing eggs for a late brood. The adult moth has a wing expanse of two-thirds of an inch. It is dusky in general color, marked with black and ash-gray.

The Locust Skipper (Eudamus tityrus).—This is a much larger insect than the preceding miners and skeletonizers and as an adult is very common about clover

blossoms and other flowers during the summer. It is a brown butterfly with a large silvery blotch on the under side of each hind wing. The young, which works in locust leaves, is a thick-bodied, yellowish green worm, with a singular, large, reddish brown head marked with two large, round, yellow spots resembling eyes. It draws the leaflets together and lives within and feeds upon them. The brown pupa is formed in these shelters and is the condition in which the insect spends the winter.

Puncturing Insects.

A good many insects puncture the leaves or young twigs and suck the sap. They are common enough at times to weaken the trees greatly, but ordinarily the mischief of a season is done by the gnawing insects. The following puncturing insects have been frequently observed on locust trees in Kentucky:

Lopidea robiniae.—A common insect at times.

Tree-hopper (Thelia bimaculata).—One of the commonest tree-hoppers on the locust, from the twigs of which it sucks the sap. It is not often observed because of its remarkable resemblance to some of the thorns on the twigs. I have been impressed with this resemblance more than once since my attention has been given to locust insects. If there is anything in the idea of "protective resemblance," this is certainly an instance of it. The photograph shows very well the nature of the resemblance.

Tree-hopper (Vanduzea arcuata).—This insect is another common locust tree-hopper. It is gregarious in habit, and numbers, young and adult, are often found together on the twigs, where they are attended by a large black ant, probably after the sap also.

Tree-hopper (Acutalis calva).—A small, shining, black species, frequent on the trees.

Two-spotted Tree-hopper (Euchenopa binotata).—Not as common on locust as the two preceding.

Buffalo Tree-hopper (Ceresa brevicornis).—Occasionally found on the trees.

Ormenis pruinosa.—Frequent.

Flata conica.—Occasional.

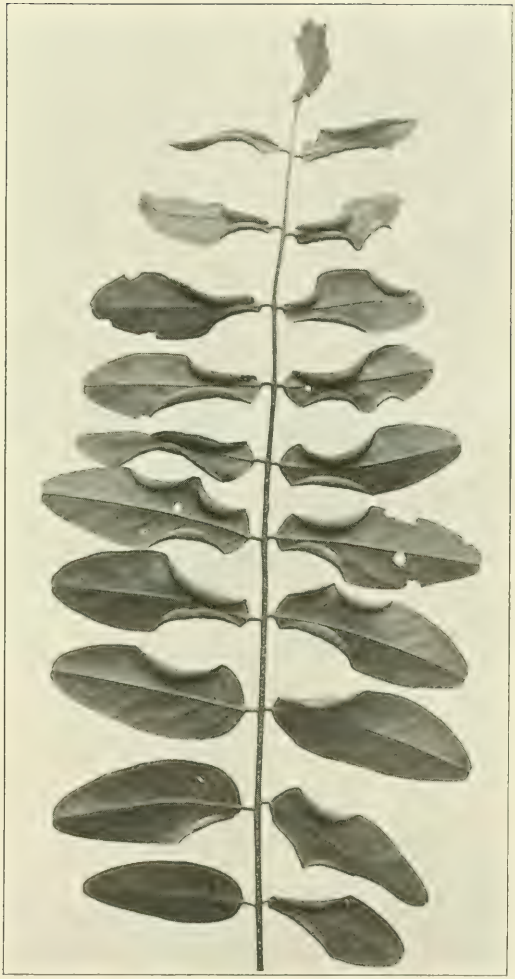

Fig. 20. Leaflets rolled by the locust midge (Cecidomyia robiniae), a very common injury in Kentucky. Reduced.

Nezara pennsylvanica.—This is one of the stink bugs, a broad, flat, green species, sometimes found about the trees.

Empoasca mali.—Frequent.

Empoasca splendida.—Common.

Typhlocyba querci-bifasciata.—Occasional.

Diedrocephala coccinea.—Not rare.

Acanthia multispinosa.—Frequent. Like the wheel bug, this smaller insect is predatory. It probably attacks some of the small, injurious locust insects, but has not been observed doing so on the trees. In confinement it catches and destroys large numbers of flies.

Treatment for Gnawing and Puncturing Insects.

While the number of species gnawing, mining and puncturing the leaves is large it is not to be supposed that they render the growing of locust trees unpromising as a business proposition. They can be controlled in most cases by spraying and by care in gathering up and destroying rubbish about the trees when they become numerous and are likely to hibernate in large numbers about the plantings. A spray of three or four pounds of arsenate of lead paste in a barrel of water should destroy most of the gnawing species. The puncturing sorts are more difficult to deal with, but sprays of lime-sulphur in winter, and of coal-oil emulsion should suppress these also. In fact, after watching these insects for two seasons, I am of opinion that the locust borer presents a more serious problem than all of the others together.

The Goldenrods.

The name "goldenrod" is applied to these plants because of the frequent arrangement of the small heads of yellow flowers in close, often cylindrical, spike-like thyrses, or terminal panicles. They constitute a conspicuous feature of our late summer native plant life.

Along roadsides, on railroad right-of-ways, at the edges of fields, in thickets, along streams, the bright yellow hues of the flowers always appeal to the eye of the artist and nature lover, present in us all in large or small measure, and add to the attractiveness of the coun-

try at a time when cultivated crops are likely to be in a sere and unpleasing state. We shall lose something of the pleasure of living when these sprightly autumn flowers have all been banished from our fields. That they appeal to most of us is shown by the frequency with which they have been chosen as State Flowers. Even in Kentucky the goldenrod has had many votes as a flower representative of the Commonwealth.

But the term "goldenrod" has a very vague meaning when we consider the large number of species of plants properly so called. In the United States there are no less than 74 species, with numerous named varieties.

Seventeen species of the genus Solidago occur in Kentucky and perhaps a few more. An additional species *(Brachychaeta sphacelata),* sometimes in botanies called the false goldenrod, is regarded as a goldenrod, without question, by those not familiar with the obscure characters which have led botanists to place it in a separate genus; so for all practical purposes we may say that there are eighteen known Kentucky goldenrods.

They differ widely in character, with species, and to some extent with the situation and soil in which they grow. For while the different species show marked tendencies to thrive and become numerous in particular situations, chance often plays a part in their distribution and influences their character.

Thus such species as *Solidago altissima* are at their best on low, moist, rich ground, where they are often five or six feet in height; on higher, drier ground they are not so tall, though still showing a tendency to rankness of growth. They are pretty generally plants of the open fields, and are not at all disposed to invade woodland. *Solidago latifolia* and *S. ulmifolia* are examples of slight, low-growing plants, being commonly only eighteen inches or thereabouts in height, and are found along rocky wooded banks or bluffs.

The species are in some cases so closely related that even botanists find difficulty in separating them. The difficulty is enhanced by the disposition of some of them to hybridize, and the amateur flower lover is to be excused when he is unable to place to his satisfaction all the plants of the genus he finds.

Fig. 21. Several panicles of the Tall Goldenrod (Solidago altissima) flowers; greatly reduced.

Fig. 22. A single panicle of the Tall Goldenrod, showing the characteristic curve and droop of the branchlets; natural size.

The characters most depended on are the shape and size of the flower clusters, the shape of the leaves, and the presence or absence of down on stems, leaves and developing seeds (achenes).

As examples of two extremes *S. latifolia* and *S. altissima* may be selected. The former bears the flowers in small isolated clusters along the stem in the axils of the upper leaves, sometimes with a continuous cylindrical assemblage several inches in length at the tip. There are no *very* long lateral flower-bearing branches. The leaves, too, are broad, oval, the width sometimes two-thirds to three-fourths the length. *S. altissima*, on the other hand, is a tall, stout-stemmed plant, with narrow, tapering leaves, the flowers restricted largely to a large, wide-spreading terminal panicle, the lower branches of which may be six inches or more in length.

Some of the native species are now listed by dealers in florists' stock, but are not as much grown at the present time as they deserve to be, merely for their beauty. Some of them deserve attention, also, because of reputed medicinal value. The European *Solidago virgaurea* was at one time employed in medicine. *Solidago odora* of this country is also said to have some value of this sort. The word Solidago means to make whole, and has reference to the use of infusions of the plant to cure wounds.

A yellow dye has been obtained from some of the species. The name Dyer's Weed, applied to *S. nemoralis*, seems to have reference to this use of the plant.

The following species occur in Kentucky:

Wreath Goldenrod *(Solidago caesia).* In woods. High Bridge, Oct. 15, 1892. Natural Bridge, Oct. 21, 1911. Earlington, Oct. 3, 1914. Central City, Oct. 5, 1914.

Broad-leaved Goldenrod *(Solidago latifolia).* Shaded banks and bluffs in rich soil. Elk Lick Falls, Aug. 17, 1892. High Bridge, Oct. 15, 1892. Frankfort, Sept. 30, 1914. Clifton, Oct. 4, 1914.

Curtis' Goldenrod *(Solidago curtisii).* Kentucky (Gray's Manual). Said to occur in mountain woods.

Pale Goldenrod *(Solidago bicolor.)* Kentucky (Gray's Manual). Dry soil.

Puberulent Goldenrod *(Solidago puberula).* Soldier, Ky., Sept. 9, 1893.

Early Goldenrod *(Solidago juncea)*. McHenry, July 30, 1892. Leitchfield, Aug. 7, 1904. Dry soil.

Anise-scented Goldenrod *(Solidago odora)*. Natural Bridge, Oct. 21, 1911. Dickey's Mills, July 14, 1896.

Elm-leaved Goldenrod *(Solidago ulmifolia)*. Elk Lick Falls, Aug. 17, 1892. Benson Creek, Frankfort, Sept. 30, 1914. Edges of woods.

Rough-leaved Solidago *(Solidago rugosa)*. Natural Bridge, Aug. 29, 1915.

Short's Goldenrod *(Solidago shortii)*. Clay's Ferry, Aug. 22, 1892. Among rocks along streams.

Dyer's Weed *(Solidago nemoralis)*. Hopkinsville, Aug. 8, 1892. Richland, Aug. 19, 1904. Dry soil in the open.

Canadian Goldenrod *(Solidago canadensis)*. Lexington, Aug. 29, 1892. Nortonville, Aug. 7, 1892. Tarascon, Aug., 1910. Rich soil in tangles of herbage, etc.

Rock Goldenrod *(Solidago rupestris)*. Clifton Banks of Kentucky River, Oct. 4, 1914.

Tall Goldenrod *(Solidago altissima)*. Lexington, Sept. 12, 17, and Oct. 8-12, 1914. Clifton, Oct. 4, 1914. Earlington, Oct., 1914. Aden Springs, Oct. 2, 1892. Common in rich soil in open situations.

Late Goldnrod *(Solidago serotina)*. Tyrone, Aug. 25, 1892.

Ohio Goldenrod *(Solidago ohioensis)*. McHenry, July 30, 1892. Wet land.

Flat-topped Goldenrod *(Solidago graminifolia)*. Nortonville, Aug. 7, 1892. Waco, Aug. 20, 1902. Moist situations.

False Goldenrod *(Brachychaeta sphacelata)*. Elk Lick Falls, Aug. 17, 1892. Clifton, Oct. 4, 1914. Wooded banks of streams.

Summary and Suggestions.

1. The locust borer is a black and yellow beetle when adult, occurring from the latter part of August until late October on the flowers of goldenrod, particularly on those of the common, rank-growing species known as *Solidago altissima*.

2. The injury is done to locust trees by the grubs or immature beetles which mine the trunks and branches,

Fig. 23. The Canadian Goldenrod (Solidago canadensis), as it grows in thickets about Lexington, Ky.

being most active from May until mid-August, when they become quiescent pupae within the burrows.

3. The food of the borer is the wood of the locust trees; that of the adult, the pollen of goldenrod.

4. Since the adult insects seem dependent on pollen and are abundant only where it may be secured it is suggested as a means of lessening the injuries, that all goldenrod in the vicinity of plantings be destroyed, or be sprayed with arsenate of lead in early September so as to destroy the beetles. A spray consisting of three or four pounds of the poison in a barrel of water should be used.

5. Spraying the trunks of trees with the same poison is suggested as a further precaution, and should be applied about the first of September when the beetles begin to emerge from the trees.

6. Old, badly infested locust trees in the vicinity of plantings serve as a breeding place for the borers and if of no value should be destroyed.

7. Baits other than goldenrod have thus far not proved very successful. A few beetles were captured in fly traps hung in young trees near the Station Building, and baited with banana, but the number was not large. More of the beetles were attracted to Solidago of several species, near by.

8. The gathering of the beetles from goldenrod by children, as suggested years ago by Harris, is not, it seems to me, impracticable for all plantings and would no doubt reduce the injuries.

9. The locust borer is not evenly distributed over the State. It is most numerous and injurious on open tracts of good soil where the Tall Goldenrod, *Solidago altissima*, is most abundant. It becomes less common in those parts of the State where this plant and the closely related *Solidago canadensis* are least common. It feeds upon other goldenrods when the above species are not present, but these two bloom at the time when the adult borers come from the trees and appear to be their main dependence for food.

In the mountain counties, accordingly, the injury to locust is less severe than elsewhere, and this region affords thousands of acres of cheap land upon which the

trees may at present be grown with the assurance that the injury will be less severe than elsewhere in the State. By keeping goldenrod of all sorts suppressed in the vicinity of plantings that may be established there the chances seem to me good to keep the injury from becoming severe in the future.

NOTE.—The writer is indebted to several members of the Staff of the Department for assistance of one sort or another in making this study. Assistant Professor Vaughn has made many of the photographs. Messrs. Jewett and Niswonger examined the commercial plantings of locust and from time to time have collected material for examination. A student, Mr. Leon Leonian, has aided by cutting out larvae and pupae, and on one occasion collected from the foliage of trees in this neighborhood the miscellaneous insects commonly found there.