Author: Pennsylvania Dept. of Forests and Waters

Title: Leaflet

Place of Publication: Harrisburg

Copyright Date: 1934

Master Negative Storage Number: MNS# PSt SNPaAg054.4

<223314> * Form:serial Input:BAL Edit:FMD
008 ENT: 820728 TYP: d DT1: 1934 DT2: 19uu FRE: u LAN: eng
037 PSt SNPaAg054.4 $bPreservation Office, The Pennsylvania State University, Pattee Library, University Park, PA 16802-1805
090 00 SB608 $b.P36 $l+no. $cax $s+U1(1933)+U3+U5-U6+U8-U26+U28-U39
090 20 Microfilm D344 reel 54.4 $l+no. $cmc+(service copy, print master, archival master) $s+U1-U39
110 1 Pennsylvania $bDept. of Forests and Waters
245 00 Leaflet
260 Harrisburg $b[The Dept. $c1934-]
300 v. $c24 cm.
362 0 No. 1-
515 Each no. has also a distinctive title
533 Microfilm $mNo.1-no.39 $bUniversity Park, Pa. : $cPennsylvania State University $d1998 $e1 microfilm reel ; 35 mm. $f(USAIN state and local literature preservation project. Pennsylvania) $f(Pennsyovania agricultural literature on microfilm)
590 Archival master stored at National Agricultural Library, Beltsville, MD : print master stored at remote facility
590 This item is temporarily out of the library during the filming process. If you wish to be notified when it returns, please fill out a Personal Reserve slip. The slips are available in the Rare Books Room, in the Microforms Room, and at the Circulation Desk
650 0 Trees $xDiseases and pests $zPennsylvania $xPeriodicals
650 0 Forest insects $xControl $zPennsylvania $xPeriodicals
650 0 Pests $xControl $zPennsylvania $xPeriodicals
830 0 USAIN state and local literataue preservation project $pPennsylvania
830 0 Pennsylvania agricultural literature on microfilm

Commonwealth of Pennsylvania

Department of Forests and Waters

Leaflets

1, 3, 5-6, 8-26, 28-39

CONTENTS

29 Fall webworm.

30 Locust leaf-miner.

31 Two-lined chestnut borer.

32 Canker worms.

33 Poplar borer.

34 Mottled willow borer.

35 Imported willow leaf beetle.

36 Beautiful hickory borer.

37 Sugar maple borer.

38 Leopard moth.

39 Gipsy moth.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 1

THE CONTROL OF INSECT PESTS OF SHADE AND ORNAMENTAL TREES

By Josef N. Knull, *Entomologist*

Intensive methods of insect control, which may not be practical under forest conditions because of their excessive cost, may be economical when applied to certain shade and ornamental trees of high aesthetic value. In order to understand the methods used in combatting the insects it is necessary to know that they are divided according to their feeding habits into two great groups: chewing insects and sucking insects. The method of treatment for control will depend upon the type of pest involved.

The chewing insects have sharp mandibles which correspond to our teeth. These mandibles work in and out and are adapted for chewing foliage, or mining the hardest wood as the requirements of the species may demand. In the case of these chewing insects, it may be the larva form which does the damage, as is the case with most of our moths and butterflies (Lepidoptera), or it may be the adult form which causes the injury, or both the larva and adult forms may be injurious, as is the case with the Japanese beetle.

Most of the chewing insects are combatted with poisonous sprays or dusts, which cause the death of the individuals when taken into the digestive systems. It requires very little stomach poison to kill a chewing insect, either in the adult or larva stage.

In the sucking insects, such as scale insects, plant lice, leaf hoppers, and spittle bugs, the mouth parts are formed for extracting the juices from the trees and plants. These mouth parts are inserted into the hosts and the sap is sucked up through tubes. In this group it is the nymphs and adults which cause the injury to the trees. Some of them work on the leaves, while others work on the different parts of the trees, depending upon their requirements. It is impossible to poison insects of this type, hence contact sprays and dusts must be used to combat them. If poisons are used they are not effective, because the sucking insects insert their beaks through the thin films of poison to receive the nourishment through their mouth parts, without any bad effects from the poison which is naturally outside the feeding point. The contact insecticides, however, cause the death of the insects by clogging their breathing pores,

by affecting the nervous systems, or by an action on the body tissues. Contact sprays are also sometimes used in combatting certain chewing forms.

STOMACH POISONS

Sprays. Powdered arsenate of lead is the most widely used poison in combatting chewing insects. It has good adhesive properties and there is not as much danger of burning foliage with it as with other chemicals. This poison also comes in a paste form. Other stomach poisons have their uses for controlling chewing insects, varying somewhat with the kind of insect and the host upon which it is feeding. Poisonous sprays are mixed either in spray tanks or in containers and applied with a spray outfit. For tall trees power sprayers must be employed, but for small trees knapsack or hand sprayers can be used. The more pressure, the finer the spray mist and the better the trees will be covered with the film of poison.

Some borers can be controlled by using poisonous sprays mixed with a carrier such as miscible oil or kerosene. By spraying the places on the trees where the dust (frass) is being thrown out by the larvae, these sprays penetrate into the galleries and poison them. Poisonous sprays should always be applied when the chewing insects are feeding.

Dusts. Poisonous dusts are often used in the place of sprays and in many instances they have proven quite satisfactory. These dust particles adhere to the foliage and when taken into the digestive systems of the insects cause death. Dusts can be applied either by hand or by power dusters as the circumstances may require. Dusting by aeroplane is used in some sections for certain pests, when large areas must be covered. Dusts can be applied much faster than sprays, although they are not always as satisfactory for insect control.

CONTACT INSECTICIDES

Sprays. There are many contact insecticides used in combatting sucking insects, chief of which are lime-sulphur, nicotine sulphate, miscible oils, extracts of derris, soap and extracts of pyrethrum. Some of these can be used during the growing season while others must be used in the trees' dormant season, to avoid burning the foliage. Oil sprays should be applied when there is no danger of the spray material freezing before it has dried on the sprayed trees. There are now a number of satisfactory miscible oil sprays on the market, and the once popular kerosene emulsion is seldom used.

Dusts. Contact dusts are sometimes used instead of contact sprays, although as a general rule they are not as effective as the sprays.

FUMIGANTS

Fumigants such as carbon bisulphide, calcium cyanide, and paradichlorobenzine are sometimes used to combat certain tree borers that cannot be reached by stomach poisons. These fumigants can be injected into the holes which are made in the trees and used by the larvae to throw out frass or which in the case of adult insects like carpenter ants, extend to the exterior.

REPELLENTS

Repellents such as carbolic acid emulsion, lime sulphur sludge, and other substances are often applied to trees to prevent insects from laying eggs on them. These repellents are so distasteful to the insects that they avoid the sprayed trees.

BANDING

Banding trunks of trees with cotton or sticky substances is often practical. However, these bands have a rather limited use and are only efficient against certain species of insects. Bands of this type work out successfully against insects like the white-marked tussock moth, whose larvae are migratory in their habits, or against insects like carpenter ants and canker worms. The female canker worms are wingless and crawl up the trunks of the trees to lay their eggs.

TRAPS

Light traps have been used for a number of years for collecting certain species of insects. Traps containing sweet liquids or other substances which will attract insects are being used in many localities. These traps have worked out quite successfully in obtaining large catches of Japanese beetles.

PREVENTIVE MEASURES

Infestations of secondary insects can often be prevented by stimulating the growth of weakling trees with fertilizer. This treatment together with thorough pruning and cultivation will often stimulate growth and in this way prevent attack of insects which breed in unhealthy trees. Liberal applications of water will stimulate growth.

TREATMENT OF WOUNDS

Wounds caused by injuries or severe pruning should be painted with creosote and then given a coat of coal tar. If no treatment is given they make ideal breeding places for certain wood borers and are apt to cause cavities. Painting wounds also prevents the entrance of fungi which cause decay.

TIME TO SPRAY

The time to spray and the kind of spray to use will depend upon the species of insect concerned. It is always advisable to spray on clear sunshiny days when the spray material will dry rapidly. Humid, sultry, partly cloudy days are more apt to cause burning with certain sprays. Spraying should not be done in the winter when the temperature is 40° or below. Calm weather is more suitable for spraying than windy days.

TIME TO DUST

Dusts should be applied when the weather is perfectly calm. This condition is more apt to be found late in the evening or very early in

the morning. It is best to apply nicotine dusts in the heat of the day, for the nicotine will volatilize more readily at this time. Rains wash sprays and dusts from treated trees and their effectiveness is always lessened after a rainy period, often necessitating a second treatment.

CARE IN HANDLING INSECTICIDES

Since many of the insecticides for combatting insects are poisonous, it is necessary to use precaution in handling and using them. The commercial containers of insecticides should always indicate if the material is poisonous.

(9-33)

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934
Leaflet No. 3

APHIDS OR PLANT LICE

By Josef N. Knull, *Entomologist*

Aphids, or plant lice, probably the best known form of insect life owing to their great abundance on all sorts of vegetation, are very common on forest, shade, and ornamental trees. They are delicate, soft bodied creatures about 1/16 to ¼ of an inch in length, each possessing six legs, antennae, and in some cases wings. Some species have tubes on their abdomens which secrete honey-dew.

One of our common shade tree pests is the Norway maple aphid, which in some years becomes plentiful enough in Pennsylvania to cause the leaves to drop from the infested trees. The pine bark aphid is also a common species which is often very noticeable on the trunks and branches of white pines. The alder blight-aphid is another striking example and the overwintering forms can be seen in large white clusters on the stems of alders through the winter months.

Although aphids are common on forest trees, their damage does not show up as it does on shade and ornamental trees. They injure the trees by sucking the juices from the parts attacked. Most of them work on the foliage, but others infest the branches or roots. There are a few species which form galls on trees. Those attacking the foliage often cause the leaves to curl, thus making the appearance of the foliage unsightly. In addition to the injury they cause they often prove to be a nuisance by the secretion of the honeydew which is apt to fall on automobiles or other objects under infested trees.

Ants are invariably found on plants infested by aphids, because they feed on this honey-dew, which is a sweet, sticky liquid. Thus ants are often blamed for injury caused by the aphids. Ants are known to herd these little creatures and aphids are often found associated with them in their nests.

The life histories of many of the aphids are complicated, since most of the species have alternate hosts and they breed without fertilization during certain seasons of the year. Winged and wingless forms occur depending on the season. Some species are covered with fluffy waxy secretions which resemble cotton.

The aphids have many enemies which constantly tend to reduce their numbers, but because they are such prolific breeders these parasites and predators are rarely sufficient to hold them in check.

CONTROL MEASURES

In view of the fact that the aphids are sucking and not chewing insects, contact insecticides are necessary to combat them. It is advisable to apply the treatment when the first individuals are observed, and before the leaves on which they are feeding start to curl. Aphids in general can be controlled by a thorough application of the following spray:

> Nicotine sulphate, containing 40 per cent nicotine, diluted at the rate of one part to 800 parts of water; or one-half pint to 50 gallons. To each 50 gallons of diluted spray material add 3 pounds of cheap soap dissolved.
>
> Gallon lots may be prepared as follows:
> 2 teaspoonfuls 40 per cent nicotine sulphate
> 1 inch cube laundry soap
> 1 gallon water

Extracts of derris root and pyrethrum are on the market under certain trade names. Some of these products are satisfactory for controlling aphids, if properly applied.

In some cases, infestations can be reduced by the application of a strong stream of clear water, applied with a hose. The water will wash many of the aphids from the trees.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 5

MITES ON TREES

By Josef N. Knull, *Entomologist*

Forest, shade, and ornamental trees are infested with numerous species of mites which vary greatly in their life histories, appearances, and nature of injury produced. The common red spider is probably the most common and best known species. These small creatures, which are almost microscopic, are not true insects, but belong to the order Acarina. The adults are brown and have eight legs instead of the six which the insects possess. Owing to the fact that these pests are so small, they are seldom noticed, but their presence is indicated by the injury produced.

Mites, though present and working on forest trees, seldom cause any severe injury, or at least their injury is not of much importance as far as the welfare of the forest is concerned. On the other hand, shade, ornamental, and nursery trees suffer considerably, especially the smaller evergreens. On hardwoods, some mites cause galls on the small branches. Others form irregular gall-like or blister-like areas on the leaves. Still others cause a mottling of the foliage. Some species are capable of spinning webs. The greatest damage is done to evergreens, where the presence of these pests is indicated by a mottling and discoloration of the foliage, together with small webs. Injury is caused by the adults piercing the epidermis and sucking the juices from the foliage. The injury is more pronounced in dry weather, which is favorable to the mites and unfavorable to the trees. Small evergreen trees are often killed by mites, or made so unsightly by the loss of foliage that they become worthless as ornamentals. Mites lay eggs and the winter is spent in either the adult or egg stage.

CONTROL

Miscible Oil During Dormant Season. A thorough spraying with a good miscible oil in the dormant season will eradicate these pests on hardwoods or conifers. Oil sprays should not be used in the winter when the temperature is 40° Fahrenheit, or below, and dormant strengths of spray should not be used in the growing season. In other words, do not spray evergreens or hardwoods with dormant strengths of miscible oils when the hardwood leaves are on the trees.

Miscible Oil During Growing Season. Good results were obtained by the writer with "Volck" spray oil applied to various infested evergreens

during the growing season, at the rate of 1 gallon of oil to 100 gallons of water. Infested trees should be sprayed as soon as the damage is noticed. All applications should be thorough, for the adults are capable of concealing themselves in leaf crotches where they are hard to reach with spray. It may be necessary to give several applications before a thorough clean-up is obtained.

Washing With Water. Where it is impossible to spray evergreens with oil sprays, syringing the infested trees with a strong stream of clear water will tend to check the infestation. This operation washes many of the adult mites to the ground, where they become imbedded in the mud and fail to return to the infested trees. The water will tend to stimulate the growth of the trees and in this way counteract the injury produced by the mites. Trees should not be sprayed with water during the heat of the day in midsummer; morning and evening are the best times for this work.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934
Leaflet No. 6

THE PINE BARK APHID

By Josef N. Knull, *Entomologist*

The pine bark aphid (*Chermes pinicorticis* Fitch) is common on forest, nursery, and ornametal white pines in Pennsylvania, and will also attack balsam fir. Its presence is indicated by white cottonylike masses on the trunks or branches of the infested trees.

Although this insect apparently does not seriously injure large white pines, it is often injurious to small trees. Aside from the white masses of the insects, which are often rather unsightly, the aphids suck the juices from the trees, causing a stunting of the growth and a discoloration of the foliage. The needles on small infested trees become short and have a brush-like appearance.

The pine bark aphid is one of the numerous members of the family which secrete a white, flocculent substance which tends to act as a protection to them. The adult insects are seldom seen, since they are usually hidden beneath the white masses. The winter is spent in the egg stage, the downy masses of eggs being deposited near the bases of the needles. These eggs hatch in May into young aphids which settle down in new localities after moving about for a short time. By the end of May these young are mature and eggs are deposited by them. There are several generations each year in Pennsylvania.

CONTROL

Nicotine Spray. Since the pine bark aphid is a sucking insect, a contact insecticide must be used for control. The following spray should be applied in May, after the overwintering eggs have hatched, with sufficient pressure to enable the spray material to penetrate the downy covering of the aphids. In order to clean up a tree it may be necessary to spray it several times during the season.

Nicotine sulphate (40 per cent)	½ pint
Cheap soap (dissolved)	3 pounds
Water	50 gallons

Gallon lots can be prepared as follows:

Nicotine sulphate (40 per cent)	2 teaspoonfuls
Laundry soap (dissolved)	1 inch cube
Water	1 gallon

Washing With Water. Syringing infested trees with a strong stream of clear water will wash many of the insects off. Those dislodged in this way will not be able to get back on the trees again.

(9-33)

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 8

THE WHITE-MARKED TUSSOCK MOTH

By Josef N. Knull, *Entomologist*

The white-marked tussock moth (*Hemerocampa leucostigma* Abb. & Sm.) is one of our most common and destructive shade tree pests in Pennsylvania. It does its damage in cities and towns where artificial conditions exist and seldom if ever causes any injury in the natural forest. With the exception of evergreens, it attacks almost every species of tree.

The damage is done by the caterpillars which eat the foliage of the trees, often leaving nothing but the midribs of the leaves. It is not unusual to see a tree which has been entirely defoliated. In addition to the injury to the trees, the caterpillars spin cocoons on trunks, branches, and buildings which tend to make surroundings unsightly.

LIFE HISTORY

The over-wintering eggs, which are laid by the females in white masses on the outside of the cocoons, hatch about May into small caterpillars. These young larvae crawl to the foliage and start feeding. They are capable of suspending themselves by slender cords to new food supplies when they have exhausted the foliage where they are feeding, or can crawl considerable distances to new feeding grounds.

The mature caterpillars, which are about 1½ inches long, with bright red heads and ornamented with tufts of black and yellow hairs, are rather striking in appearance. When the larvae are fully developed they crawl to buildings or trunks and branches of trees and spin silken cocoons, utilizing the hair from their bodies in the construction of these structures.

In these cocoons the caterpillars transform to pupae. This pupation occurs about June or July. The pupal stage is the resting stage of the insect and lasts about fifteen days. At the end of this time the adults appear.

The adult male is a light gray moth with a wing spread of about one inch, with figured upper wings and darker lower wings and two feathery antennae. The males are capable of flying long distances.

The female, on the other hand, is wingless and does not have feathery antennae like the male. She is about five-eighths of an inch long, light gray in color and much plumper than the male. After emerging from her cocoon and being fertilized she starts laying eggs. The eggs are in

the form of a white mass and are always laid on the outside of the cocoon. After egg laying the female dies, without having travelled any distance from the cocoon constructed by the larva.

Approximately two weeks after deposition, the eggs hatch and a second brood of young caterpillars emerge. These in turn pass through a life history similar to the preceding ones, which have been described. The latitude will determine the number of generations this insect has in a single year. There are two generations in Pennsylvania, although north of us there is but one, and south of us, three.

CONTROL MEASURES

Spraying. Since the young caterpillars are easily killed by the application of a poisonous spray, it is easy to prevent injury to foliage in infested localities. The following spray should be applied when the caterpillars are first observed on the foliage, or some time in May and again in August when the second generation of larvae appear:

Powdered arsenate of lead	1½ pounds
Water	50 gallons

Destroying the Egg Masses. In badly infested sections it will be advisable to gather the cocoons by hand and burn them any time between the first of October and the first of May.

The egg masses may be destroyed by daubing them with creosote. It may be necessary to thin the creosote with turpentine in cold weather, since it tends to thicken at low temperatures.

BANDING

Since the adult female moths do not fly and the caterpillars are somewhat migratory in their habits, it is advisable in heavily infested sections to band trees which do not contain egg masses, or whose branches are not intertwined with the branches of infested trees. Sticky banding material, or ordinary cotton batting can be used for this purpose. The caterpillars, which would ordinarily crawl up the trunks of the trees for feeding, are prevented from passing the band barriers. The bands should be placed on the trees just before the eggs hatch.

To place a cotton batting band, cut the strip of cotton so that it is about six inches wide and just a trifle longer than the circumference of the tree to be banded. Place the batting around the trunk and tie the bottom edge by wrapping a string around the tree. After the bottom edge is securely fastened, turn the top part down over the string, thus forming an off-set of loose cotton around the trunk.

Sticky banding material may be prepared by placing 5 pounds of rosin and 3 pints of castor oil in a pan and slowly heating until the rosin is melted. More oil should be added if the mixture is too thick.

Another formula for banding material is as follows:

Axle grease	1 pound
Fish oil	1 pint
Powdered rosin	2 pounds

Heat the axle grease in a pan until all the water in it is evaporated. While the pan is still on the fire slowly stir in the fish oil and then the powdered rosin. When the rosin is dissolved the mixture should be removed from the fire. It will be ready for use the following day.

Since some sticky banding materials are apt to cause injury to the trunks of trees it is not advisable to place them in direct contact with the bark. This is best averted by placing the sticky banding material on heavy tarred building paper which has been fastened tightly around the tree. By placing a two-inch strip of cotton batting around the tree underneath the building paper, all of the cracks between the paper and the bark will be closed. This prevents any of the small caterpillars crawling underneath the paper.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 9

TERMITES OR WHITE ANTS

By Josef N. Knull, *Entomologist*

The name white ants is a misnomer, for termites are not related to true ants in any way. Owing to the fact that they resemble ants in appearance and have similar social habits and actions, they have acquired this name.

Termites are common throughout Pennsylvania and do considerable damage to wood which is in contact with the soil. It is a common occurrence for them to work into buildings from infested sills. They hollow out the interior of the parts infested with their extensive galleries which run parallel with the grain, leaving only a shell of wood on the outside. The food of termites consists of wood (cellulose), which is eaten over and over again until all of the nutriment is taken from it.

Since only the sexed adults can withstand bright sunlight, there is very little evidence of their presence in the parts attacked, until an immense amount of damage is done. Their workings often extend a long distance from the part of the wood actually coming in contact with the soil. In order to get at further food supplies they construct covered runways, or shelter tubes, over objects not suitable for food. These tubes are made of moist earth mixed with excrement, and allow the insects to travel about from one place to another without exposing themselves to the sunlight. They also travel through galleries under ground for long distances. In addition to working in sawed lumber and poles which are in contact with the soil, they live in dead trees, logs, and fallen timber in the woods.

LIFE HISTORY AND HABITS

Termites have three stages of transformation: eggs, nymphs, and adults. Each nest contains wingless workers of both sexes, which do all of the work and provide food for the colony. Another class consists of wingless soldiers, of both sexes, with large heads and long, sharp mandibles. These soldiers are the defenders of the colony and protect it against insect enemies. A third class includes the darker colored sexual individuals, which have wings when they are fully mature, and which furnish the kings and queens for future colonies. When the colony swarms, it is this class that sallies forth in great numbers, flying to new localities where they pair, shed their wings and develop into kings and

queens, thus being in a position to start new colonies. These winged sexual individuals are often observed in houses, or emerging from dead wood out-of-doors. Their shed wings are frequently observed in houses where this pest is present. The mortality of this class is very high.

The queen in her new location lays the eggs which result in the young for the new colony. As her egg laying capacity increases she develops in size, often attaining a length of over one-half inch.

As previously stated, the presence of termites is not usually known until the migratory flight begins, or after it is too late to prevent damage. When the winged sexual individuals appear it is an indication that there is a colony of termites close at hand. Killing these winged forms is no method of control, for they only represent the swarm from the main colony. Another indication that these pests are present is the presence of shelter tubes previously described.

CONTROL METHODS

Removing Infested Wood. When the presence of termites is observed in a building it is advisable to locate the place where the insects are working. If this section of wood is found, it should be removed and replaced with new material.

Fumigation. If the part infested is of such a nature that it is impossible to replace it, the use of a fumigant such as calcium cyanide, orthodichlorobenzene, paradichlorobenzene dissolved in kerosene, or carbon bisulphide can be used. It is necessary to know that the fumes of carbon bisulphide are extremely explosive and great care should be exercised in using it. Calcium cyanide gives off hydrogen cyanide gas, which is extremely poisonous to humans. The fumes of calcium cyanide are light, while the fumes of the other substances mentioned are heavier than air and will penetrate into the ground. In order to exterminate the colony, the queen must be killed.

PREVENTIVE MEASURES

Removing Breeding Places. Old logs and stumps make ideal breeding places for termites, especially on recently cleared land. Since the insects are apt to travel from them to buildings or to stored lumber, it is advisable to remove such debris from the vicinity of buildings or lumber which might become infested.

Placement of Wood. Untreated wood should not be allowed to come in direct contact with the soil, or two pieces near the ground should not be joined in such a way that their joint will retain moisture. Stone, concrete, brick, tile, or a substance other than wood should always separate untreated wood from the soil.

Treating Wood. All wood, including poles, that comes in contact with the soil should be thoroughly impregnated with coal tar creosote, or some other good wood preservative. This not only prevents decay, but also acts as a repellent to termites.

REFERENCES

The White Ant. United States Department of Agriculture, Bureau of Entomology, Circular 50. Marlatt, C. L., 1908.

White Ants. United States Department of Agriculture, Farmers' Bulletin 1037. Snyder, T. E., 1919.

Preventing Damage by Termites or White Ants. United States Department of Agriculture, Farmers' Bulletin 1472. Snyder, T. E., 1926.

Termites in Buildings. United States Department of Agriculture, Leaflet 31. Snyder, T. E., 1929.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 10

THE LOCUST BORER

By Josef N. Knull, *Entomologist*

The black locust is severely injured and often killed by one of the long-horn borers known as the locust borer (*Cyllene robiniae* Forster). It attacks perfectly healthy trees, mining the heart wood to such an extent that the trunks and large branches are often broken off by the wind. This borer is largely responsible for the peculiar shape of the majority of locust trees throughout Pennsylvania and often renders black locust wood unfit for commercial purposes. It has been practically impossible to grow pure stands of locust because of this pest, and numerous attempts to do so have invariably been failures.

The adult beetles, which are rather striking in appearance, emerge about the latter part of August or the first of September. They are from ½ to ¾ of an inch in length, rather stout, and ornamented with yellow on a black background. They are pollen feeders and can usually be found on the flowers of the goldenrod, the color of which blends in with the yellow markings of the beetles, and affords them more or less protection from their enemies. The adults can also be seen on the trunks of locust trees travelling rapidly up and down in the bright sunlight, seeking mates, or suitable places to lay their eggs.

The first eggs are laid in the crevices of the rough locust bark in September. They hatch into small larvae which bore into the bark with their sharp mandibles. As cold weather approaches they become quiescent and remain in this condition until spring. When the weather becomes warm the following spring they again start operations, boring through the bark and into the sapwood of the trees. From the sapwood, the larvae enter the heartwood where their burrows extend for considerable distances parallel with the grain.

In constructing and enlarging these galleries, the larvae find it necessary to push out the borings in order to have room to move about. This necessitates making openings to the exterior, which result in irregular, rough areas on the trunks and limbs where the injuries heal. As fall approaches the larvae reach maturity and enlarge parts of the burrows to form cells for pupatation, the outer ends of which are tightly plugged with shredded wood (frass). The frass acts as a barrier against certain enemies. In these cells the larvae transform to pupae, which is the resting stage of the insect between the larval and adult forms. The pupae

transforms to adults which liberate themselves by gnawing away the wads of frass which separate the pupal cells from the burrows leading to the exterior of the trees.

Silvicultural Control. The locust borer is a light-loving insect, and for laying its eggs prefers rough branches and trunks which are exposed to bright sunlight. Trees with shaded trunks are not so severely attacked. Therefore, it is advised that locust be grown in mixture with other species, which afford some measure of protection by their shade. It is particularly essential that the trunks of small trees, from 1½ to 6 inches in diameter, be well shaded.

It is advisable to grow black locust on good soils where the injury produced by the borers will be counteracted by the rapid growth of the trees. Locust trees grown on poor soils seem to suffer most.

Control on Shade and Ornamental Trees. Shade and ornamental trees often have an aesthetic value which warrants intensive treatment for this pest. Such measures would not be economical under forest conditions because of the high cost.

Either of the following sprays have been recommended for infested trees, to be applied to the trunks and branches about the time the buds burst in the spring. Care should be taken not to get any of the spray material on the opening buds, for burning is apt to result. The sprays are recommended for poisoning the young, over-wintering larvae before they have a chance to enter the heartwood of the infested trees. The spraying should be thoroughly done and all parts of the trunk and large branches should be covered in order to secure good results. Trees containing larvae can be recognized by the exudation of sap and the small piles of dust borings on the trunks.

¼ pound of sodium arsenate, or sodium arsenite, dissolved in 5 gallons of water.

1 quart of miscible oil should be added to this and the entire mixture should then be thoroughly stirred.

In case it is not convenient to obtain miscible oil, kerosene emulsion can be substituted. In this case the following formula can be used:

¼ pound of sodium arsenate, or sodium arsenite, dissolved in 4 gallons of water.

1 gallon of kerosene emulsion stock solution should be added to this and the whole stirred thoroughly until it is well mixed.

Kerosene emulsion stock solution can be prepared as follows:

Kerosene	2 gallons
Fish oil, or laundry soap	½ pound
Water	1 gallon

Place the water and soap in a utensil and heat until all the soap is dissolved, remove from the stove and add the kerosene, stirring until it is thoroughly mixed.

Since many of the young larvae fail to mature in rapidly growing trees, it is advisable to stimulate the growth of valuable locust trees with water, or fertilizers.

REFERENCES

Protection from the Locust Borer. United States Department of Agriculture, Bulletin 787. Craighead, F. C. 1919.

Some Insects Injurious to Forests: Additional Data on the Locust Borer. United States Department of Agriculture, Bureau of Entomology, Bulletin 58, Part III. Hopkins, A. D., 1906.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 11

THE ELM LEAF BEETLE

By Josef N. Knull, *Entomologist*

The elm leaf-beetle (*Galerucella xanthomelaena* Schrank), originally native to southern Europe and the Mediterranean islands, has been introduced and is now established in various parts of Pennsylvania. Both the larvae and adults feed on the foliage of elm, and about the first indication of their presence is the lace-like appearance of the foliage where the leaves have been skeletonized. It is primarily a shade tree pest and is commonly found in the cities, where the adults find ideal hibernating quarters.

The winter is spent in the adult stage in cracks and crevices in sheltered places. The adults emerge from their winter quarters about the time the buds begin to swell in the spring. When the buds burst they start feeding on the new foliage, and mating occurs. In feeding the adults eat holes in the leaves. When the foliage is almost fully developed the eggs, which are orange-colored, are laid in clusters on the under surfaces. In about a week the eggs hatch into small larvae. These feed on the under sides of the leaves, which they eventually skeletonize. Later the leaves which have been injured, turn brown and dry up.

About twenty days after egg hatching the larvae are fully developed. These mature larvae are each about one-half inch in length, yellow in color, with two dark stripes along the body and a dark head. The larvae possess six legs for crawling and upon becoming full grown they travel down the trunks to sheltered places, where they pupate. The pupae are dark yellow, about one-fifth of an inch in length, and can be found in clusters under the bark, or at the bases of the infested trees.

The adult beetles emerge from the pupae about July. They are about one-fourth of an inch in length, yellowish-green in color, with dark markings on the thorax and dark stripes on the wing covers. The color and markings of the adults vary considerably with their age.

The number of generations each year depends on the latitude, and may vary in different parts of the State. In the vicinity of Harrisburg there are two generations annually.

CONTROL MEASURES

Since this insect is a leaf feeder, stomach poisons must be used to combat it. The following spray is recommended for application about

the time the leaves are unfolding in the spring. This will kill the adults before they have had a chance to lay their eggs and will prevent the injury caused by the feeding of the hibernating forms:

Powdered arsenate of lead	2 pounds
Water	50 gallons

Gallon lots may be prepared as follows:

Powdered arsenate of lead	6 teaspoonfuls
Water	1 gallon

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 12

BARK BEETLES AND AMBROSIA BEETLES

By Josef N. Knull, *Entomologist*

Bark beetles and ambrosia beetles (family Scolytidae), are responsible for the injury and death of many evergreen and hardwood trees throughout Pennsylvania every year. The bark beetles usually mine beneath the bark, destroying the vital cambium layer of the trees. The ambrosia beetles bore into the solid wood, making irregular galleries, thus causing what is known as pinhole injury in lumber. One species of bark beetle works in the cones of living white pine; numerous species mine the pith of small branches.

The majority of the bark and ambrosia beetles are small, ranging in size from less than 1/16 to over 1/4 of an inch in length. They are usually brown or black in color and cylindrical in form. Some species, such as those of the genus *Dendroctonus* and the hickory bark beetle, which has killed hickories very extensively throughout the State, are primary in their attack and infest perfectly healthy trees. Other species attack freshly cut trees, logging slash, or living trees of low vitality.

LIFE HISTORY

Bark Beetles. The histories of the various species of bark beetles differ with the species themselves. In most cases the adults fly to uninfested trees where they gain entrance by burrowing through the bark with their sharp mandibles, and start tunnels beneath it. The entrances of the burrows are well marked by the holes in the bark and the small patches of fine borings, thrown out by the adults in their excavations. Some species which attack living pines produce "pitch-tubes" or "resin-tubes" on the sides of the trees, caused by the exudation of pitch at the points of entrance.

The eggs are laid by the females in niches on each side of the burrows underneath the bark. These eggs hatch into small, cream-colored legless larvae with strong mandibles. The larvae start feeding in the cambium layers, gradually enlarging the diameters of their burrows as they work away from the main tunnels made by the adults.

The markings of their tunnels on the outer wood and the inner bark often resemble engraving, and they are sometimes called engraver beetles for this reason. Each species has its characteristic gallery which can be

readily identified by an experienced entomologist. Wood staining fungi sometimes accompany bark beetle attacks and often make the wood unfit for commercial purposes.

When the larvae are full grown they prepare pupal cells at the ends of their burrows, where they transform to pupae. The pupae develop into mature adults which liberate themselves by gnawing holes through the bark to the exterior of the infested trees. These adults are then free to fly to other trees where the same life history is repeated. The number of generations in a year depends on the species and latitude of location.

Ambrosia Beetles. The ambrosia beetles do not work in the cambium layers, but extend their burrows through the bark and into the wood of the infested trees. The females lay eggs in the irregular galleries which have been made by adult insects. The eggs hatch into larvae resembling the larvae of the bark beetles.

The larvae are fed on certain fungi which are propogated by the adults in the burrows. These fungi, which are usually different species of ambrosia, stain the side walls of the galleries, making them dark in color. The beetles get their name from the fact that they make use of these fungi for food.

In some species the larvae are known to do a little boring, but most of the injury is caused by the adult ambrosia beetles. Unlike most beetles, the adults pair and live together in the burrow attending to their young until maturity. In addition to the pinhole injury of the wood produced by these insects, the stain resulting from the fungi in the galleries often makes the lumber unfit for commercial purposes.

CONTROL

Stimulants. Since many of the secondary bark and ambrosia beetles attack and kill only slowly growing or unhealthy trees, infestations may be prevented if the trees are kept in a vigorous growing condition. Some species attack healthy, fast growing trees, but will not be able to cause much injury if the trees are growing rapidly. Since drought conditions are quite favorable for the attack of bark and ambrosia beetles, it is advisable to see that valuable shade and ornamental trees have sufficient water, for abundant moisture is one of the greatest factors in keeping down infestations of these pests.

In other instances it is advisable to apply fertilizers in order to stimulate the growth of weakened trees which might be susceptible to attack. In Pennsylvania, the evergreens have more bark beetle enemies than the hardwood trees.

Trees attacked by bark beetles are easily recognized by their brown tops, and upon closer examination, by the dust-like borings on their trunks thrown out of the burrows by the adults. It is useless to try to save trees in this condition, but neighboring individuals can often be kept free from infestation by stimulating their vigor and growth.

Destroying infested trees. Since the insects in infested trees are apt to spread to surrounding trees, it is advisable to eliminate them in any one of the following ways:

1. Cut and burn all parts of the infested trees.

2. In case of a forest infestation, cut and utilize all infested trees. Bark should be peeled and burned, together with all logging slash, limbs, and tops. Trees killed by bark beetles are subject to the attack of secondary wood borers which soon render the wood unfit for lumber. Infested trees should be cut as soon as noticed if they are to be salvaged.
3. In well-exposed, sunny situations, infested trees can be cut in midsummer and if all parts are kept fully exposed to the sun, the insects will soon be killed by the heat. The logs and tops should be turned every few days to allow the hot sun to strike all the surfaces. It is most effective to lay them in a north and south direction.

PREVENTIVE MEASURES

Healthy, fast-growing stands of forest trees are usually not attacked by bark beetles. Hence the application of silvicultural improvement cuttings, which thin out the weakened or inferior trees and leave the best individuals for further growth, tends to prevent attack of bark beetles, as well as of many other tree pests.

If infested trees are cut during the winter, and immediately utilized, or the bark peeled, the insects will be destroyed. Trees cut in the winter, when the beetles are inactive, will be dried out to such an extent before spring that there is no danger of their becoming infested.

If summer cutting is practiced, logs should be barked or utilized as soon as possible and all slash should be burned. Fresh cutting in the summer attracts bark beetles and ambrosia beetles. Many species of insects will not infest logs which have been barked.

REFERENCE

The Southern Pine Beetle; A Serious Enemy of Pines in the South. United States Department of Agriculture, Farmers' Bulletin 1586. St. George, R. A. and Beal, J. A. 1929.

(9-33)

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 13

THE BRONZE BIRCH BORER

By Josef N. Knull, *Entomologist*

The bronze birch borer (*Agrilus anxius* Gory) is responsible for the death of many birches throughout Pennsylvania every year. Although the birches are most commonly injured, the insect also attacks the poplars. It infests living trees, often causing irregular swellings over the galleries, where the injuries tend to heal. The first symptom of infested trees is the death of the top branches. Slowly growing trees in an unhealthy condition are most susceptible to attack.

The adults are small bronze beetles about one-half inch in length and somewhat pointed at the posterior end. They emerge from their pupal cells in the infested trees about June, and, after mating, start laying eggs in crevices on the bark of other trees, or on the same tree if it has not been killed. They are light lovers and are most active in the bright sunlight.

The eggs hatch into small larvae which bore through the bark and mine for a short time underneath it. The galleries are irregular and often are intertwined in such a way as to cut off entirely the food supply of the infested trees by girdling them. The larvae eventually enter the sapwood and after boring in and out through it, construct pupal cells in which they pass the winter.

The full grown larvae are cream colored, kite shaped worms, which is typical of flat-headed borer larvae. They have two spine-like appendages on the posterior end and can be found doubled up (U-shaped) in their pupal cells. They do not transform to pupae until the following spring shortly before the adults emerge. The adults are formed in the pupal cells and liberate themselves by gnawing holes to the exterior. Their exit holes are not round, but semi-circular and flat on the one side.

CONTROL MEASURES

No practical control methods are known for this insect. Valuable shade and ornamental birches should be kept in a healthy, fast growing condition, if necessary by the use of stimulants such as water or fertilizers. The bronze birch borer is less apt to infest trees of rapid growth. Infested trees standing with valuable ornamental birches should be cut and burned in the winter, any time before May.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 14

SPRUCE GALL FORMING APHIDS

By Josef N. Knull, *Entomologist*

There are several species of aphids in Pennsylvania that cause galls to form on spruce trees. These galls, which are green in color, are located on the small branchlets and range from three-fourths of an inch to three inches in length. Although trees are never killed by these insects, the small branchlets often die and these brown twigs, together with the gall-like deformations, make the trees very unsightly. The injury is more noticeable on nursery and ornamental trees than it is on natural forest growth.

The most common species in Pennsylvania is called the spruce gall aphid (*Chermes abietis* Linnaeus). This insect lays its eggs about May in small clusters covered with a white, fluffy secretion at the bases of the buds on the infested trees.

The eggs hatch in about a week and the young aphids crawl to the tender growth where they start sucking the sap at the bases of the needles in the cracks caused by the feeding of the adult females. This sucking of the plant juices by female aphids, together with the feeding of the nymphs, produces an abnormal growth which tends to inclose the young in cells, eventually forming cone-like, many-celled galls on the infested branchlets. As the growth continues the cells are entirely closed, thereby inclosing the aphids and giving them protection from outside enemies.

The young aphids become full grown about August, when the galls turn from green to brown in color. At this time the galls open, allowing the nymphs to emerge from their cells. After shedding their skins they develop wings, become mature, and in several days the females start laying eggs. In about two weeks a second generation of young nymphs emerge from these eggs. These young aphids distribute themselves on various parts of the tree, where they pass the winter. They are small and are covered with a white, waxy-like secretion which acts more or less as a protection to them.

METHODS OF CONTROL

Hand Picking. Localized infestation of these gall-forming aphids can be controlled by collecting and burning the galls just after all the openings have closed, and before they have turned brown and opened to allow the

nymphs to escape. Cutting the galls from the branches and throwing them on the ground is not effective as a control measure.

Spraying. Since the mouth parts of these insects are adapted for sucking and not chewing, contact insecticides are necessary to combat them. For extensive infestations the following spray should be applied about the time the new growth starts in the spring:

Nicotine sulphate (40 per cent nicotine)	½ pint
Cheap soap	3 pounds
Water	50 gallons

Gallon lots can be prepared as follows:

Nicotine sulphate (40 per cent nicotine)	2 teaspoonfuls
Laundry soap	1 inch cube
Water	1 gallon

COMMONWEALTH OF PENNSYLVANIA.
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 15

THE BAGWORM

By Josef N. Knull, *Entomologist*

The bagworm (*Thyridopteryx ephemeraeformis* Haw.) is found throughout Pennsylvania and is one of the common shade and ornamental tree pests. The larvae, which are concealed in silken cases or bags, feed on the foliage of most hardwod trees and also certain evergreens. The greatest damage is done to evergreens since the parts which are defoliated always die. Occasionally trees are entirely defoliated and killed by this insect. Black locust and arbor vitae are the favorite food plants, although other species are often severely injured.

The insect winters in the egg stage within the tough silken bags, which are about 2 inches long, one-half inch in diameter, and protected with small sticks attached to the outer surfaces. The bags can be seen through the winter months tightly fastened to branches of trees.

The eggs hatch during May or June, and the young larvae, or worms, emerge from the bags and start feeding on the foliage. They soon inclose themselves in small silken, portable bags or cases, which are enlarged as the larvae develop in size. These cases are at first carried in an upright position, but as the worms develop in size and the bags are added to, they become heavy and hang down. The caterpillars move about from place to place, protruding their bodies which permits the use of the fore legs, feeding as they go and carrying their bags with them. The larvae become full grown in August and, having a somewhat migratory habit at this stage, are apt to travel considerable distances with their bags before they finally attach them to twigs or branches. The larvae then transforms to pupae, which is the resting stage of the insect. In September the adults develop.

In the transformation of the males, the pupae first partly protrude from the lower ends of the silken bags and then the adults emerge from them in this way. The adult males are small, dark gray moths, with feathery antennae, and measure about one inch across their spread wings, which are translucent. They can be seen flying about in the early fall.

The females, on the other hand, are wingless and develop entirely within the silken cases. After being fertilized by the males which fly to the bags for this purpose, the females lay their eggs on the inside of the silken cases, as many as 3,000 being recorded in a single bag. When the eggs are all laid, the females crawl from the bags and die.

CONTROL MEASURES

Collecting bags. As pointed out in the life history, the only means of distribution is by the wanderings of the larvae with their heavy silken bags. Therefore infestations are rather local and often severe, owing to the great number of eggs laid. On small ornamental trees the pest can be controlled by collecting the bags through the winter months and burning them, thus destroying the eggs which produce the young larvae.

Spraying. Since the larvae of the bagworm are somewhat resistant to arsenical poisoning, the same proportions of arsenate of lead used for most leaf chewing insects will not control them. The following spray thoroughly applied to the foliage in May or June, when the first larvae are observed, should give good results:

Powdered arsenate of lead	2 pounds
Water	50 gallons

Gallon lots can be prepared as follows:

Powdered arsenate of lead	6 teaspoonfuls
Water	1 gallon

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 16

LEAF EATING INSECTS

By Josef N. Knull, *Entomologist*

There are numerous species of insects, representing several orders, which eat the foliage of evergreen and hardwood trees. In some cases the larvae do the injury; in others, the adults. The leaf-eaters consist of caterpillars or many moths and butterflies, larvae and adults of numerous leaf beetles, adults of certain scarabs such as the Japanese beetle, and larvae of a few of the sawflies.

Since all of these forms mentioned have chewing mouth parts, they can be controlled by an application of some poisonous insecticide. Powdered arsenate of lead is one of the most widely used stomach poisons, in view of the fact that it is not apt to cause burning of the foliage and is easily procurable at any store handling insecticides.

Most of the above types of insects, with the exception of the adult Japanese beetle, can be controlled with the following spray, which should be thoroughly applied to both surfaces of the leaves:

Powdered arsenate of lead	1½ pounds
Fish oil (best grade of light pressed)	6 ounces
Water	50 gallons

Gallon lots can be prepared as follows:

Powdered arsenate of lead	4½ teaspoonfuls
Fish oil	1 teaspoonful
Water	1 gallon

This spray can be used without the fish oil, which is only added to increase the sticking properties of the arsenate of lead. It makes the spray more effective, in view of the fact that it is not easily washed off by rain. When the fish oil is used livestock should not be allowed to feed under sprayed trees.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 17

THE CARPENTER WORM

By Josef N. Knull, *Entomologist*

The carpenter worm (*Prionoxystus robiniae* Peck) is common throughout Pennsylvania and its work in hardwood forest and shade trees is often noticeable. The larvae mine the heartwood of the infested trees, making large irregular galleries, which leave the wood unfit for commercial purposes. Trees are sometimes weakened to such an extent by this hollowing out of the heartwood that they are easily broken by the wind. The large exit holes make ideal places for the entrance of heart rot, decay, and carpenter ants.

The carpenter worm is a primary insect and attacks perfectly healthy trees. It does not confine its attack to any one species, but will work in a number of hardwoods, including oak, black locust, sour gum, ash, maple, and chestnut. Oak and black locust are ordinarily attacked most severely, but trees are rarely killed because of the fact that the insect confines its feeding to the heartwood.

LIFE HISTORY

The adults of this species emerge from the infested trees in June and can often be seen flying around street lights after dark. The fact that these moths are attracted by lights is probably responsible for so many of the oaks on city streets being infested.

The female is a gray moth of striking appearance, with a wing spread of about 3 inches. Her front wings are gray with dark markings; the hind wings contain traces of yellow.

The male is somewhat smaller, measuring about 2 inches across his expanded wings. The front wings are much darker than those of the female, with light markings, whereas each hind wing has a large yellow area, edged with dark gray on the upper side.

The eggs are stuck in crevices usually around wounds, or on roughened areas of healthy trees. These eggs hatch into small pink larvae, or worms, which have stout mandibles adapted for chewing the hardest wood. The larvae work through the bark and eventually into the heartwood of the infested trees. The life cycle probably extends over a period of three years. In this time the heartwood is thoroughly tunnelled with long galleries which run parallel with the grain of the wood. Openings to the exterior are always made in order that the larvae may throw out the waste materials.

The full grown larva is a large, cream colored worm about 2½ inches in length and possesses stout mandibles, with a brown head and thorax. When the larva is full grown it clears the opening to the exterior and returns to the inner extremity of the burrow where it transforms to a pupa, or chrysalis, in a specially constructed oval cell. This cell is closed with borings (frass) at the open end. When the adult is ready to emerge, the pupa pushes away the frass and travels toward the entrance to the exterior.

Although the insect possesses no legs in the pupal stage, it travels by a squirming motion, together with the aid of its spines, which point backward on the segments. The empty pupal cases can be seen extended from the entrances on the infested trees, indicating that the pupae had worked their way partly out of the openings before the moths were entirely liberated. It is not unusual to see a number of these old empty pupal cases protruding from a single tree. For egg laying the insect seems to prefer trees which have been infested before.

CONTROL METHODS

Even though this insect is a serious forest pest, it is not practical to try to control it under forest conditions on account of the high cost. Where trees have aesthetic value and expense is not the first consideration, the following methods can be employed.

Fumigants. By injecting carbon bisulphide or calcium cyanide into the openings made and used by the larvae to throw out borings, the worms can be killed. After injecting fumigants of this kind, the openings should be tightly closed immediately with clay or putty in order to keep the toxic fumes in the burrows.

Poisonous sprays. When the first evidence of attack is observed on trees, the young larvae can often be killed by either of the following sprays, which should be applied with a strong hand sprayer, or, better, injected into the larval openings with a syringe. These sprays will burn the foliage if allowed to fall on the leaves.

¼ pound of sodium arsenate, or sodium arsenite, dissolved in 5 gallons of water.

1 quart of miscible oil should be added to this and the entire mixture thoroughly stirred.

In case it is not convenient to obtain miscible oil, kerosene emulsion can be substituted. The formula is as follows:

¼ pound of sodium arsenate, or sodium arsenite, dissolved in 4 gallons of water.

1 gallon of kerosene emulsion stock solution should be added to this and the whole stirred thoroughly until it is well mixed.

Kerosene emulsion stock solutions may be prepared as follows:

Kerosene	2 gallons
Fish oil soap, or laundry soap	½ pound
Water	1 gallon

Place the water and soap in a utensil and heat until all of the soap is dissolved. Remove from the stove and add the kerosene. Stir the mixture until it is thoroughly mixed.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 18

THE PARANDRA BORER

By Josef N. Knull, *Entomologist*

Shade and ornamental trees are often infested with one of the longhorn borers known as the parandra borer (*Parandra brunnea* Fabricius), which works in old wounds and causes cavities to form. The insects keep breeding in the same areas year after year, until the trees attacked are so weakened by the destruction of the surrounding wood that they break or split. This insect also attacks untreated poles beneath the ground, weakening the structure to such an extent that they sometimes break.

The adult parandra borer is a somewhat flattened, shiny, light brown beetle about ¾ of an inch in length. The males can readily be distinguished from the females by their larger, stouter mandibles. The adults appear about July and egg laying begins shortly after they emerge. The eggs which are laid in wounds, usually where wood decay has started, hatch into cream-colored larvae. These young larvae have stout mandibles for chewing and work in the wounded areas, later extending their burrows into the sound wood of the infested trees.

The larvae develop slowly and it is supposed that they live at least three years in the wood. In this time they are able so to extend their irregular galleries, that the entire heartwood is honeycombed. When they are fully grown they are about 1¼ inches in length and construct pupal cells in which to transform. In these cells the larvae pupate and the pupae in turn transform to adults. These adults liberate themselves by gnawing through the dead wood to the exterior.

PREVENTIVE MEASURES

Since this insect only attacks wounds and dead wood on trees, it is advisable to keep valuable shade and ornamental specimens in a thrifty growing condition. Wounds sterilized and properly treated to prevent decay are not liable to infestation. Dead stubs make ideal breeding places and should be removed.

CONTROL MEASURES

Cavities in trees of aesthetic value infested with this insect should be thoroughly cleaned out with a sharp chisel or gouge. All decayed wood should be removed, leaving a clean cavity larger on the inside than at the

entrance to hold the filling. The edges of the sapwood and bark adjoining the cavity should be shellacked as soon as the chiseling is finished.

The cavity should then be sterilized by giving it a thorough painting on the inside with coal tar creosote. This will act as a repellent to any insects which might come to oviposit in the area and at the same time it prevents decay.

The cavity should then be filled with cement prepared by mixing 1 part of the best grade of cement and 3 parts of fine sand with water. This can be placed in the cavity with a mason's flat trowel, being careful to tamp it in firmly in order to get the cavity entirely filled.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 19

TWIG AND BRANCH PRUNERS

By Josef N. Knull, *Entomologist*

There are a number of hardwod twig and branch pruning insects native to Pennsylvania. While these species never kill large trees, they often deform them in such a way that their growth is interfered with or made unsightly for ornamental use. Some of the species prune small trees severely, interfering with their form and sometimes cutting them off entirely. Occasionally branches 3 inches in diameter are cut from living trees. One of these insects is a flat-headed borer; all of the other species mentioned are long-horn borers.

In all but one species, the pruning is done by the larvae, which bore in a circular manner, either cutting the twigs off entirely or so weakening them that they are easily detached by the wind. The first operation of the larvae is usually to bore through the parts to be disconnected, and the pruning of the branches is completed about the time the worms become full grown. Their purpose in pruning is to stop branch growth at the time the transformation cell (pupal cell) is ready to be formed. The larvae usually fall to the ground in the pruned branches, although occasionally they remain in the stubs on the trees.

One of the flat headed borers (*Agrilus arcuatus* Say) prune twigs and branches of oak, beech and hickory. Young hickory trees are often severely deformed, or cut off by its work.

The twig girdler (*Oncideres cingulatus* Say) girdles the small branches of various hardwood species, but shows a preference for hickory. The adult female girdles the branches and lays her eggs in the parts girdled. The branches, which are killed by the girdling of the adults, either fall to the ground, or remain for some time on the trees. The larvae mine the girdled parts.

Branches are pruned from beech, birch, and alder by one of the long-horn borers (*Xylotrechus quadrimaculatus* Haldeman).

The maple and oak twig pruner (*Hypermallus villosus* Fabricius) prunes the branches from various species of hardwood trees. Oaks suffer most and the pruned twigs and branches under oak trees in the fall are often noticeable. The larvae cut through branches in the late summer while the leaves are still on the trees.

Another long-horn borer (*Pseudibidon unicolor* Randall) prunes the small branches from black walnut, beech, hickory, and oak in the spring.

A striking long-horn borer (*Purpuricenus axillaris* Haldeman), which is coal black with bright vermillion markings, cuts larger branches than any of the other branch pruners. The larvae do the pruning and work completely through the branch and branchlets of the limbs cut.

Another long-horn borer (*Aneflomorpha subpubescens* Leconte) attacks white oak seedlings. The larvae hollow out the stems, leaving nothing but a thin shell of bark. Toward fall, the trees are cut off at the surface of the ground, the full grown larvae going into the roots to pass the winter.

Members of the genus Oberea are twig pruners on a number of hardwood trees and shrubs. Aside from damaging certain ornamentals they are not of much economic importance.

CONTROL MEASURES

The injury in the forest caused by these insects can ordinarily be disregarded, for it does not cause serious economic loss. However, persons who find the pruned branches are often curious to know how the damage occurred.

Where considerable damage is done to valuable ornamental trees it is advisable to collect and burn the fallen branches during the winter, or early spring. Where properties are adjacent to wooded areas, which act as a constant source of infestation, control methods are not apt to be effective.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 20

ANTS AND TREES

By Josef N. Knull, *Entomologist*

The large black carpenter ant (*Camponotus herculeanus pennsylvanicus* DeG.), which normally breeds in old decayed logs and stumps in the woods, often causes severe injury to living trees by honeycombing the interiors to such an extent that they are broken by the wind. Entrance is usually gained at a wound where decay has started, for this insect is not capable of attacking perfectly sound trees. Its presence is always indicated by the dust-like borings which are thrown out by the workers at the points of entrance. In addition to injuring living trees, it often finds its way into buildings, attacking and mining the larger timbers, and proves to be a general nuisance in the household.

The mound building ant (*Formica exsectoides* Forel) constructs large nests in the form of mounds which are often 6 feet in diameter. The mounds consist of material carried out in constructing the galleries. It is not uncommon for a number of these mounds to belong to a single colony of ants. They are always located on sites where they receive full sunlight, and never on slopes with a northern aspect.

Mound building ants are known to kill trees in the vicinity of their nests, especially those whose branches tend to shade these structures. This is recorded as being accomplished in several ways. White pines are killed by the ants gnawing away the epidermis around the bases of the trees, and ejecting formic acid on the injured parts. This acid coagulates the cell contents and prevents the downward flow of sap, thus killing the trees. Ants have glands for secreting formic acid which is used by them in subduing their prey. The foliage of hardwood trees is often removed by the ants severing the petioles of the leaves.

The food of ants consists primarily of insects, although they are general feeders, and are very fond of sweet substances. They eat the honeydew or sweet liquid secreted by aphids and scale insects, and by their presence are often blamed for causing the injury which is produced by these other insects. Ants actually herd aphids for their sweet honeydew. Some species are known to take care of aphid eggs in their nests during the winter and to carry the young plant lice out in the spring, placing them on food plants.

The life histories of ants are very interesting, for they have complete transformation (metamorphosis), are social insects, and the colony is

divided into castes. Each individual has a duty to perform and works for the good of the entire colony. The workers have great courage and will attack anything, including man, when their nests are disturbed. Most colonies contain a queen, wingless workers which do the work for the entire nest, and also winged males and females. When a colony swarms, it is these winged males and females which sally forth in great numbers to new localities, where new colonies are established: At certain times of the year, the air is full of these flying forms and most persons have observed them at one time or another. The males die after fertilization takes place, but the females tear off their own wings and become queens for new colonies. The queen does the egg laying for the entire colony and it is necessary to kill her to destroy a nest.

CONTROL MEASURES

In trees of ornamental values it is practicable to destroy carpenter ants by injecting carbon bisulphide into the openings where the dust-like borings are thrown out by the workers. After this liquid is injected the opening should be immediately and tightly closed with clay or putty. When a colony has been destroyed the openings should be permanently sealed with cement to prevent further infestation.

Ants working in woodwork of buildings can be exterminated by fumigation in the same way. It is of course necessary to locate their galleries in order to know where to apply the fumigant.

When ants become a nuisance in houses, they can be killed by sprinkling sodium fluoride around the place where they frequent. This will not destroy the colony, however, for the queen is constantly laying eggs which restock the colony.

Nests of mound building ants can be destroyed by pouring carbon bisulphide into them. About 1½ pounds are necessary for a large nest, and is best applied by pouring it into holes which have been punched into the hill with a stick. As soon as the liquid has been poured it is advisable to cover the mound with a layer of papers, or bags, and shovel earth over it. This will tend to keep the fumes in. In using carbon bisulphide it is necessary to bear in mind that it is very volatile and the fumes, which are heavier than air, are highly explosive.

According to experiments conducted at the Pennsylvania Forest Research Institute, it appears that colonies of mound building ants may be eradicated by covering their nests with a thick layer of brush, which excludes the sunlight and warmth which a colony must have for development.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 21

POWDER-POST BEETLES OF THE GENUS LYCTUS

By Josef N. Knull, *Entomologist*

Well seasoned sapwood of a number of hardwood trees, especially ash, hickory, and oak, is subject to the attack of powder-post beetles belonging to the genus *Lyctus,* which mine the wood and literally pulverize it with their borings. A thin shell of wood is always left on the outside of the pieces in which they are working, which tends to conceal their depradations. Indications of their presence are the small, round exit holes (one-sixteenth of an inch in diameter) of the adults, together with the dust-like borings.

The insects not only work in sapwood which is being seasoned, but also bore in manufactured articles, thus weakening their structure and often endangering human life. Implement handles are sometimes pulverized to such an extent that they fall apart when they are picked up. Furniture and the wood work of buildings are often infested. Beetles continue to breed in the same pieces of wood until the interior has been reduced to powder and there is no wood left for further borings.

Although the life histories of the different species vary, they are somewhat similar in many respects. Under out-of-door conditions there is one generation a year, but in heated buildings this regularity is often upset.

The adults, which emerge from infested wood in the late spring, are small, narrow, brown beetles about one-fourth of an inch in length. They are capable of flying to new localities for egg laying. The eggs are laid in the pores of sapwood which has been seasoned for two years, or longer.

These eggs hatch into small, cream colored larvae which are nearly round in cross section and somewhat curled. They possess sharp mandibles and are capable of mining the hardest wood. They continue to work through the sapwood, pulverizing it as they go. Where heartwood and sapwood meet in the same stick, the larvae always avoid the former. For this reason a sharp line of infested and uninfested wood is often noticed in the same piece of material. The larvae remain in the wood through the winter, and transform to pupae the following spring. The pupae transform into adults which emerge from the infested sticks by gnawing small round holes to the exterior. A heavily infested piece of wood will often look as if it has been shot at with fine shot.

PREVENTIVE MEASURES

It is always advisable to try to prevent these pests from entering and establishing themselves in places where lumber and other wooden articles are stored. The following precautionary measures have been advised.

(a) Sort stored wood according to species, keeping the heartwood and sapwood separated.

(b) Inspect all lumber and manufactured articles of sapwood once a year, burning all infested material. This especially applies to stock two or more years old. The round exit holes of the adults are an indication that the parts are infested. An inexperienced individual might be confused by the pinhole injury caused by ambrosia beetles and some of the other insects. If in doubt cut into the wood around the exit holes. The *Lyctus* beetles pulverize the wood and their work is characteristic.

(c) If possible, avoid keeping sapwood materials over two years.

(d) Prevent the accumulation of any odds and ends of wood in which the insects may breed. Burn them.

(e) Use heartwood piling sticks for lumber.

(f) Avoid the introduction of these pests into lumber yards or storage houses. Be careful not to bring in infested pieces of lumber.

(g) Since heartwood is never infested by these insects, it is advisable to use it in construction and manufacturing wherever possible.

(h) In case it is advisable to protect valuable sapwood lumber, of articles manufactured from sapwood, it can be done by applying any substances which will fill up the pores, such as varnish, paint, shellac, creosote, and linseed oil. If paint or color are objectionable for any reason, use boiled linseed oil. This dries readily and will prevent checking. Ordinarily wood is immune to attack until it has seasoned for at least ten months. Any treatment of wood subject to out-of-door infestation should be done during the winter.

CONTROL MEASURES

After an infestation is well established, as is frequently encountered in storehouses and lumber yards, the following methods of control are advised:

(a) Burn all stock not of sufficient value to treat, for it acts as a constant source of infestation.

(b) Kiln drying of wood at a temperature of 180 degrees Fahrenheit will kill all insects, providing all of the parts infested are brought to this temperature. The insects will survive the ordinary dry kiln process. Wood should not be subjected to this high temperature for more than one hour and provision should be made to keep up the humidity to avoid excessive surface drying. In addition to the regular dry kiln process, the temperature should be brought to 180 degrees Fahrenheit and held there for at least one half hour.

(c) Steaming for one and one-half hours at a temperature of 135 degrees Fahrenheit in a chamber with a saturated atmosphere will kill all stages of the insects.

(d) Painting infested wood with kerosene, or immersing it in vats of kerosene, will kill all of the insects in the wood, providing they have not gone too deeply.

(e) Painting or immersing in a mixture of either of the following, which has been strained through coarse cloth, will have more penetration than the above materials:

(1)	Coal tar creosote	3 parts
	Kerosene	1 part

If the black color of the creosote is objectionable, either of the following proportions may be used:

(2)	Coal tar creosote	1 part
	Kerosene oil	3 parts
(3)	Coal tar creosote	1 part
	Naphtha	3 parts

The fumes of naphtha are very explosive.

It is better to apply these materials hot. Since it is not advisable to heat them on the stove, they should be warmed by steam pipes.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 22

THE JAPANESE BEETLE

By Josef N. Knull, *Entomologist*

The Japanese beetle (*Popillia japonica* Newman), introduced into the United States from the Orient, was first found in New Jersey in 1916. By 1920 the infestation had spread into Pennsylvania and today it is well established in scattered areas, especially in the southeastern counties of the State. The adults are very injurious defoliators of hardwood shade and ornamental trees.

The grubs or larvae work in the ground and are destructive to lawns. The adults are sun lovers and are very active on bright, sunshiny days. Because of the habits of the adult, this insect will probably never be a forest pest. It can, however, be considered one of our most serious pests of shade and ornamental trees since it feeds on the foliage of practically all of them.

The adults, which appear in June or early July, are rather striking beetles about one-half inch in length, metallic green in color with brown wing covers. There are several closely related species which resemble the Japanese beetle, but the adult can always be recognized by the white markings at the sides of the segments of the abodmen and by two of such markings on the top side of the last abodminal segment.

The females crawl into the ground in July and lay their eggs, which hatch into small grubs or larvae. These worms feed on the roots of grasses until cold weather approaches, after which they burrow deeper into the soil. With the warmer weather of spring they resume their feeding on the roots of grasses.

The grubs are fully developed about June and although considerably smaller in size, they resemble common white grubs. They are cream colored, stout worms, always curled in such a way that the head and last segment nearly meet. The head is light brown and they possess six well developed legs. These fully developed larvae construct pupal cells in the ground, in which they transform to pupae. Mature adults develop from these pupae in about ten days and start to emerge from the ground in June. The life history varies somewhat from year to year, depending on the season. There is only one generation a year.

CONTROL MEASURES

Spray for Adults. The ordinary poisonous insecticides used for controlling most leaf chewing insects are not satisfactory for combatting adult Japanese beetles. They act more as repellents than actual killing agents. Since the adults feed on both surfaces of the leaves, a thorough application of either of the following sprays is recommended for control of the adults on hardwood shade and ornamental trees. The spray should be applied at the time the first adults appear, or about the first week in July.

Powdered acid lead arsenate	3 pounds
Ordinary household flour	2 pounds
Water	50 gallons

Mix the arsenate of lead and flour dry, add enough water to make a paste, then add additional water to pour the mixture into the spray tank. Fill up the spray tank to the desired amount of water required.

Gallon lots can be prepared as follows:

Powdered acid arsenate of lead	9 teaspoonfuls
Ordinary household flour	6 teaspoonfuls
Water	1 gallon

Coated arsenate of lead, developed by the United States Bureau of Entomology, is highly recommended as a spray. The usual dilution is 4 pounds of this material to 50 gallons of water, although some brands call for slightly different proportions.

Traps for Adults. The adult beetles can be trapped in large numbers. Several types of traps are on the market at the present time. In order to get the beetles to come to the traps, it is necessary to bait them with attractive substances. The following formula is recommended in United States Department of Agriculture, Circular 130:

Geraniol (at least 58 per cent pure)	4 teaspoonfuls
Eugenol (U.S.P.)	½ teaspoonful
Bran	1½ cupfuls
Water	1 tablespoonful
Molasses	2½ tablespoonfuls
Glycerine	1½ teaspoonful

Add the water and glycerine to molasses and stir well. Pour this mixture into the bran, stirring thoroughly. When mixed add the geraniol and eugenol stirring the mixture well, to get them thoroughly distributed. The bait should be kept in a tightly closed container until used. About ⅓ of a pound, or 5 ounces is sufficient for one trap.

Poisoning grubs. It is possible to add poison to the soil in such a way that the grubs will be killed. The Japanese beetle laboratory at Moorestown, N. J., has recommended the following treatment:

(a) In preparing land for new lawns, acid arsenate of lead should be applied by mixing it with soil and then distributing the mixture as

evenly as possible over the area. The following proportions are recommended for each 100 square feet of ground.

Acid arsenate of lead	3⅓ pounds
Moist, but not wet, soil	3 times the bulk of the poison

After the mixture has been applied, it should be worked thoroughly into the top 4 inches of soil. The land may then be seeded in the usual way. One application is sufficient every five years.

(b) Lawns which have already been established should be treated by applying the arsenate of lead and earth as a top dressing, at the rate of 7½ pounds of the mixture to each 100 square feet of ground. The mixture is prepared as follows:

Acid arsenate of lead	½ pound
Moist, but not wet, top soil	7 pounds (approximately)

This treatment should be repeated every year for three years in succession and applied when the ground is not frozen.

Fumigation. The grubs in the ground can be killed by a thorough application of carbon bisulphide emulsion which may be applied to the earth in the spring or in the fall. The proper and most effective way to apply this mixture is with a special equipment described in the Pennsylvania Department of Agriculture Bulletin 440.

REFERENCES

The Japanese Beetle in Pennsylvania. Pennsylvania Department of Agriculture Bulletin 473. Guyton, T. L., 1929.

The Japanese Beetle in Pennsylvania. Pennsylvania Department of Agriculture, Bulletin 390. Hadley, C. H., 1924.

Control of Japanese Beetle Grubs. Pennsylvania Department of Agriculture, General Bulletin 440. Leach, B. R., and Lipp, J. H., 1927.

The Japanese Beetle. United States Department of Agriculture, Circular 363. Smith, L. B., and Hadley, C. H., 1926.

Grub-proofing Lawns with Arsenate of Lead. United States Department of Agriculture, Bureau of Entomology, Letter. 1929.

Traps for the Japanese Beetle. United States Department of Agriculture, Circular 130. Van Leeuwen, E. R., and Metzger, F. W., 1930.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 23

WHITE GRUBS

By Josef N. Knull, *Entomologist*

White grubs, the larvae of May beetles or "June bugs" (genus *Phyllophaga*), often severely injure young trees by chewing off the roots. The adult May beetles feed on the foliage of hardwood trees and sometimes cause serious defoliation to single trees or to small groves. These pests are always most numerous on land that has been lying idle for a number of years. Young trees in nursery beds and trees that have been recently planted suffer most.

The adults are clumsy, brown beetles about seven-eighths of an inch in length with rather thin legs which seem to be somewhat out of proportion to the size of their bodies. The adults vary a little in color and size depending on the species. They emerge from the soil in May or June, which accounts for their common names. They fly at dusk or after dark, and their presence is always indicated by the humming sound produced by the vibration of the hind wings, or by their flying into objects and falling. They will often swarm in large numbers around certain trees, presumably after food.

The adults burrow into the ground to lay their white eggs, which are deposited in masses on the roots of plants in the spring shortly after the appearance of the beetles. They hatch into small grubs or larvae which start feeding first in decayed vegetation and later on the roots of plants and trees. In most of the species the grubs remain in the ground for two years or longer, feeding on roots during the warm months and going below the plow depth in the winter months.

In the third summer from the time the eggs were laid, the grubs are fully developed. The mature larvae are recognized by most people because of their great abundance in the soil. They are cream colored, plump worms always curled in such a way that the heads and last segments nearly meet. Their heads are dark brown in color and they possess six well developed legs.

These mature grubs construct small, smooth oval cells in the earth in which they transform to pupae. The pupal stage is the resting stage of the insect and lasts a comparatively short time. The adults mature in their cells toward fall and remain in them until the following Spring, when they crawl to the surface of the soil. The pupal cells, which are within the plow line, are not as deep in the soil as the hibernating cells of the grubs. The life histories of the different species vary somewhat,

some forms maturing in the Spring instead of the Fall. In general, it may be stated that the life history extends over a period of three years. The second and third years the grubs do the most damage.

CONTROL MEASURES

Adults. Valuable shade trees which are being defoliated by the adult May beetles should be sprayed with the following mixture, when the adults swarm in the late spring:

Powdered arsenate of lead	1½ pounds
Water	50 gallons

Gallon lots may be prepared as follows:

Powdered arsenate of lead	4½ teaspoonfuls
Water	1 gallon

Grubs. Deep Fall plowing is advised as a control for white grubs. This plowing should be done early in the Fall, before the grubs go deep into the ground for winter, preferably between October 1st and 10th. The object of the Fall plowing is to disturb the grubs just before they are ready to go deeper into the ground and not too long before this period. This will also disturb any adults which may have developed in the late Summer.

Deep summer plowing is advised following a season of marked injury. If these grubs have been especially destructive one season, plow in the summer the following year, as soon after July 15th as possible. All plowing should be deep and the soil should be thoroughly broken up in the operation. Disking after plowing will also aid in the destruction of these pests. If chickens are present when the plowing is done they will aid greatly in reducing the number of grubs.

Where cost is not a limiting factor white grubs can be controlled by the use of carbon bisulphide emulsion, which may be applied to the earth in the spring, or in the fall when the soil temperature is 45 degrees Fahrenheit or above. The stock solution should be diluted at the rate of 1 quart to 50 gallons of water. This diluted material should be applied to the surface of the ground at the rate of 3 pints to each square foot of soil surface.

One and one-half pints should be put on and allowed to soak in, then another one and one-half pints should be applied. In this way the area has to be gone over twice and after the two applications, each square foot of land will have received 3 pints of the diluted stock solution. The proper and most effective way to apply this mixture is with a special equipment described in Pennsylvania Department of Agriculture Bulletin 440.

The stock solution can be purchased on the market, or may be prepared as follows:

Cold water, soluble resin, fish oil soap	1 part by volume
Water	3 parts
Carbon bisulphide	10 parts

Add soap and water and thoroughly mix together in a churn or other receptacle, until they are thoroughly united. Then add the carbon bisulphide, and thoroughly agitate until an emulsion is obtained. The emulsion becomes milky in appearance. Stock solutions should be kept in tightly closed receptacles. Carbon bisulphide is volatile and the fumes are highly explosive. This should be kept in mind in handling either the pure material or the emulsion.

REFERENCES

Common White Grubs. United States Department of Agriculture, Farmers' Bulletin 940. Davis, J. J., 1918.

The Japanese Beetle, United States Department of Agriculture, Circular 363, p. 49. Smith, L. B., and Hadley, C. H., 1926.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 24

INSECTS IN LOG CABINS AND RUSTIC FURNITURE

By Josef N. Knull, *Entomologist*

Timbers that are used with the bark on, such as logs for cabins or poles for rustic work, are frequently infested with insects, which breed in these unfinished sticks. Freshly cut, unbarked trees are particularly attractive to most borers for egg laying, but peeled timbers are seldom infested. Sometimes the infested parts are reduced by the borings of the insects to such an extent that they become unsightly, or are so weakened that they become unserviceable. The workings of the insects eventually disconnect the bark from the wood and it falls off. In addition to the dust-like borings, which are thrown out of the logs by the larvae, these worms often produce objectionable noises when they feed.

Trees that are felled for rustic work are apt to be infested if they are cut during the period (late spring to early fall) in which the adult borers lay their eggs. The species which infest wood of this kind vary according to the kind of trees cut and the season of the year in which the felling is done. In other words, the beetles show a decided preference for certain species of trees, and the wood must be in the proper stage of dryness before they will oviposit.

PREVENTIVE MEASURES

Proper Cutting. Since it is very difficult to eradicate borers in timber after they have gained entrance, it is advisable to use preventive measures in order to avoid them. Most of the trouble caused by insects working in unbarked wood can be averted by cutting the trees used for this purpose at the proper time of the year. It is advisable to cut all trees for rustic work after the adult beetles have laid their eggs. The trees should be cut in November and the parts to be used in construction should be piled off of the ground or under cover in such a way that they will dry out thoroughly before spring. Very few insects will infest logs cut and dried during this period.

Barking. When unfinished sticks used in construction are barked, the trees from which they are taken can be cut any time of the year. In order to prevent infestation the trees should be barked immediately after they are cut.

Chemical Treatment. When it is found necessary to cut trees for rustic finish where the bark is to be retained during the time the adult borers are active, they should be chemically treated. By application of the following preparation to the timbers with a brush, infestation can be prevented:

Coal tar creosote (grade 1, liquid oil)	1 part
Kerosene	3 parts

The two materials should be thoroughly mixed by stirring and the mixture should be strained through burlap.

TREATING INFESTED TIMBERS

Chemical Treatment. Since most of the injury caused by wood borers of this type is usually not observed until after considerable damage is done, it is often not advisable to treat infested pieces. The advisability of treatment should be considered before any work is started. Logs to be treated should be painted or sprayed with paradichlorobenzene dissolved in kerosene. One part of the former to three parts of the latter by weight should be mixed together until the paradichlorobenzene crystals are thoroughly dissolved. One gallon of the mixture should be used to every 50 square feet of log surface.

After the logs have been treated it is advisable to cover them if possible with papers or cloths in order to retain the fumes. The kerosene acts as a carrier for the paradichlorobenzene and it is absorbed by the logs. The fumes given off are toxic to the larvae in the logs and produce death. Some time is required for it to act, however, and the covers should not be removed for two weeks.

Heat Treatment. Kiln drying infested wood used in the manufacture of rustic furniture has been advised. The lethal temperature is 130° Fahrenheit and it is necessary to maintain this heat for a definite length of time depending on the thickness of the sticks. Following this the wood should be placed in live steam in a saturated atmosphere. The following table for this treatment is given by Fisher:

Thickness of Sticks	Hours required after the kiln has reached 130° F.	Hours held at 130° F. in saturated atmosphere of live steam	Total hours in kiln at 130° F.
1 Inch	1	1½	2½
2 Inches	2½	1½	4
2½ Inches	3¾	1½	5¼
3 Inches	5	1½	6½

REFERENCE

Protection of Log Cabins, Rustic Work, and Unseasoned Wood from Injurious Insects. United States Department of Agriculture, Farmers' Bulletin 1582. St. George, R. A., 1929.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 25

THE NANTUCKET PINE MOTH

By Josef N. Knull, *Entomologist*

The Nantucket Pine moth *(Rhyacionia frustrana* Comstock) has done considerable damage to pine plantations and nursery stock in Pennsylvania in the past few years. The larvae mine the buds and terminals of a number of the yellow or hard pines, but do not attack the white pines. The infested trees, which develop brush-like growth, are sometimes killed by this pest.

The insect overwinters in the pupal or chrysalis stage within the infested parts. The adult moths, which are copper colored and about one-half inch across their expanded wings, emerge from the pupae about April or May. They are usually concealed in the pine foliage during the day and fly about dusk on warm evenings.

Shortly after emerging they lay their eggs on needles, buds, and twigs of the new growth. These eggs hatch into small worms or larvae which start feeding immediately in the buds. Usually the presence of the larvae is not noticed until after the terminals are injured and turn brown.

The larvae transform to pupae in the tunnels formed by the borings, and a second generation of moths emerges about July. These moths of the second generation in turn lay eggs and the life history is repeated, the insect spending the winter in the pupal stage within the injured pine terminals.

CONTROL MEASURES

Collecting terminals. On valuable trees or plantations the infested terminals should be gathered and burned in the fall and again in the summer during June, before the adults of the second generation emerge.

Spraying. Since the larvae of this moth work within the buds and shoots of pines, poisonous sprays are of little or no value in controlling them. Contact insecticides used as ovicides to kill the eggs have given good results in reducing the infestations. A 2 per cent dilution of a good miscible oil is recommended, to be applied about once a week when the adult moths are laying their eggs. By shaking the trees in the daytime, the moths can be observed flying from the needles where they have been concealed. The time of emergence varies from year to year, depending on climatic conditions.

The following proportions of miscible oil should be used:

Miscible oil	1 gallon
Water	49 gallons

Small quantities may be prepared as follows:

Miscible oil	1 pint
Water	6 gallons and 1 pint

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 26

THE APPLE TREE TENT CATERPILLAR

By Josef N. Knull, *Entomologist*

The curiosity of people is often aroused by the webs of the apple tree tent caterpillar (*Malacosoma americana* Fabricius) which appear in the crotches of the trees in the spring, about the time the leaves unfold. As the name implies, this insect is more of an orchard pest than a forest insect. It shows a decided preference for wild cherry above all other forest trees. Aside from the unsightly webs made by the caterpillars, these larvae are a nuisance later in the season when they migrate from their nests.

The egg masses can be seen in the winter, encircling the branchlets. These masses are about three-fourths of an inch long, and have been recorded as containing as high as 250 eggs. The eggs hatch into larvae about the time the wild cherry leaves are unfolding. The caterpillars spin webs in the crotches of the trees on which the eggs have been placed. The larvae work out from these webs, devouring the foliage and increasing the size of the webs as they develop.

The mature worms are about two inches long approximately six weeks after the eggs have hatched. They are dark in color and each one has a light stripe down the middle of the back. At this stage the caterpillars wander from the infested trees to sheltered places where oval white silken cocoons are constructed. In these cocoons, the worms turn to pupae.

The adults which emerge from these cocoons are stout, light brown moths from one to two inches across their spread wings. The eggs are laid by the female moths in the late summer.

CONTROL MEASURES

Collecting eggs. Since the egg masses are conspicuous on the branchlets during the winter months it is advisable to collect and burn them.

Collecting nests. The nests can be destroyed early in the spring when they are first observed. This will prevent any further defoliation of the trees.

Eradicating cherry. Where trouble is experienced in large forest areas, the eradication of wild cherry will lessen the infestation.

Spraying. Where the infestation is of such a nature that it is advisable to spray, the following proportions of arsenate of lead will kill the

larvae. The spraying should be done in the spring just as soon as the webs are noticed:

Powdered arsenate of lead	1½ pounds
Water	50 gallons

Gallon lots may be prepared as follows:

Powdered arsenate of lead	4½ teaspoonfuls
Water	1 gallon

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF FORESTS AND WATERS

Harrisburg

1934

Leaflet No. 28

PINE SAWFLIES

By Josef N. Knull, *Entomologist*

Two species of sawflies, Leconte's sawfly (*Neodiprion lecontei* Fitch) and the imported pine sawfly (*Diprion simile* Hartig), are found in Pennsylvania. They are capable of doing considerable damage to both hard and soft pines by eating the foliage. The worms, which resemble larvae of butterflies or moths, are about five-eighths of an inch in length and are light colored with dark heads and markings. They are gregarious in their habits and do their feeding in clusters.

The adult is a bee-like insect about three-eighths of an inch in length with four clear wings. The male has feathery antennae; those of the female are plain. The eggs are inserted in the needles of pines in pockets made by the saw-like ovipositors of the females. It is due to these modified ovipositors that the insects get the name sawflies. Mature larvae spin small, brown, oval cocoons about seven-sixteenths of an inch in length in which they transform to pupae. Later these pupae change to adults, which liberate themselves by cutting the ends off of the cocoons. The insects pass the winter in the cocoons.

CONTROL MEASURES

The following methods of control are advised for nurseries and valuable plantings where the cost is justified. It is necessary to keep a close watch for the reappearance of larvae when control measures are exercised for these insects are two-brooded.

Hand picking. The larvae feed in clusters and can be knocked off into a pan of kerosene, or crushed by hand.

Spraying. Where spraying is deemed advisable, the following spray is recommended:

Powdered arsenate of lead	2 pounds
Water	50 gallons

Gallon lots may be prepared as follows:

Powdered arsenate of lead	6 teaspoonfuls
Water	1 gallon

REFERENCES

A Sawfly Injurious to Young Pines. United States Department of Agriculture, Farmers' Bulletin 1259. Middleton, William, 1922.

The Imported Pine Sawfly. United States Department of Agriculture, Department Bulletin 1182. Middleton, William, 1923.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 29

THE FALL WEBWORM

By Josef N. Knull, *Entomologist*

Undoubtedly most persons have observed the webs of the fall webworm (*Hyphantria textor* Harris) on various fruit and forest trees in late summer. Aside from the unsightly webs spun by the larvae, the caterpillars cause injury to the foliage by skeletonizing the leaves within the tents or webs.

The insects spend the winter in the pupal or chrysalis stage in silken cocoons, usually spun in sheltered places, often on the ground. The adult moths, which are white ornamented with black markings, emerge in June. The eggs are laid in clusters on the under sides of the leaves, as high as 500 being recorded in a single group.

These eggs hatch into hairy caterpillars, which are gregarious and spin webs over the branches for protection while feeding on the foliage. As the larvae develop they increase the size of the webs, in order to include more foliage. When the caterpillars are mature they leave the webs and migrate to sheltered places where they construct their cocoons. There are two generations a year, the pupae of the second generation overwintering in the cocoons.

CONTROL MEASURES

When valuable shade trees are infested the following control methods are recommended:

Destroying Webs. If the branches containing the small webs are cut and burned when they are first observed, the caterpillars on the inside will be destroyed. Torches, made by attaching kerosene saturated rags to poles, may be used to destroy the webs, but care should be taken not to injure the branches by burning.

Spraying. Ordinary arsenical sprays will kill the larvae if applied during the feeding period. The following mixture is recommended:

Powdered arsenate of lead	1½ pounds
Water	50 gallons

Gallon lots may be prepared as follows:

Powdered arsenate of lead	4½ teaspoonfuls
Water	1 gallon

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 30

THE LOCUST LEAF-MINER

By Josef N. Knull, *Entomologist*

Late in the summer most people have observed that the foliage of the black locust often turns brown and has the appearance of being scorched by fire. This discoloration and drying up of the foliage is caused by the locust leaf-miner (*Chalepus dorsalis* Thumb), the larvae of which mine between the layers of the leaves. The adults are also ravenous foliage feeders and the skeletonizing which they cause makes the leaves dry up. This damage to the locust foliage is not only unsightly, but also interferes with the tree's growth.

The adults are somewhat flattened, dark orange colored beetles ornamented with black, about one-fourth of an inch in length. They pass the winter in sheltered places and emerge from their hibernating quarters in the spring about the time the new growth of the black locust starts. The eggs, which are laid in masses on the under sides of the leaves, hatch into small larvae which crawl into the leaves and mine between the layers.

After the food supply in one leaf is exhausted these worms emerge, crawl to other leaves, and again start mining in a similar manner. The parts of the leaves containing the irregular mines turn brown and form blister-like areas which make the foliage unsightly. Transformation to pupae occurs within the mines and the adults emerge by gnawing their way to the exterior.

CONTROL MEASURES

Since the adults are extensive leaf feeders and the larvae crawl out of certain leaves and into others, poisonous insecticides give good results. It is advisable to use a spreader in connection with the spray on account of the smooth surface of the black locust foliage.

A thorough application of the following spray is advised immediately after the leaves have developed and again in the latter part of July:

Powdered arsenate of lead	2 pounds
Calcium caseinate, or "Kayso"	½ pound
Water	50 gallons

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 31

THE TWO-LINED CHESTNUT BORER

By Josef N. Knull, *Entomologist*

The two-lined chestnut borer (*Agrilus bilineatus* Weber) is a serious pest of chestnut and oak in Pennsylvania, and a variety infests American beech, blue beech, and ironwood. The larvae work beneath the bark of the infested tree, destroying the vital cambium layer by their extensive irregular mines which often cross each other and effectively girdle the tree. Trees which are attacked are always killed. Slowly growing trees in an unhealthy condition are most susceptible to attack. The first evidence of infestation is the death of the upper limbs.

The adults, which emerge about June, are small, dark blue beetles about three-eighths of an inch in length. They are sun lovers and are very active on warm, sunshiny days. The common name is derived from two dorsal stripes.

The eggs, which are laid in crevices of bark, hatch into flattened, kite-shaped, cream colored larvae, each worm possessing two spines on the last segment of the body. The mature larvae are about three-quarters of an inch in length and can be found doubled up (U-shaped) in their pupal cells in the winter months. These pupal cells are constructed in the bark or sapwood, depending on the thickness of the former.

Transformation or pupation of the larvae occurs in the spring shortly before the adults emerge. The adults emerge from the pupal cells by gnawing holes which are semi-circular and flat on one side. These exits are characteristic of flat-headed borer emergence holes.

CONTROL MEASURES

No practical control measures are known for this insect under forest conditions. On estates with valuable plantings, where cost is not the main consideration, the following methods of control are advised.

Stimulation. Since healthy, fast growing trees are less susceptible to attack, all oaks should be kept in a thrifty growing condition, if necessary by the use of stimulants such as water or fertilizers. Trees that have become weakened through defoliation or from other causes are liable to attack.

Sprays. The adults are extensive foliage feeders and can be killed by poisonous insecticides. Valuable trees in sections where this insect is doing damage can be protected by the following spray which should be applied to the foliage about the first of June:

Powdered arsenate of lead	2 pounds
Water	50 gallons

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 32

CANKER WORMS

By Josef N. Knull, *Entomologist*

In Pennsylvania there are two species of cankerworms, or measuring worms, which are often very destructive to the foliage of fruit and forest trees. The depredations of these insects have been observed since colonial times and some years the injury produced by them is more severe than others. During the past several years certain areas in the Allegheny Plateau Section have suffered from these pests.

The two species resemble each other somewhat in appearance, although their life histories differ. Since the females of both species are wingless, the infestations are often local. When the larvae are disturbed they suspend themselves by slender silken cords, or raise the front parts of their bodies and become perfectly motionless, thus mimicking branchlets.

THE SPRING CANKERWORM *(Paleacrita vernata* Peck)

The eggs of the spring cankerworm are dull pearl in color, oval in shape, and are laid mostly in the spring in masses in the crevices of bark on trees. They hatch about April or May. The full grown larvae are about one and one-sixteenth inches in length, striped, the color varying from various shades of brown and green to very dark blue. They each possess two pairs of prolegs on the ends of their bodies. The larvae crawl into the ground to transform to pupae, which are enclosed in earthen cells; no cocoons are spun.

Adults of the spring cankerworm emerge in the early spring or occasionally during mild days in the winter. The adult females are wingless creatures about three-eighths of an inch in length; the males are gray in color with a wing spread of about an inch. Double transverse rows of spines occur on the abdomen of each sex.

THE FALL CANKERWORM *(Alsophila pometaria* Harris)

The eggs of the fall cankerworm are brownish gray in color, like the frustrum of a cone in shape, and are laid usually in the fall in compact, single layered clusters in exposed locations. They hatch about April or May. The mature larvae are striped, about one and one-sixteenth inches in length, and vary in color from light green to brown. They each possess three pairs of prolegs on the ends of their bodies.

These larvae crawl into the ground and spin cocoons in which they pupate. The adult moths, which emerge in the spring, somewhat resemble those of the preceding species, the females being without wings. However, they lack the spines which are present on the bodies of the spring cankerworms.

CONTROL MEASURES

No economic control methods are known for large forest areas. Small areas, where cost is not the principal consideration, can be treated as follows:

Plowing. Plowing the ground around infested trees, any time during the late fall or winter before the adult spring cankerworms emerge, will act as a control for this species. Plowing in the late summer, before the fall cankerworm adults have emerged, will not give much control because the pupae are in cocoons.

Banding. Since the adult females of both species are not capable of flying, but crawl up the trunks of the trees to lay their eggs, banding trees will protect them. It is useless to apply bands to trees whose limbs touch trees not banded, or are close enough for the larvae to drop from infested branches of other trees. For the spring cankerworm the bands should be placed on the trees about March 1st, and for the fall cankerworm they should be applied during the first half of October.

To place a cotton batting band cut the strip of cotton so that it is about six inches wide and just a trifle longer than the circumference of the tree to be banded. Place the batting around the trunk and tie the bottom edge by wrapping a string around the tree. After the bottom edge is securely fastened, turn the top part down over the string, thus forming an offset of loose cotton around the trunk.

Sticky banding material may be prepared by placing 5 pounds of rosin and 3 pints of castor oil in a pan and slowly heating until the rosin is melted. More oil should be added if the mixture is too thick.

Another formula for banding material is as follows:

Axle grease	1 pound
Fish oil	1 pint
Powdered rosin	2 pounds

Heat the axle grease in a pan until all the water in it is evaporated. While the pan is still on the fire, slowly stir in the fish oil and then the powdered rosin. When the rosin is dissolved the mixture should be removed from the fire. It will be ready to use the following day.

Since some sticky banding materials are apt to cause injury to the trunks of trees, it is not advisable to place them in direct contact with the bark. This is best averted by placing the banding material on heavy tarred building paper which has been fastened tightly around the tree. By placing a two-inch strip of cotton batting around the tree underneath the building paper, all of the cracks between the paper and the bark will be closed. This will prevent moths or young larvae from crawling underneath the bands.

Spraying. Spraying infested trees with poisonous insecticides will kill the larvae. This should be done in the fore part of May, just after the eggs have hatched. The following spray is recommended:

Powdered arsenate of lead	1½ pounds
Water	50 gallons

REFERENCE

The Cankerworms. United States Department of Agriculture, Department Bulletin 1238. Porter, B. A., and Alden, C. H., 1924.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 33

THE POPLAR BORER

By Josef N. Knull, *Entomologist*

Practically all species of poplars are susceptible to attack by the poplar borer *(Saperda calcarata* Say), the larvae of which mine the trunks of poplars and cause the trees to break off at the weakened points. Evidences of attack are the large irregular holes in the trunks which are used by the larvae to throw out borings. Certain individual trees seem to be chosen by the insects as "brood trees" and act as a source of infestation for a region. These trees are often infested from top to bottom by the larvae and small piles of borings can be seen at their bases.

The adults emerge about July. They are striking beetles about one and one-fourth inches long with antennae or feelers about seven-eighths of an inch in length. They are light gray in color, irregularly mottled with yellow. The females can be found during the latter part of July and August laying their eggs on the trunks of poplars. In ovipositing the female first cuts through the thin bark with her sharp mandibles, then she reverses her posterior and inserts the eggs. These holes in the bark are called egg scars.

The eggs hatch into young larvae which bore beneath the bark, remaining there through the winter. At the approach of warm weather the following spring, the larvae again become active and work into the solid wood of the infested tree. Exterior exits for throwing out borings are always maintained by the larvae at the places where the eggs were laid.

The full grown larvae are cream colored worms about two inches long, and have sharp mandibles. These mature larvae construct pupal or transformation cells at the ends of their extensive burrows, which are somewhat spiral and extend into the heartwood of the infested tree. The outer ends of the pupal cells are plugged tightly with a stringy frass, which protects the insects from their enemies.

About July of the third year the larvae pupate in their cells and the pupae later change to adults. The adults liberate themselves by gnawing away the frass at the entrance to the pupal cells and then crawl through the galleries maintained by the larvae for expelling borings, to the exterior. Three years are required for the complete life cycle of this insect.

CONTROL MEASURES

The poplar or aspen in our forests is a pioneer tree of little present commercial value; however, it has its place as one of the trees which

help make conditions favorable for the establishment of more valuable species. Poplars often have aesthetic value in parks or large estates.

Cutting Infested Trees. Badly infested trees which might be classed as "brood trees" should be cut and burned before the middle of June. It is not sufficient to cut trees of this kind and let them lie on the ground, for the insects will often continue to develop within them. Infested trees can be recognized by the holes in the trunks and the borings at their bases. Extensive woodpecker work is usually present on trees of this type.

Killing Young Larvae. Poplars of aesthetic value can be kept free from borer injury by killing the young larvae with carbolineum or coal tar creosote. Either of these two materials can be used and should be applied with a brush to the egg scars on the trunks and branches in October. These scars, which are made by the females for egg laying, resemble small nicks in the bark of the trees and are easily recognized.

REFERENCES

The Aspen Borer and How to Control It. United States Department of Agriculture, Farmers' Bulletin 1154. Hofer, George, 1920.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 34

THE MOTTLED WILLOW BORER

By Josef N. Knull, *Entomologist*

The mottled willow borer *(Cryptorhynchus lapathi* Linn.), an insect native to Europe, was found in New Jersey in 1887, and since that date it has become well established in Pennsylvania. The larvae mine the trunks and branches of willows and poplars, usually greatly deforming or killing them.

The adult is a stout, dark brown curculio or snout beetle about three-eighths of an inch in length, with a light pink band across the back part of the wing covers. Adult weevils emerge in July from their pupal cells in the heartwood of the infested trunks and branches, and egg laying starts shortly afterwards. The eggs, which are deposited by the females usually around buds or crotches on the trees, hatch into legless grubs.

These larvae have strong mandibles adapted for chewing and feeding on wood. They work into the trunks and branches, making encircling burrows which tend to weaken the structure of the trees. The winter is passed in the larval stage within the infested parts. In June when the grubs are full grown they construct transformation cells in the heartwood where they change to pupae. Later the adults emerge from their pupal cells at the ends of the burrows.

CONTROL MEASURES

When willows and poplars are of sufficient value to warrant treatment the following methods of control are recommended:

Burning. Cut and burn all infested parts of trees during the first part of June. Since the larvae will be throwing out borings (frass) at this season of the year, it is not difficult to ascertain which trees are infested.

Painting. Painting the trunks and branches of infested trees with carbolineum, or carbolineum emulsion, will kill many of the larvae. The application should be made in April, or December.

The emulsion is prepared as follows:

Carbolineum avenarius	1 quart
Sodium carbonate	1 quart
Hot water	1 quart

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 35

THE IMPORTED WILLOW LEAF BEETLE

By Josef N. Knull, *Entomologist*

The imported willow leaf-beetle *(Plagiodera versicolora* Laich), a native of Europe, has become established in various parts of Pennsylvania and often causes serious damage to the foliage of willows. It will also feed on poplar, but it seems to prefer the willow as a food plant. Both the adults and the larvae are ravenous leaf feeders and it is not unusual in midsummer to find willows with their foliage destroyed.

The adults are dark metallic blue, or green tortoise shaped beetles about three-sixteenths of an inch in length and can be found in the winter months hibernating under loose bark of willows, or in protected places in the vicinity of willow trees. The larvae, which feed on the under sides of the leaves entirely, are dark colored worms about one-fourth of an inch in length and are capable of traveling from one leaf to another. These larvae transform to pupae on the under sides of the leaves.

CONTROL MEASURES

Since both the larvae and adults have mouth parts adapted for chewing foliage, they can be controlled with poisonous insecticides. Valuable willows should be sprayed with arsenate of lead in the fore part of May, after the leaves have unfolded. Spray material should be directed to the under sides of the leaves.

The following proportions are advised:

Powdered arsenate of lead	2	pounds
Water	50	gallons

Gallon lots may be prepared as follows:

Powdered arsenate of lead	6	teaspoonfuls
Water	1	gallon

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 36

THE BEAUTIFUL HICKORY BORER

By Josef N. Knull, *Entomologist*

The beautiful hickory borer *(Goes pulchra* Haldeman) does considerable damage to the trunks and large branches of healthy living hickories in Pennsylvania. The larvae mine into the heartwood of the infested trees, making extensive irregular galleries in the wood. Trees are seldom killed by this insect and few trees break due to the toughness of hickory wood. However, this pest does cause a stunting of the growth and abnormal irregular areas on the trunks and branches on the infested trees where the injuries try to heal. Young trees standing in the open or trees under park conditions seem to suffer most. Certain trees are often singled out by the insects and the trunks will be full of the larvae.

As the name implies, the adults which emerge about the fore-part of June are striking in appearance. They are about one and one-eighth inches in length, possess antennae about one and three-eights inches long, are yellow ochre in color with a transverse brown band across humeral angles and another one back of middle. The adults can be found in the crowns of the trees in the daytime where they feed on the tender bark of the small branchlets.

During the egg laying season the females are active about dusk and they lay their eggs on the smooth trunks and branches of young hickory trees. The females first gnaw slits which are called egg scars through the thin bark with their stout mandibles. Then they reverse their positions and deposit the eggs under the bark. These eggs hatch and the young larvae start working underneath the bark. Three years are required for a complete life cycle of this insect and the young larvae spend the first winter under the bark. These worms become active the following spring and work into the solid wood of the infested trees, making irregular galleries as they go. The borings are thrown out by the larvae at the places on the trunks where the eggs were laid.

The mature larvae are cream colored with stout mandibles. These mature worms construct pupal cells in their burrows where they transform to pupae in the spring shortly before the adults emerge. The pupae develop into adults which liberate themselves by gnawing round holes about three-eighths of an inch in diameter to the exterior. These holes are clean cut and resemble auger holes in the trunks. They make excellent entrances for wood decaying fungi.

CONTROL MEASURES

Since this insect is seldom a pest under forest conditions, probably because of the shade, the following control methods are applicable to valuable trees where intensive methods of control are practical.

Chemical Treatment. The young larvae can be killed by painting the egg scars with paradichlorobenzine dissolved in kerosene, the latter part of August. One part of the former to three parts of the latter by weight are about the right proportions.

Sprays. Since the adults feed on the tender bark of the branchlets, valuable trees might be given protection by an application of an arsenical spray. The following proportions are recommended to be applied to the trunks and small branchlets about the first of July, after the adults have emerged:

Powdered arsenate of lead	2	pounds
Water	50	gallons

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 37

THE SUGAR MAPLE BORER

By Josef N. Knull, *Entomologist*

The sugar maple borer *(Glycobius speciosus* Say) is a serious pest throughout the natural range of hard maple in Pennsylvania. The larvae make extensive mines, often several feet in length, underneath the bark of perfectly healthy trees. Large branches and entire trees are frequently killed by this pest.

The adult insects, which emerge in June, are very striking beetles about one inch in length, black in color, ornamented with brilliant yellow markings. The eggs are laid usually on the trunks and bases of large branches shortly after the adults appear. In the operation of egg laying the females cut small slits in the bark with their sharp mandibles, then reversing their positions they deposit eggs in these egg scars. The eggs hatch and the young larvae throw out borings at the places where the eggs were deposited. These egg scars on the trunks and branches are indicated by a discoloration of the bark and the presence of the borings.

The young larvae spend their first winter in shallow excavations in the sapwood of the infested trees. Two years are required for a complete life cycle and during this time the larvae make extensive mines underneath the bark, often nearly girdling a large limb or an entire tree.

Later in the life of the surviving trees the bark tries to heal over the burrows made by the larvae, but it cracks, becomes loose, and eventually falls off, often exposing the winding galleries beneath.

Up to the time that the girdling is completed there is very little evidence of the presence of insects. About the first indication is the drying up of the foliage on the parts infested. In the fall of the second year the larvae become mature and construct pupal cells, usually about four inches deep in the wood. The mature larvae are cream colored worms approximately two inches in length and have sharp mandibles for chewing wood. Transformation of the larvae to pupae occurs in the spring in the cells which have been prepared for this purpose. The mature adults emerge from the pupal cells by chewing oval holes to the exterior.

CONTROL MEASURES

It is not practical to try to control this insect under forest conditions because of the cost. Trees standing in the open, such as shade and ornamental trees, are more susceptible to injury than those in closed

stands. For this reason it is not advisable to do too much improvement cutting or weeding in sugar maple groves. Badly infested trees should be cut and burned any time during the winter before the first of June.

Removing Larvae. The following control measures are recommended for valuable shade and ornamental trees: In September the trees should be examined and egg scars located. By cutting in at these scars on the trunk and limbs, the young larvae can be located and killed. The cuts should be made clean with a sharp knife and painted first with shellac and then with coal-tar creosote. In case it is necessary to make extensive cuts, coal-tar should be applied over the creosote.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 38

THE LEOPARD MOTH

By Josef N. Knull, *Entomologist*

The leopard moth (*Zeuzera pyrina* Linn.), a native of Europe, has become established in the eastern part of Pennsylvania. Larvae of this insect work in the limbs of practically all of our deciduous trees, the most injury being done to elm and maple. Excavations of the larvae so weaken the structure of the limbs and branches that they are easily broken by the wind. About the first indications of the presence of this pest are the dead and broken branches on the living trees. Although trees are not always killed by this insect, the broken branches make them very unsightly and their growth is considerably hindered.

The adults which emerge about June are beautiful white moths mottled with blue and black markings, the females sometimes having a wing spread of three inches. The insect gets its name from the peculiar markings of the adults. The orange colored eggs are laid in crevices of the bark. It has been recorded that a female is capable of laying 800 eggs. These eggs hatch into small worms which first mine the heartwood of the small branches and later work into the larger limbs and trunks.

The larvae often leave the branches in which they are working and go to other limbs where they start mining in a similar manner. The burrows are very extensive and usually include a considerable portion of the cambium layer, which of course kills the branch. Excavations of the larvae necessitate holes to the exterior for throwing out borings. These holes, which are frequently made at a concealed place, are closed immediately after the frass is expelled in order to protect the worms from their enemies. The life cycle extends over a period of two years, the first winter is spent by the half grown larvae in their tunnels.

The mature larvae are light colored worms about two and one-fourth inches in length with dark heads and scattered symmetrical markings. After these mature larvae have cut holes through the bark, they retire to the burrows where they transform to pupae in the spring a short time before the adults appear. When the adults are ready to emerge, the pupae travel toward the openings cut by the larvae. Although the pupae have no legs they move by a squirming motion, together with the aid of the spines, which point backward on the segments of the bodies. The empty pupal cases can be seen protruding from the exit holes in the infested trees.

CONTROL MEASURES

This insect is more of a shade and ornamental pest than forest insect. Infested trees can be recognized by the dead and broken top branches and by the abundance of pellet-like borings on the ground, which have been thrown out by the larvae.

Burning Infested Branches. It is advisable to cut and burn all infested branches in late summer, for at this season of the year the work is most easily recognized.

Killing the Larvae. In valuable trees the larvae can be killed by injecting carbon bisulphide into the burrows with an oil can and plugging the holes immediately with clay after the liquid has been inserted. The fumes of carbon bisulphide are highly explosive and care should be exercised in handling this liquid. Carbon bisulphide should be applied only when the temperature is 70 degrees Fahrenheit, or above.

Some of the larvae can be killed by inserting a wire in the burrows from the entrances. It is advisable to put a small loop in the end of the wire before using it, for it will enter the galleries better and one can better observe when he kills a worm.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Harrisburg
1934

Leaflet No. 39

THE GIPSY MOTH

By Josef N. Knull, *Entomologist*

In 1869 egg masses of the gipsy moth (*Porthetria dispar* Linn.) were brought to Massachusetts from France by a French mathematician who had the idea that he could cross the insect with the silkworm and develop a hardy race of silk producing insects. The pest escaped from his rearing cages and its destructive work was not noticed until 1889.

The insect spread rapidly through parts of New England and from time to time outlying colonies of this moth were discovered in states adjacent to the infested area. Extensive infestations have been found in New York, New Jersey, and more recently in southern Lackawanna and northern Luzerne Counties, Pennsylvania.

INJURY

The injury is produced by the larvae which have been recorded as feeding on 150 food plants including both hardwoods and conifers. In New England thousands of trees have died as a result of defoliation by this pest. Many trees are so weakened by the loss of their foliage that they are attacked by wood borers which soon cause their death.

LIFE HISTORY

The eggs of the gipsy moth are deposited in clusters of 400 to 1000 in number. They are usually placed in sheltered places on the trunks of trees, or the sides of stones, or buildings and many other similar places. The masses of eggs are oval in shape and about ½-inch or more in diameter and are covered with the light brown scales from the under surfaces of the female moths. These eggs which have been out all winter start hatching in the latter part of April.

The hairy larvae which emerge from the egg are about 1/10 of an inch long and they start feeding on the opening leaves of the trees. It is not unusual to see trees entirely stripped of their foliage by the end of June. The full grown larvae are from 2 to 2½ inches in length. Each hairy caterpillar has a conspicuous row of tubercles down its back. Those in front are blue and those toward the rear are red. Similar tubercles are located on the sides. Some of these larvae are full grown in June, and they spin loose webs in which they pupate.

The dark brown pupae which are suspended in the silken webs are 3/4 to 1½ inches in length. The first moths appear in the latter part of June and frequently they are present in the field until September.

The buff colored female moths, which are not capable of flying, are about 2 inches across their spread wings. The wings are ornamented with irregular dark wavy markings. The males are dark olive brown in color, ornamented with wavy dark brown markings and they have a wing spread of about 1½ inches. The males are active fliers and aside from their size and markings they can be separated from the females by the feathery antennae. The eggs which are deposited by the females in July and August usually do not hatch before the following April.

WHAT TO LOOK FOR

During the dormant season the presence of the gipsy moth can be told by the oval, light brown egg masses which resemble fungi on the trunks of the trees. These clusters of eggs might go unnoticed unless one were looking for the insect.

In the season when the foliage is on the trees infestation can be identified by the destruction of the leaves. Since the caterpillars are more or less nocturnal in their habits they might be overlooked.

CONTROL MEASURES

Spraying. The application of spray at the rate of 5 pounds of powdered arsenate of lead to 100 gallons of water has proved very satisfactory in killing the larvae. The proportion of arsenate of lead can be reduced if a sticker such as fish oil is used. High power spray machinery is needed for tall trees.

Banding. Various banding materials have proved satisfactory in keeping the caterpillars from going to the foliage of the trees.

Destroying Eggs. The egg masses can be destroyed by painting them with creosote.

Natural Control. In addition to numerous native parasites and predators which attack this insect, certain exotic species have been introduced and established for this purpose. These enemies of the moth are a great help in reducing its numbers.

REFERENCES

The Gipsy Moth and the Brown Tail Moth. United States Department of Agriculture, Farmers' Bulletin 1623. Burges, A. F., 1930.

Gipsy Moth Tree Banding Material: How to Make, Use, and Apply It. United States Department of Agriculture, Bulletin 899. Collins, C. W., and Hood, C. E., 1920.

Food Plants of the Gipsy Moth in America. United States Department of Agriculture, Bulletin 250. Moser, F. H., 1915.

End of Title