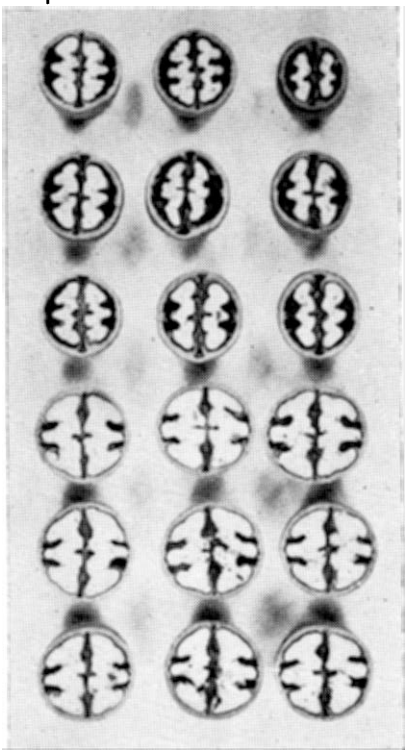
THE WALNUT DATANA

By Ephriam Hixson



Injury to pecan crop caused by walnut datana. The nine nuts at the top are from a tree partially defoliated, and show smaller size and incomplete fill. Nine normally filled nuts are shown at the bottom for comparison.

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Oklahoma A. and M. College
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Experiment Station Bulletin B-246 March, 1941

Summary

The walnut datana defoliated black walnut and pecan trees throughout Oklahoma during 1935, 1936 and 1937. The outbreak was brought under control in 1938 by natural enemies. The defoliation in 1937 reduced the quality and quantity of the pecan crop and caused the death of many trees and much bearing wood.

The life history and control of this insect was studied at Stillwater, Oklahoma, in 1937 and 1938. It was found to have two generations annually, the first of which was present from early May to July, while the second appeared during late July and was present until November.

The principal host plants in Oklahoma are black walnut, pecan and hickory.

The completion of a generation required an average of 59 days. The eggs hatched in from 6 to 7 days after deposition, and the duration of the larval and pupal stages averaged 19 and 33 days respectively during the summer. The insect hibernated as a pupa, remaining in this stage for a period of from 7 to 11 months.

The eggs were laid in clusters averaging 800 each on the under sides of the leaves in the lower part of the tree. Measurements showed that the average distance of the egg masses above the ground was 7.8 feet, the range being from 3 to 18 feet.

There were 5 larval instars. The first instar larvae fed on the upper side of the leaf, eating only the upper layer of cells. All other instars ate the entire leaf. The number of leaves eaten by each larva during its development averaged 6.9.

The pupal stage was spent in the ground at a depth of from 1 to 3 inches. The first generation moths were on the wing and were collected in traplights during May and June and the second generation during July, August and September.

Spraying with 3 pounds of lead arsenate, 6 pounds of lime and 100 gallons of water was found to be effective against this pest. One-half pint of fish oil per 100 gallons spray increased the adherence of arsenic on the leaves by about 50 percent. Cutting off or pruning the leaves or branches with the clusters

of larvae and placing them on the soil at some distance from the tree, or burning the caterpillars with a torch, were also effective controls, provided the pruning or burning was done before the larvae reached the fifth instar. At this stage the larvae scattered over the tree and were more active and difficult to kill. Dusting with calcium arsenate 20 to 25 pounds per acre was found effective in killing the larvae, but its only possibility of practicable use would be in native groves and applied with an airplane, a method still to be proven profitable for pecan groves.

Sheep feeding upon the vegetation under a block of pecan trees sprayed with lead arsenate and under another block dusted with calcium arsenate at the above rates showed no ill effects after being confined in pens under the trees for from 3 to 7 days, during which time they ate most of the contaminated vegetation.

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The Walnut Datana

By EPHRIAM HIXSON
Assistant Professor of Entomology

The walnut datana,* *Datana integerrima* G. and R., defoliated black walnut and pecan trees throughout their range in Oklahoma during the fall of 1935, the spring of 1936, and the entire summer of 1937. Prior to 1935, there had been no record of an outbreak in Oklahoma.

The outbreak which began in 1935 started with the second generation of the insect, and during September and October of that year trees over large areas were stripped of their foliage. In some places as many as 50 percent of them were completely defoliated, and no more than 10 percent of the black walnut and pecan trees in the state escaped some defoliation.

In 1936, the spring brood of larvae had defoliated large numbers of trees by July 1; but no second generation moths emerged, and there was no further defoliation that year. Both generations of the pest developed in 1937, and the larvae defoliated the trees throughout the state. Stiles (6)** reported that the first generation larvae completely defoliated the trees in 15 counties, partially defoliated them in 30 other counties, and that the second generation was equally destructive. Although only four counties reported complete defoliation by both generations, many other trees were defoliated twice during the summer.

In 1938, the spring brood of moths appeared in large numbers and laid many eggs, but parasites destroyed a high percentage of them. The few eggs that survived the egg parasites hatched, but predators destroyed most of the larvae. As a result of these attacks by its natural enemies, the datana did very little damage to the trees that year.

No further damage by this insect was noticed until the fall generation in 1940, which was present in sufficient numbers to defoliate some small trees, branches on large trees, and occasionally an entire large tree.

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* This common name is widely used in Oklahoma and has therefore been adopted in this bulletin in preference to the name "walnut caterpillar," the common name used elsewhere.

** Numbers in parenthesis refer to "Literature Cited."

INJURY CAUSED

Tree Damage Is Both Direct and Indirect

The injury caused by the datana is due to the defoliation of the trees (Fig. 1).* Loss of leaves stops the manufacture of food by the tree. This in turn affects the production of fruiting buds for the next year's nut crop, causes slack fill of the nuts (See cover picture), and results in meats of light weight and poor quality. Defoliation also injures the trees indirectly by exposing the branches and trunk to direct sunlight. This causes sun scald, prevents proper conditioning of the wood for resistance to winter killing, and by weakening the tree makes it susceptible to infestation by flat-headed borers.**

The extent and type of injury depends upon the time of year, the size of the crop of nuts present, and the size of the tree at the time of defoliation. Trees defoliated early in the summer are more likely to be attacked by the flat-headed borer than are those defoliated late in the summer when there are fewer adult borers present. Trees burdened with a large crop of nuts are less likely to recover than trees without nuts; and large, mature trees are less likely to recover than small, vigorous ones. Trees defoliated in September and October are not likely to be seriously injured by sun scald; but defoliation at this time of year weakens their resistance against winter-killing, and also results in poor filling of the kernels in that year's crop of nuts.

Damage in Oklahoma, 1935-1940

The damage to trees from defoliation was not serious following the attack by the second generation in 1935 and therefore the effect on the following crop was not measurable because it was lost due to a late spring freeze in 1936. The defoliation in June and July of 1936 had no immediate effect, since there were no nuts that year and no second defoliation.

The most serious damage was done in 1937. There was a nut crop that year; defoliation occurred both in the spring and summer, with many trees being defoliated twice; and the summer was dry. Furthermore, there was a large population of flat-headed borers in the field and they immediately attacked the trees. As a result of these adverse conditions, many branches and some trees were in a dying condition by September, and young leaves that had grown four or five inches since the de-

* All photographs in this bulletin are by G. A. Bieberdorf, assistant professor of entomology.

** *Chrysobothris femorata.*

Figure 1. Effect of defoliation of a large pecan tree by the walnut datana. The picture on the left was taken September 4, 1937. The one on the right was taken in early March, 1941.

foliation were dead. The extent of the damage to the trees was not so apparent until 1938 and the years since. Dead trees are now a common sight along the creeks, and dead branches are still more common. The loss in bearing wood in unprotected native pecan timber was probably 25 percent, and in many areas reached almost 100 percent. The 1937 loss in nuts, due to slack fill and the high percentage of low quality meats, has been estimated at from 25 to 50 percent of the crop value.

Damage Done Annually in Other States Since 1900

The walnut datana was described by Grote and Robinson in 1865 (2) from specimens collected in New York and Rhode Island. It has been referred to in the literature almost every year since 1900 as causing damage in some part of its range. During that time it has practically destroyed the black walnut, *Juglans nigra* L., in parts of its range due to frequent defoliations. Since the pecan, *Hicoria pecan* (Marsh) Britton, has become a valuable commercial crop, the injury sustained by it has been considerable.

DISTRIBUTION AND HOST PLANTS

Covers Eastern and Central United States

The walnut datana is a native insect of eastern North America and has been reported from Ontario, Canada, southwestward to Jalapa, Mexico, by Packard (5). The western limit of its range in the United States is Minnesota, Iowa, Nebraska, Kansas, Oklahoma, and Texas as far southwest as Del Rio.

Walnut, Pecan and Hickory Attacked in Oklahoma

The principal host plants of the walnut datana are in the walnut family Juglandaceae and include the black walnut, butternut, pecan, and hickory. It has also been reported as feeding on beech, oak, willow, honey locust, thorn, English walnut, Japanese walnut, and apple by Baerg (1), Packard (5) and others. In Oklahoma it has been observed to feed only upon black walnut, pecan and hickory, named in the order of preference.

DESCRIPTION

ADULT

The color of the adult or moth stage (Fig. 2) varies from light to dark reddish brown, with the head and thoracic patch a darker reddish brown. The front wings are darker than the second pair of wings and have five dark-brown, transverse lines. In some specimens the fourth and fifth lines frequently have merged. The second pair of wings is lighter in color and is without lines. The moths vary in wing spread from 1 7/16 to 2 3/16 inches (37 to 55 millimeters).* There seems to be no constant difference in the wingspread of the males and females, the larger males having about the same wingspread as small females. The females are usually heavier bodied than the males, but this character is not sufficiently constant to be used alone in determining the sexes. The sex of a specimen can be distinguished, however, by examining the frenulum and antennae. The males have a single frenular bristle, while the females have more than one and also have a tuft of hairs adjacent to the frenulum. The males have hairs arising from projections on the underside of the antennae, while the females have no hairs on the antennae. These differences were verified by dissection.

EGG

The eggs are light green when laid, soon turning white, and finally darkening just before hatching (Fig. 3). They are 0.6 to 0.7 mm in diameter and 0.8 mm long or about 1/35 of an inch in diameter and 1/30 of an inch long. They are placed on end in clusters averaging about 800 each. The cluster shown in Fig. 3 contained 957 eggs.

LARVA

Measurements of larvae during each instar are given in Table I, page 13.

The first instar larvae (Fig. 4) are green with a black head and thoracic shield. The body hairs are present but inconspicuous. The second, third and fourth instar larvae are red with white lateral stripes on each side, and have white body hairs. The head and thoracic shield are black. The fifth and last instar larvae are black with white lateral stripes and conspicuous white body hairs (Fig. 5).

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*25.4 mm = 1 inch.

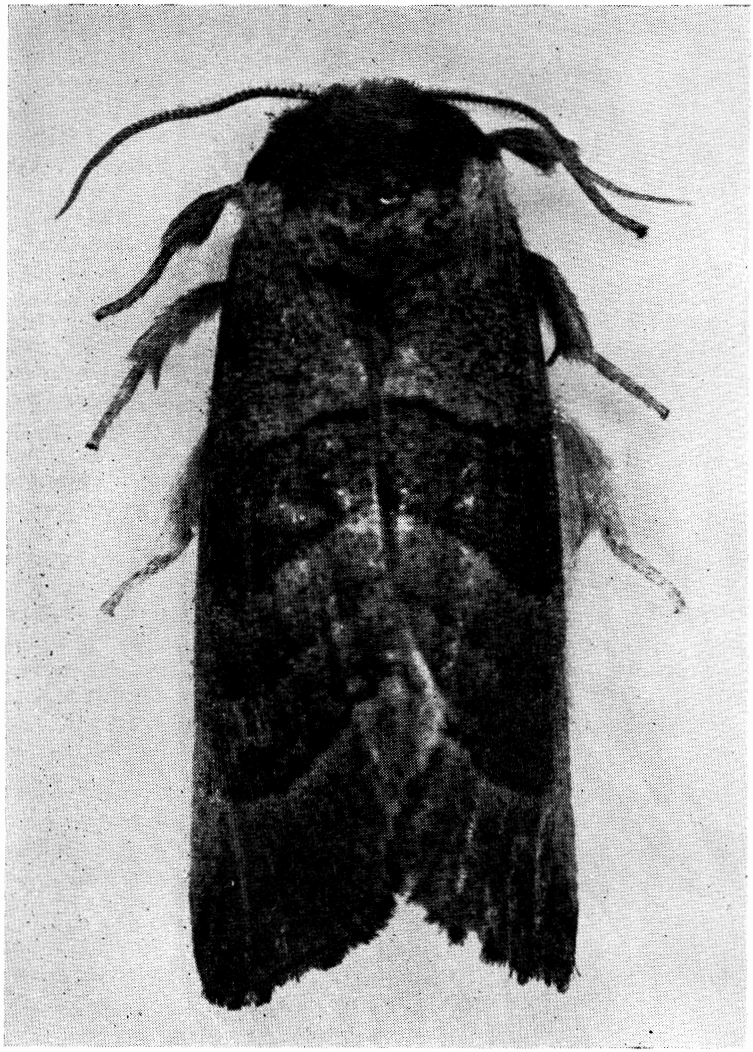

Figure 2. The adult or moth stage of the walnut datana (male).

Table I.—Measurements of Walnut Datana Larvae.
(Millimeters)

Instar	Width of head capsule	LENGTH OF LARVAE	
		At beginning of instar	At end of instar
First	0.3	2	4
Second	0.7	4	7
Third	1.5	7	17
Fourth	3.	17-19	24-30
Fifth	4.	24-30	35-43

PUPA

The pupa (Fig. 6) is green at first, but soon turns dark brown. It varies from ¾ to 1¼ inches long and has a posterior projection.

LIFE HISTORY AND HABITS

METHODS OF INVESTIGATION

The life history and control of the walnut datana were studied at Stillwater, Oklahoma, during 1937 and 1938. Only the spring generation was used for the life history studies; but observations of the second generation, made in connection with control work, showed that the rate of development and habits of the stages of the two generations were about the same. The studies were made in an experimental pecan grove, where the larvae were reared on growing trees and the eggs were observed where they were placed by the moths in nature.*

Egg clusters were found in 1937 by looking on the under sides of the leaves during the day, but in 1938 it was discovered that they could be more easily seen by using a flashlight at night. The light made the white eggs stand out plainly against the green background, whereas in daylight the shadows made their discovery most difficult. All egg clusters were tagged, dated, and left undisturbed until they hatched.

The larvae hatched, in many cases, in locations suitable for observation; and in such cases they were left undisturbed. If the location was not suitable, the leaf upon which they were feeding was transferred to a small tree or stump-sprout, care being taken to disturb them as little as possible. With the exception of a few colonies which had to be protected from pred-

* Attempts were made to rear the larvae in the insectary on a cut branch containing growing shoots. This method was quite unsatisfactory due to the high mortality of the larvae and the much longer periods required for the larval instars, and was therefore abandoned after about two weeks' trial.

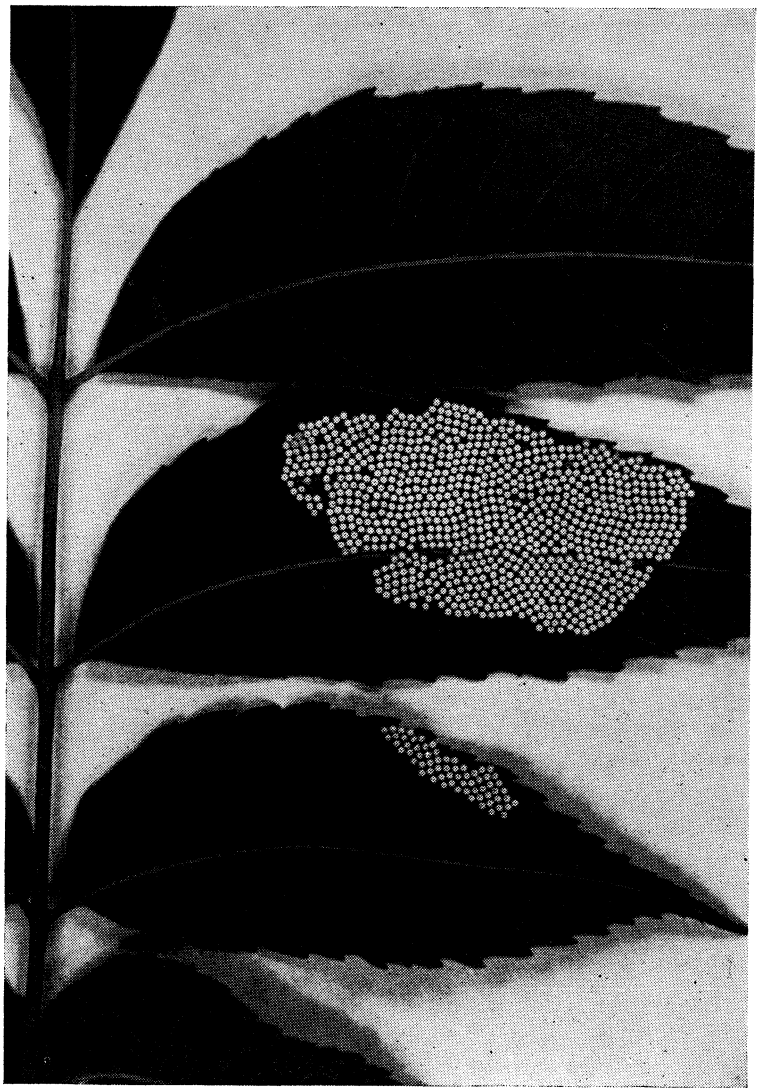

Figure 3. Cluster of eggs on a pecan leaf. The cluster average is about eight hundred eggs each. This one contains 957 eggs.

ators with cheesecloth bags in the spring of 1938, the larvae were permitted to feed under natural conditions on the tree. They were observed twice daily without disturbing their feeding, which seemed to occupy most of their time. In 1938 there was considerable disturbance of the larvae by predators and parasites. When enemies appeared, the whole colony would stop feeding, the larvae would rear their two ends in a threatening manner, and swing their heads from side to side in perfect rhythm until the disturbance passed.

In order to determine the duration of the pupal stage and to check the time of appearance of moths in the grove, mature larvae were collected and placed in cages.* The cages were examined daily and any moths that had emerged were recorded and removed. The presence of moths in the grove was also determined by the use of traplights placed in or near the trees. One was placed at a height of 5 feet and the other 25 feet from the ground. Standard 100-watt, inside-frosted lamps were used as the light unit, and a ½-gallon fruit jar with calcium cyanide was used as the killing unit. The light was turned on at dusk each evening and operated all night. The moths were removed and counted each morning.

Observations

HIBERNATION AND SPRING EMERGENCE.—The walnut datana hibernates in the soil as a pupa at a depth of from one to three inches. The first generation moths emerge and are on the wing in May and early June. The earliest record of moth flight for Oklahoma is May 5, 1936, at Stillwater. The traplight catch during May and June, 1938, yielded 262 walnut datana moths, of which 227 were males and 35 females. The last moth was collected that spring on June 17.

OVIPOSITION.—The moths oviposit in clusters averaging 800 eggs each. The eggs are attached to the under side of the leaf in the lower portion of the tree. The observation that the moths place their eggs on leaves on the lower part of the tree was verified by measuring the distance from the ground of 127 clusters of first and second instar larvae which were feeding near their respective egg clusters. These records were made in a cultivated grove of uniform trees. It was found that the distance of the clusters from the ground ranged from 3 to 18 feet

* The cages were 10 inches deep and 20 inches square. The top was 4 inches deep and 20 inches square so as to fit on top of the lower part, and was covered with 16-mesh screen wire. The bottoms of the cages were placed in the ground to a depth of seven inches by digging a trench 20 inches square so that the soil inside of the cage was disturbed as little as possible.

Figure 4. First instar larvae feeding on pecan leaf.

and averaged 7.8 feet. Only 24 of the 127 clusters were higher than 10 feet, and only 4 were above 15 feet. In native groves where the trees are headed high, the eggs would be placed higher, but in most cases they will be found on leaves on the lower branches. It is not known whether the moths lay more than one cluster of eggs.

INCUBATION.—The eggs usually hatch in six to seven days, although this period may be extended during cool weather. A very limited number of egg clusters which had been laid within the preceding 24 hours before discovery were observed during this study. In these few cases, it was found that six and seven days were required for hatching. Haseman (3) reported a week; and in cooler periods the incubation period is no doubt longer, as found by Baerg (1) who reported 9 to 10 days.

LARVAL HABITS AND DEVELOPMENT.—When the larvae are ready to emerge, they cut a ragged-edged, circular hole in the top of the egg and crawl out. As they crawl over the surface of the egg cluster and the leaves, they spin a silken thread to insure them against dislodgement, and so that they can stay bunched when following the leader. Soon after hatching, the larvae crawl to the upper surface of the leaf and start feeding. They usually start feeding from the edge of the leaf and eat only the upper layer of cells (Fig. 7); rarely do they cut completely through the leaf in the first instar. The leaf soon turns brown and is easily seen from a distance. All of the larvae in a cluster feed together and move about over the plant together, each larva continuously spinning a thread of silk as described above. In that way they have only to follow the silk thread of the leader in order to remain together. Therefore, they never pass the branch upon which they are to feed or molt, or down which they move to leave the tree to pupate.

The growth of the first instar is completed in three days. At the end of this period, the larvae molt or shed their skin on the same leaf where they have been feeding. The molt is accomplished by splitting the skin just back of the head and crawling and wriggling out of the old skin, which is left behind webbed to the leaf or stem. They then rub the head capsule off and are in the second instar. Newly molted larvae are a bright light red, but soon darken to the normal color of the instar. When all of the larvae have molted, they resume feeding on the same leaf or a nearby one. They rarely make long moves before the fifth instar. In the second instar and all following instars the larvae eat all of the leaf, but may leave the midrib and leaf petiole. The second instar requires four days for development. At the end of this time the larvae cluster

Figure 5. Fifth instar larva, the final form of the datana before it goes into the ground to pupate. During this stage of its life, which lasts four days, each larva eats about five pecan leaves.

near where they have been feeding and molt to the third instar. They feed during another four days and then move to the base of the branch and molt to the fourth instar. When they move onto a branch or the trunk to molt in the later instars, they pile up more and web themselves together until they look like a pile of wriggling hairs (Fig. 8). In this instar they usually go higher into the tree, or at least find a new branch upon which to feed, since each larva requires 1½ leaves to complete its growth in the fourth instar. This instar lasts four days, at the end of which time the larvae go to the tree trunk and molt for the fourth time into the fifth instar. Following this molt they crawl up into the tree and scatter out more than they ever do in the earlier instars, usually one to the leaf. The average duration of this instar is four days, and each larva requires 5 leaves for its development. When they have all finished feeding, they crawl back down the branch to the trunk and thence to the ground, where they scatter in all directions seeking a place to go into the ground to pupate.

The larval stage lasts an average of 19 days. In 1937, one cluster required only 18 days for its development while all the others required 19 days. In 1938, the average duration of the larval stage was 19.98 days. The increased time in 1938 was due to the third and fourth instars in several clusters of larvae requiring five days each for growth. In no case did the duration of first instar vary from three days, the second from four days and the fifth from four days; nor did it require more than 21 days for the completion of the larval stage. Haseman (3) reports 20 to 30 days as the length of the larval period under favorable conditions and longer under laboratory conditions. Baerg (1), who used cut branches with growing shoots in his studies, reports 26 to 30 days and 6 instars. The lengthened feeding period and extra instar are most probably accounted for by his use of cut branches, since the same difficulty was encountered in this work and by Haseman. Other workers have reported 25 or more days as the length of the larval stage.

PUPATION.—The mature larvae ordinarily burrow into the ground from one to three inches deep and form an oval cell in which to pupate, although many go under logs and stones to pupate when the ground is hard and dry. After the pupal cell is completed, the larva becomes shortened and thick. This stage is known as the prepupa and lasts two days. At the end of this time it molts to the pupal stage. The average duration of this stage for the first generation was 33.3 days, with the shortest period being 16 days and the longest 43 days. Hibernating pupae remain in the ground from 7 to 11 months. One moth emerged from a cage in which the larvae had been placed 11

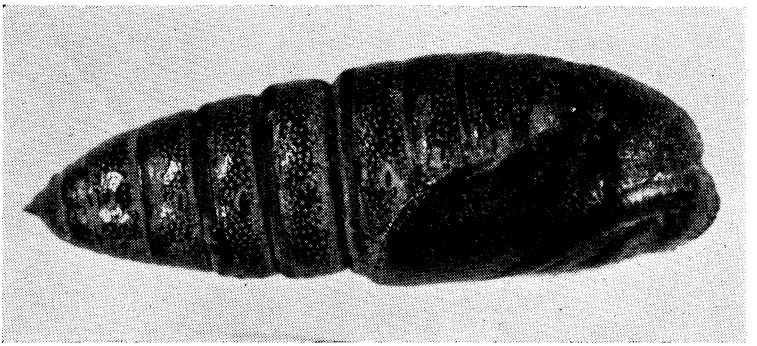

Figure 6. Walnut datana in the pupal stage, spent underground at a depth of one to three inches.

months and 8 days before. The carryover of first generation pupae from one year to the next as happened with the spring generation of 1936, is not uncommon. Baerg (1) reported a carry-over from 1924 to July 1926, in Arkansas.

DEVELOPMENT OF THE SECOND GENERATION.—Moths for the second generation began to emerge in the cages at Stillwater, Oklahoma, July 18, 1937, and continued to emerge until August 12, 1937. They were taken in the traplights from July 24 until September 15. The peak of emergence as measured by the traplight catch and cage emergence was August 8, 9 and 10. In 1935 the last caterpillars were leaving the trees for pupation October 31, but in 1937 they had all gone from the trees by September 30.

CONTROL

Natural Control

Natural control of the walnut datana may be due to parasites and predators which attack the various stages; or it may be due in part to weather, although the latter factor is apparently of very little practical importance in Oklahoma.

WEATHER.—It was observed that extremely high temperatures killed the eggs and young larvae on the trees and also the mature larvae when they left the trees and came in contact with the hot soil. The number killed in this way, however, seems to be of little importance in controlling an outbreak population. High temperatures, dry weather, or both, apparently delayed the emergence of the second brood of moths in 1936; but the population of moths appearing in the spring of 1937

would indicate that the mortality due to these conditions was extremely low and of no importance in control.

NATURAL ENEMIES.—The walnut datana is normally controlled by its natural enemies, the parasites and predators which attack the various stages of the insect. The most important of these attack the eggs. Two species of egg parasites are known in Oklahoma: *Trichogramma minutum* Riley,* yellow strain and *Telenomus ichthyurae* Ashm. The former was reported by Leiby (4) and the latter by Baerg (1). These two species were directly responsible for the reduction of the datana population in 1938. *Trichogramma minutum* was found throughout the infested area of the state in 1938. This species has a shorter life cycle than *Telenomus ichthyurae,* and each datana egg yielded an average of four adult *Trichogramma* while only one adult of *Telenomus* was obtained.

Three larval parasites are known to attack the walnut datana in Oklahoma: An ichneumon wasp *(Anomalon) Labrorychus relictus* (F.); and two species of tachinid flies, *Achaetoneura frenchi* (Will) and *Phorocera claripennis* Macq. The ichneumon wasp was never abundant and was of little importance in control, but the tachinid flies were common and successfully laid their eggs on the mature larvae after they had crawled from the trees to the ground. One small collection of larvae examined showed that 44 out of 53 had tachinid eggs attached. The largest number of tachinid eggs found on one datana larva was 69. This promiscuous egg laying shows the extreme wastefulness of the tachinid's efforts and probably explains its inability to bring large populations of larvae under control. These flies were abundant each year from 1935 to 1938, but did not seem to reduce the datana population to any great extent.

Predators which were found feeding upon walnut datana larvae during this study were: The paper-nest wasp, *Polistes canadensis* var. *annularis* (L.); the soldier bug, *Podisus maculiventris* (Say); the green ground beetle, *Calosoma scrutator* Fab.; the wheel bug, *Arilus cristatus* L.; lacewing fly larvae, *Chrysopa* sp., *Nabis* sp. (adult); and a spider, *Phidippus insolens* (Hentz). In the spring of 1938, the Polistes wasps killed large numbers of larvae and became so persistent in their attack that those larvae being observed for life history data had to be protected with cheese cloth bags. With this exception, predators were never numerous and probably did little to control the outbreak, although many larvae were killed by them.

* Determinations of species were by specialists in the museum of the United States Bureau of Entomoolgy and Plant Quarantine, through the courtesy of Dr. C. F. W. Muesebeck.

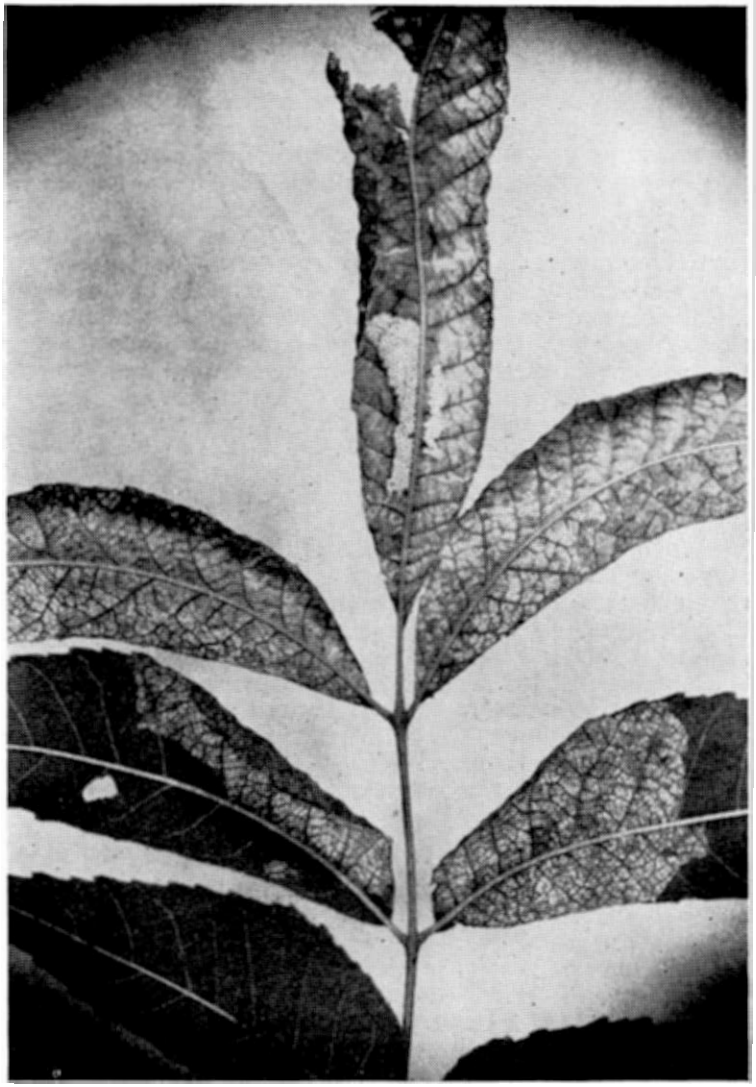

Figure 7. Pecan leaf damaged by first-instar larvae. During this stage, only the upper layer of leaf cells is eaten.

Applied Control

Control work was carried out in the pecan grove of the Department of Horticulture. The following methods were tried:

Burning. The clusters of larvae were burned with a torch made with burlap wired on a long pole and saturated with kerosene.

Pruning. The leaves or branches with larvae on them were pruned or broken off and thrown some distance from the tree.

Spraying. Spraying was done with a power orchard sprayer developing a pressure of 300 pounds. Lead arsenate was used at the rate of 3 pounds per 100 gallons of water and 6 pounds of hydrated lime. In 1938, lead arsenate was used at the rate of 8 pounds to 16 pounds of hydrated lime per 300 gallons of water with and without fish oil as a sticker to determine the amount of arsenic present (1) immediately after spraying and (2) in August when the second generation of larvae were present.

Hand Dusting. Calcium arsenate was applied with rotary hand dusters early in the morning when the leaves were damp and also in the afternoon when they were dry. The dust was applied to the foliage where the larvae were feeding, both by direct dusting and by floating the dust onto the foliage from a short distance.

Airplane Dusting. Airplane dusting was carried out on one area with calcium arsenate used at the rate of 20 to 25 pounds per acre to determine the possibilities of this type of application to native trees and also to determine if the resulting residue on the ground vegetation would be seriously toxic to livestock grazing there. The plane was flown at a height of about 25 feet above the tops of the trees at about 100 miles per hour.

Judging by the results of the experiments, control of the walnut datana can be accomplished by several methods. The best method to use will depend upon the type of grove, the cheapness of labor, and whether a sprayer is available.

HAND METHODS.—The hand methods which have been found practicable are: (1) Pruning the leaves or twigs upon which the eggs or larvae are present and either sacking them and removing them from the grove or throwing them on the ground 10 or more feet from the tree; or (2) burning the larvae

Figure 8. A cluster of fourth instar larvae molting to the fifth instar on a tree trunk. The older datana larvae move to a trunk or branch to molt into the succeeding instar. Here they look like a pile of wriggling hairs, as shown in this picture.

with a torch made with burlap or other material tied to a long pole and saturated with kerosene to produce a hot flame. These methods are practicable because, as noted above (page 15), most of the eggs are placed low on the tree and the larvae do not generally go high into the tree until the fifth instar. Most of the larvae can be removed by a man of average height without a ladder or pruner, while a large majority can be removed with a low ladder or a short pole pruner or torch. In native groves, where trees are headed high compared to cultivated groves, the eggs will be placed higher from the ground; but the egg clusters and the young larvae will usually be found on the leaves of the lower branches.

Hand removal by either pruning or burning is not effective against the fifth instar larvae. Because they more or less scatter to feed, effective control would require the removal of considerable wood or the burning of a large area of leaves. Furthermore, if larvae of this age are placed on the ground, they will either return readily to the tree or go into the ground to pupate; and they are difficult to kill by burning with a torch because when disturbed they immediately fall to the ground minus some hairs but otherwise not seriously injured. Younger larvae do not have this habit of falling when disturbed, but cling to the tree until killed or removed.

Hand methods are useful in small groves or where labor is cheap and the trees cannot be sprayed. For effective control by hand methods, the trees must be gone over several times. It is impossible to find all of the larvae the first time over, and repeated treatments are also necessary to kill larvae from eggs laid and hatched after the previous treatment.

SPRAYING WITH LEAD ARSENATE.—The best control found for the walnut datana is a spray containing two or three pounds of lead arsenate powder, two pounds of hydrated lime to each pound of lead arsenate, and 100 gallons of water. Better coverage will be obtained by the addition of one-half pint of fish oil, cottonseed oil, or some other spreader per 100 gallons of water. Analysis of pecan leaves sprayed June 18, 1938, with 8 pounds of lead arsenate, 16 pounds of lime, 1½ pints of fish oil and 300 gallons of water showed 3.4995 grains of arsenic per pound of dry leaves, while leaves sprayed with the same amounts of lead arsenate and lime but without the fish oil had only 2.1954 grains per pound of dry leaves. Two months later on August 28 a sample of leaves from the same trees showed that the trees treated with the spray containing fish oil had 0.3969 grains of arsenic per pound of leaves while those sprayed with only lead arsenate and lime had 0.2155 grains. The spray is

best applied with at least 300 pounds of pressure and as high into the trees as is practicable. The best time to spray is when the larvae first appear, which will usually be about June 1 in Oklahoma. One application for each brood is all that is necessary. In dry years, enough lead arsenate will usually remain on the leaves from spraying for the first brood larvae to control the second brood. Spraying with a stomach poison at that time of year for any other insect will control the walnut datana.

DUSTING WITH CALCIUM ARSENATE.—Calcium arsenate used as a dust proved quite effective in killing the larvae. The dust was applied with a hand gun early in the morning when the leaves were damp and later during the early afternoon while the leaves were dry. All larvae were killed in all tests, but they died much more quickly when the dust was applied to damp foliage. This method of application is not satisfactory at heights above 10 feet because the dust cannot be effectively driven higher. Dusting to this height would be effective in cultivated groves, but hand removal might prove as fast and more economical. The dust must be applied when the air is calm to get it as high as 10 feet from the ground effectively.

AIRPLANE DUSTING.—Preliminary tests showed that the application of calcium arsenate by airplane is possible and coverage is good when the dust is applied at the rate of 20 pounds per acre with the airplane flying at about 25 feet above the tree tops. The larval mortality from airplane dusting could not be accurately determined during this test due to the high temperature which was also causing many young larvae to die. Whether the airplane method of application of calcium arsenate dust will prove practicable depends upon many factors. The cost of each application of calcium arsenate dust by airplane is about three cents per pound when applied at the rate of 20 pounds per acre. The cost of the dust is seven cents per pound. Each 20-pound application would cost $2.00 per acre. A minimum charge for a job in a given area is $500. With native nuts selling at six cents per pound (and a native grove is the only place where this type of application might be practicable), it would require about 33 pounds of nuts per acre to pay for a single dusting.

COMPARISON OF CALCIUM ARSENATE AND LEAD ARSENATE.—Calcium arsenate in liquid spray is rather unstable and is not safe to apply to pecan foliage. In liquid sprays, lead arsenate is much safer to use and more likely to give good results; while as a dust, lead arsenate is more expensive and less effective than calcium arsenate.

EFFECT OF SPRAY AND DUST ON SHEEP

Many pecan groves are pastured with livestock and for that reason many growers do not attempt a spray program for fear of poisoning their animals. To determine the effect on livestock grazing on vegetation under trees sprayed to control walnut datana, one lot of five lambs averaging 61 pounds was confined in a pen under a plot of pecan trees which had been sprayed with lead arsenate at the rate of 3 pounds per 100 gallons. The spray was applied with a spray gun at a pressure of 300 pounds per square inch. The resulting residue on the vegetation made it look white. The first lot of lambs was confined in the pen from July 21 to 26, 1937. A second lot of five lambs was placed in the same pen from July 23 to 26, 1937. The average loss of weight of the two lots was 3.8 pounds. The average recovery gain betwen July 26 and August 10 was 7.3 pounds each. A third lot of five lambs was penned from August 15 to 21 under trees which had been dusted with calcium arsenate from an airplane at the rate of about 20 to 25 pounds per acre. The average loss in weight of these lambs was 0.6 pound.

Animal husbandmen who assisted in making the test were of the opinion that the loss in weight was accounted for by the fact that the lambs were taken off a highly nutritious diet and forced to subsist on pasture alone. All of the animals were in good condition at the end of the tests and showed no ill effects, although they ate most of the contaminated vegetation and practically all of the dry material on the ground.

It is not recommended that livestock be pastured on vegetation beneath trees which have been sprayed or dusted with arsenicals. However, if no more than one application is made it would seem safe to continue pasturing the pecan grove, since the livestock would not necessarily be confined to a small area and would not be forced to feed upon the poisoned vegetation as were the sheep in the above described experiment.

RECOMMENDATIONS AND PRECAUTIONS

in Control of the Walnut Datana

1. Decide early which method of control is best for your grove and start putting it into practice on the first generation in May and June.

2. Make a special effort to control the first generation and thereby prevent development of the second generation, which is more numerous.

3. Remove the clusters of eggs or caterpillars by pruning the infested leaves and branches and throwing them on the ground at least 10 feet from the tree or by placing them in a sack and removing them from the grove.

4. If the torch method is used to kill the larvae, keep the torch moving so as not to burn the wood. Some leaves will be killed, but this cannot be prevented.

5. The pruning or burning method of control is not effective against the fifth instar larvae.

6. Trees can be protected from defoliation by a spray containing 3 pounds of lead arsenate powder, 6 pounds of hydrated lime and 100 gallons of water. A half pint of fish oil per 100 gallons will improve the coverage of the spray and prolong its effectiveness.

7. Dusting the trees with undiluted calcium arsenate at the rate of 20 pounds per acre will kill the larvae. This method of control is not recommended except in an emergency for fast coverage with an airplane where a large number of trees are infested.

8. Pasturing livestock in groves sprayed with lead arsenate or dusted with calcium arsenate at the recommended rate appears to be safe, but do not do it unless it is necessary.

9. Although the datana moths are attracted to lights, traplights are not effective as a control measure.

10. The walnut datana is normally controlled by its natural enemies such as parasites and predators. There is no evidence at present, however, that their propagation and release in groves will control this pest.

LITERATURE CITED

1. Baerg, W. J. 1928. *Three Shade Tree Insects.* Ark. Agri. Exp. Sta. Bul. 224.

2. Grote, Aug. R., and Coleman T. Robinson. 1866. "Lepidopterological Notes and Descriptions No. 2." *Proc. Entom. Soc. Philadelphia,* 6:12-13.

3. Haseman, Leonard. 1940. *The Walnut Caterpillar.* Mo. Agri. Exp. Sta. Bul. 418.

4. Leiby, R. W. 1925. "Insect Enemies of the Pecan in North Carolina." N. Car. Dept. Agri., *The Bulletin,* February, pp. 19-24.

5. Packard, A. S. 1895. "Memoirs of the Bombycine Moths." *Mem. Nat. Acad. Sci.,* 7:105 and 120-122.

6. Stiles, C. F. 1937. "Relative Infestation of the Walnut Datana in Different Sections of Oklahoma." *Proc. Okla. Pecan Growers Assoc.,* December, p. 16.