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The New York State College of Forestry

AT

SYRACUSE UNIVERSITY

HUGH P. BAKER, Dean

Some Insect Enemies of Shade Trees and Ornamental Shrubs

BY

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Bull. Mus. Comp. Zool. Harvard Col., Vol. 48, pp. 1–138, pl. 1–9, 9 text fig.

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CONTENTS

SOME INSECT ENEMIES OF SHADE TREES AND ORNAMENTAL SHRUBS

BY

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The love of nature inherent in all of us expresses itself in the case of the dwellers in a large city in the great trouble they are willing to take to preserve a potted plant, a small strip of grass, or a more or less ornamental tree. This same love of nature is shown by those living in medium sized or small cities by the care which the householder lavishes upon the trees and shrubs upon his little plot of ground. Because of this sentimental regard of the householder and also for other reasons, a forest tree occurring along a city street or on private grounds in a city is of greater value than a similar tree occurring in the forest or in the field.

The value of an elm tree in a field or at the margin of the forest may be scarcely anything and yet the same tree well placed upon private grounds in the city might well be worth several hundreds of dollars, or even more, dependent upon the value of the real estate in the vicinity. The reason for this is that its presence makes the plot of ground upon which it occurs more attractive and increases its real-estate value to that amount. Even in the smaller towns and country villages of the State, the presence or absence of shade trees are potent factors in determining the value of real estate. A small town in which shade trees are lacking or in poor condition offers no attractions to the seeker for a suburban home.

Entirely aside from sentimental reasons it behooves us to protect our trees and shrubs against the attacks of injurious insects. The conditions prevailing in large cities make this protection especially necessary, for a tree in a city must contend for existence against a great variety of unnatural conditions. If in addition to poor light, lack of sufficient moisture, and sterile or even poisonous soil, it is also subjected to the attacks of boring or defoliating insects, it stands but a poor chance to survive the struggle unless aided by man.

It should be realized also that even in the smaller towns and in the country, trees used for shade are subjected to unnatural conditions which render them more susceptible to insect attack. An excellent example illustrating this point is furnished by the sugar maple, which is one of the most commonly used shade trees in the cities, villages and country districts of New York. When used as a shade tree it has a very serious enemy in the sugar maple borer which kills or injures immense numbers every year. Yet sugar maples growing in dense natural forests, which is their habit in nature, are practically exempt from injury by this borer. Other trees show just as striking examples of the effect of rearing them under conditions different from those to which they are accustomed in nature.

This bulletin is written with the hope that it may prove of value to the residents of New York State by assisting them to recognize some of the more common insects attacking their trees and ornamental shrubs and by guiding their efforts in combating these pests. Many valuable bulletins upon shade tree pests have been issued by the State Entomologist and by others in the State but at present these are not readily available and it has seemed to the authors that a bulletin treating the more common shade tree insects would be of real value to dwellers in the State. That there is a distinct need for such a bulletin is evidenced by the numerous inquiries regarding insects received by the College of Forestry.

It has been the endeavor of the authors throughout to avoid technical language and to do away entirely with tech-

nical descriptions of the insects treated. It is hoped that the brief popular descriptions and numerous illustrations will enable the man possessing no technical training in entomology to recognize the forms discussed. The authors do not make any claims to originality either in the way in which the subject matter is presented or in the subject matter itself. Indeed, in most cases the facts presented and the recommendations made follow rather closely the ideas generally accepted by other workers in the same field. This bulletin then is mainly a compilation and its purpose is to be of service by making previously known facts more readily available to residents of the State who are interested in the preservation of their trees and shrubs. In a few cases, however, the personal experiences or observations of the writers have led them to diverge slightly from the generally accepted recommendations or to include new observations regarding habits or life histories.

In connection with each insect treated in this bulletin certain recommendations are made regarding methods to be used in combating the pest and saving the trees attacked. However, in all cases just as in the case of human diseases, prevention is much better than cure. When proper regard is had to choice of trees for planting, manner of planting, use of proper fertilizer and proper pruning and care of the trees, their general health is maintained and they do not attract many insects which attack only weakened trees. Their powers of resistance are also greater and they are able to withstand insect depredations which to an unhealthy tree would be fatal. Perhaps, then, a few words regarding these points might be of value.

The Choice of Trees is a subject which has been treated rather at length in a recent bulletin* issued by the College of Forestry, and persons interested are referred to this for more detailed information than can be given here. In addition to beauty and to shade production, other factors must be taken into account in choice of trees. Chief among these

* Systematic Street Tree Planting for Towns and Cities of New York, by Henry R. Francis, 1915.

are hardiness to city conditions, and resistance to the attacks of insects and fungi. The following trees are not only hardy under severe city conditions but are also but little subject to insect attack;— Oriental plane tree (or sycamore), Norway maple, scarlet oak, red oak, ginko and ailanthus. American elm and sugar maple which in the past have been the favorites for street planting in the cities and towns of the State are neither hardy under severe city conditions nor do they enjoy even comparative immunity from insect attack.

In connection with choice of trees the writer wishes to reiterate recommendations already made by Dr. E. P. Felt* in connection with prevention of spread of the elm leaf beetle. He makes a plea for greater diversity in the planting of street trees. By this plan adjacent streets or blocks should be set with different kinds of trees. This would eliminate much of the danger of the rapid spread of many kinds of injurious insects.

The *proper method* of *planting* trees and of fertilizing the soil is not within the province of this bulletin. However, the importance of these factors in preventing and aiding in resisting insect attacks by building up the strength of trees cannot be overestimated. I wish here once more to refer to the bulletin by Prof. Francis mentioned in a previous paragraph.

The proper care of street trees involves many factors. It not only means the correct pruning of trees at the suitable season, but also takes into account the guarding of the tree against mechanical injury, the correct treatment of the soil surrounding the tree in order to allow for transpiration by the roots, the maintaining of soil fertility, the proper spraying to combat injurious insects and fungi, tree repair, etc. In fact the planting and care of trees is a subject requiring such special knowledge, that this work in every town and city should be in the hands of a man especially trained in that sort of work. This man should have entire charge of the planting, pruning, spraying, etc., of all trees in the parks and

* N. Y. State Mus. Bull. 156, 1912.

along the streets and in addition have suitable apparatus and a sufficient force of men to be able to do work in private yards — this to be paid for at actual cost.

In many cases the control measures recommended herein are such that they should not be done by an inexperienced man, while in other cases the spraying operation suggested requires such expensive apparatus that it is out of the question for the ordinary property owner to possess his own equipment. The creation of a municipal forester or arboriculturist is the simplest, most efficient and least expensive solution of the problem. If the office is properly conducted, this official will either do the work for private parties at cost, or will advise what should be done and recommend the proper man to do it.

In many cities and towns of the State, men advertising themselves as tree doctors or tree dentists are bidding for the patronage of tree owners. Some of these men are honest men of good training and good judgment. Many, however, possess neither good judgment nor adequate training and property owners are therefore advised to require references (other than references as to financial responsibility) before entrusting valuable trees to their care. These so-called tree doctors often make absurd claims as to what they can accomplish. For example some are still found who claim they can free trees from the devastating attacks of leaf feeders by boring a hole in the trunk and filling this with sulphur, tar or some other substance. Of course such claims are absurd, for any material which would be disseminated throughout the tree to such an extent and in such quantities as to poison insects feeding upon leaves or bark, would also be fatally poisonous to the living tissues of the tree.

" Tree doctors " often make absurd claims as to the amount of good to be accomplished by tree dentistry, i. e., by the removal of decaying tissues and the filling of the cavity with cement or other solid masses. There can be no doubt that when properly done such work is of value and often prolongs the life of the tree indefinitely, but very often the price demanded for such work is exorbitant and out of

all proportion both to the cost of the work and to the value of the results accomplished.

Cases are also numerous where men owning and operating commercial spraying outfits apparently have insufficient knowledge of the intelligent uses of sprays. In many instances trees have been sprayed with stomach poisons where the insect doing the damage was one feeding by sucking the plant juices — their habits of feeding being such that the stomach poison would be of no value whatever. The intelligent application of insecticides requires considerable knowledge of the life history and habits of the insects combated. It is therefore recommended that, just as in the case of the "tree doctor," the property owner require references as to his knowledge of the subject before employing a man to do spraying.

The authors wish to express their gratitude to a number of sources for the loan of figures or plates. Our thanks are due to Dr. L. O. Howard, Chief of Bureau of Entomology for permission to use Figs. 35, 42 and 43; to Dr. W. E. Britton, of the Connecticut Agri. Exper. Sta., for use of Figs. 5, 6, 7, 10 and 26; to Dr. E. P. Felt, State Entomologist of New York, for the use of stones for Plate II on the elm-leaf beetle; to Prof. S. B. Doten, Nevada Agri. Exper. Sta., for the use of plates of Figs. 49, 50 and 51; to Prof. H. Garman, Kentucky Agri. Exper. Sta., for use of Figs. 24 and 25; to Prof. Glenn W. Herrick for the use of Figs. 14 and 15; to the New York Agri. Exper. Sta. at Geneva for the use of plates for Figs. 3, 4, 9 and Plate 1; and to Prof. W. C. O'Kane of the New Hampshire Agri. Exper. Sta. for use of plates for Figs. 11, 12 and 13. Our thanks are also due to our colleague, Prof. J. Fred Baker, for assistance in making photographs for Figs. 32, 33, 40 and 56; to two advanced students, Mr. H. H. Stage for making drawings for Figs. 8, 20, 21, 23, 29, 37 and 38, and Mr. Alex. J. MacNab for Fig. 30.

The greater part of this bulletin was written by the senior author and he has in addition exercised a close supervision

over all of the matter entering into it. The portions on aphids and scale insects (with the exception of that on Gossyparia spuria), the accounts of the mourning cloak butterfly and the leopard moth and the treatment of sprays and spraying apparatus, were written largely by the junior author, the remainder being entirely by the senior author.

II. HOW INSECTS ARE INJURIOUS TO TREES

Insects may be injurious to trees and shrubs in a variety of different ways. As a usual thing their injuries result from their feeding habits but this is not invariably the case. For instance, the injuries by certain insects are due to their habit of slitting the tissue of the plant for the reception of their eggs — as in the case of the buffalo tree-hopper, the seventeen year cicada and the snowy tree crickets. Other kinds of insects attack the fruit, nuts or seeds of trees and shrubs doing little or no damage to the plant itself but often affecting adversely its reproduction. A third kind of injury is caused by the insect living in the live tissue of the plant, its presence there irritating the plant tissues in such a way as to stimulate their growth, thus causing the formation of unsightly enlargements or galls upon leaf, stem, fruit or root. However, although considerable injury may be done by insect injuries of the sorts mentioned, by far the greatest amount of preventable damage is accomplished by insects working in other ways — namely as leaf feeders, as borers or as sap-suckers. Insects working in these three ways are so important that all of those discussed in this bulletin fall under one of these heads.

A. LEAF EATING INSECTS

Leaf eating insects include a great number of species of considerable diversity of structure. But those especially numerous and noteworthy are the caterpillars of butterflies and moths and the grubs and adults of the leaf eating beetles (Chrysomelidae). Although there are hundreds of species of leaf eating caterpillars and grubs the particular species doing a certain injury may often be recognized by certain characteristics regarding either their choice of food or their manner of feeding. Many species of insects attack any of a large number of host plants — some being practically omnivorous — while others confine their feeding to a single species

or to a very few closely allied species of plants and if deprived of these will often starve.

Leaf feeding insects of different species or even of different stages of the same species produce different sorts of injuries to the leaf, and in many cases these are so characteristic that the insect may be recognized by its work alone. The nature of the injury may be classified under several general heads as follows:— (a) shotholes — regular small circular holes entirely through the leaf, as done by many small caterpillars and adult beetles; (b) ragged holes, as made by larger insects such as the May beetle, etc.; (c) the leaf may be skeletonized, i. e., the softer parts eaten away leaving the veins and upper epidermis; (d) the leaf may be eaten clean from the edge leaving only the main veins; (e) the inner tissues (the parenchyma) of the leaf may be mined out leaving the upper and lower layers intact.

As a usual principle leaf feeders can be controlled readily by covering the surfaces of the leaf with some poison which will be taken into the stomach of the insect when the leaf is eaten and will kill it. However, in the case of the leaf miners the outer layers reached by the poison are not eaten by the insect and therefore such insects must be controlled either by spraying with some material which will penetrate the leaf and kill by contact or by some other method than spraying.

Following are a number of leaf feeding insects injurious to trees and shrubs in New York.

1. THE APPLE-TREE TENT-CATERPILLAR

(*Malacosoma americana* Fab.)

One of the most conspicuous elements of a spring landscape in many parts of New York is furnished by the unsightly white nests (Figs. 2, 5) of this tent-caterpillar in neglected apple trees or in wild cherries. The favorite food tree is the wild cherry but other members of the same natural family, as the apple, peach, plum, pear and thorn-apple are attacked with nearly equal readiness. Occasionally other trees such as beech, birch, willow, elm, maple, poplar, oak and witch hazel are attacked, but these more rarely than the members of the family Rosaceae.

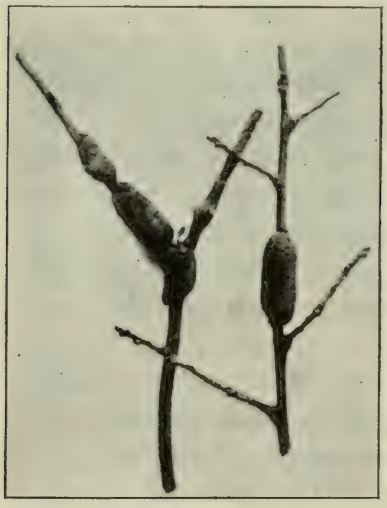


Fig. 1. Egg masses of the apple-tree tent-caterpillar upon the twigs of wild cherry trees. One-half natural size. (Original.)

The insect passes over the winter in the egg stage (Fig. 1). The young larvae emerge from the eggs with the first warm weather of the spring. They usually emerge just at the time that the leaf buds of the wild cherry begin to open. The larvae begin feeding at once, usually first eating the gluey substance which served as a covering for the egg masses during the winter. As soon as this is disposed of they attack the leaves of the opening buds and feed upon them voraciously. All of the larvae from a single egg mass remain together and construct for themselves a web or so-called "tent" (Figs. 2, 5) which serves as a protection for them at night and in cold or stormy weather. This tent is enlarged by adding new layers to the outside as the larvae grow. Frequently adjacent colonies join in the construction and use of a single tent.

The caterpillars continue feeding for a period of about six weeks before reaching full growth. When about ready to pupate, they become very restless and abandoning their tent, they leave the tree upon which they have fed, often wandering for a considerable distance. During this period of wandering they may be observed feeding upon a great variety of plants. The full grown larva (Fig. 6) is two inches or more in length. The general body color is black with a distinct white stripe down the center of the back. Each segment is marked with a pair of pale blue oval spots — one on each side. The arrangement of these markings may be seen in Fig 6.

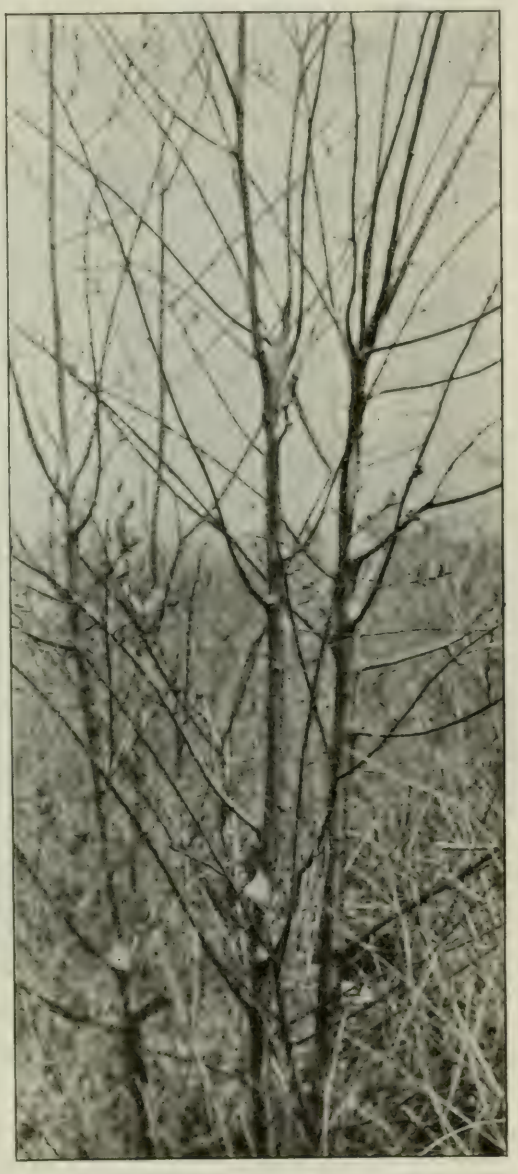


Fig. 2. Numerous young tents upon a small wild cherry tree. The beginnings of thirteen tents can be readily seen in the picture. (Original.)

The larvae finally choose some protected places such as under boards or rubbish and there pupate, first surrounding themselves with a white oval cocoon about one inch in length (Fig. 7). The cocoon is composed of coarse white threads and enclosed in the meshes of this is a yellow powder. The adults emerge about three weeks later.

They are rather stout bodied reddish-brown moths with two parallel whitish oblique stripes on each front wing (Figs. 3, 4). These adults appear during the last weeks in June and the first week in July.

The females soon deposit their eggs upon the twigs of wild cherries or of apples. Although the larvae are apparently fully developed and ready to hatch in August, they remain in the eggs throughout the rest of the summer and the following winter, not hatching until the following April. The egg clusters are deposited in the form of a band surrounding the smaller twigs of the wild cherries or apple. Each mass contains from 100 to 200 eggs, and is covered with a layer

Fig. 3. Adult female moth of apple-tree tent-caterpillar. (V. H. Lowe, Geneva, N. Y. Agri. Exper. Sta., Bull. 152.)

Fig. 4. Male moth of apple-tree tent-caterpillar. (V. H. Lowe, Geneva, N. Y., Agri. Exper. Sta. Bull. 152.)

of a greyish brown frothy glue-like substance. These egg masses are a half inch or more long and with a little practice may be readily seen after the leaves fall.

Control Measures.— This insect can be controlled in several different ways. They are very susceptible to arsenical poisons and may be destroyed by arsenate of lead or Paris green. The two chief difficulties with spraying are — first, the expense is usually hardly warranted unless the caterpillars occur on valuable trees, and second the larvae appear before the leaves are unfolded and there is no leaf surface to cover with poison.

The egg masses may be readily seen after the fall of the leaves and the twigs bearing these can be readily clipped off during the winter with a long handled tree-pruner and destroyed. Still another method is by collecting and destroying the nests at a time of day when the caterpillars are all

Fig. 5. A larger nest of the apple-tree tent-caterpillar upon apple-tree. (W. E. Britton, Bull. 177, Conn. Agri. Exper. Sta.)

in their tents. Perhaps the best method of doing this is by means of a cone-shaped stiff bristle brush about 6 inches long, mounted on the end of a long pole as recommended by W. E. Britton.* With such a brush the entire nest and its contents can be removed by inserting the point of it and

*Conn. Agri. Exper. Sta. Bull. 177, 1913.

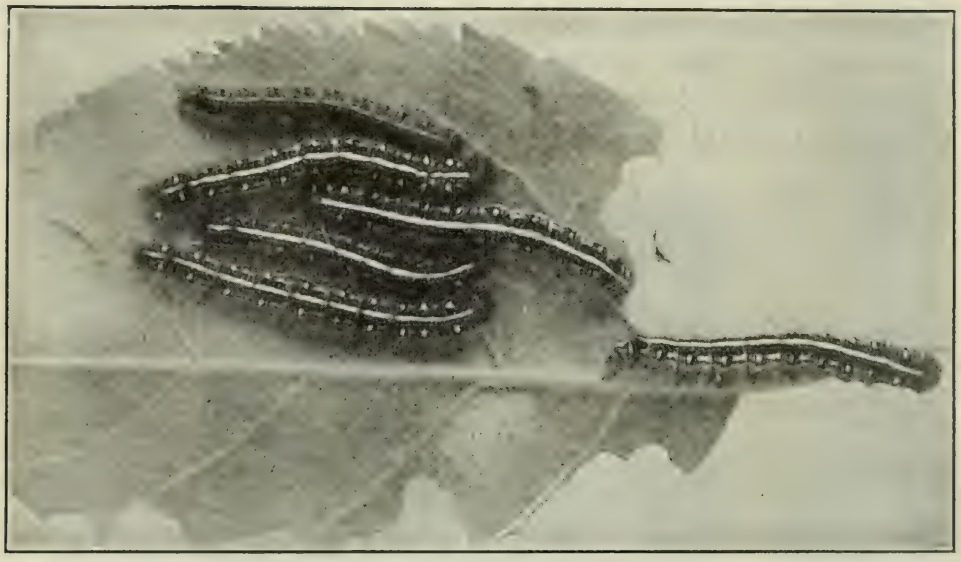


Fig. 6. Partly grown tent-caterpillars. Natural size. (W. E. Britton, Bull. 177, Conn. Agri. Exper. Sta.)

Fig. 7. Cocoons of apple-tree tent-caterpillar. One is cut open to show the contained pupa. Natural size. (W. E. Britton, Bull. 177, Conn. Agri. Exper. Sta.)

giving it a few turns. The caterpillars can be destroyed by crushing.

Another method which has been used to a certain extent is that of burning the nests containing the larvae by using a long handled torch. In the case of worthless wild cherry trees this method is good practice, but in the case of valuable trees the bark is likely to be scorched and the tree injured.

A rather unique method being used by a number of people in the vicinity of Syracuse has been brought to the writer's attention on several occasions. This is nothing less than combating the tent-caterpillar by shooting the nests out of the trees with a charge from a shot-gun. In this way an element rather distantly allied to "sport" is introduced which seems to appeal very strongly to certain individuals. Entirely aside from the excessive noise and from the element of danger due to indiscriminate shooting of firearms this method has two serious objections. In the first place it is over expensive and secondly, the bark of the trees is certain to be injured by the shot or dust, or, if blank cartridges only are used, by the burnt powder. This latter objection would of course apply only to trees of some value.

In conclusion, the writer wishes to make a strong plea for the adoption of measures which he believes will largely do away with its extreme prevalence in many parts of the State. The favorite food plants of this insect are the scrubby wild cherries found along the roadsides and fences and in neglected pastures and wood lots. These are of no value and should be grubbed out and destroyed thus doing away with the chief breeding places.

2. THE FOREST TENT-CATERPILLAR

(*Malacosoma disstria* Hubn.)

The forest tent-caterpillar is an insect which is closely allied to the apple-tree tent-caterpillar and on account of its general similarity in appearance and in work the two forms are often confused in the popular mind. It is only occasionally, however, that the forest tent-caterpillar becomes numer-

ous enough to attract general attention by its depredations and usually also outbreaks of this moth last only a year or two. The caterpillars are more universal in their choice of food than is the sister species. They feed upon a great variety of forest or shade trees, fruit trees and ornamental shrubs, but perhaps their favorite food plant in New York is the sugar maple.

Fig. 8. Egg mass of the forest tent-caterpillar. About natural size. (Original)

The winter is passed in the egg stage. The eggs occur in the form of bands encircling the twigs of forest trees (Fig. 8). These egg masses can be distinguished from those of the apple-tree tent-caterpillar by the fact that the bands are abruptly cut off at the ends (compare Figs. 1 and 8). The frothy covering of the eggs also differs in color, being gray instead of brown.

The caterpillars usually hatch from the eggs during April. The larvae immediately begin feeding upon the leaves. They do not construct a true nest as the caterpillars of the sister species do, but when not engaged in feeding they collect in clusters upon the limbs or trunks of trees (Fig. 9). The full grown caterpillars are from 1½ to 2 inches in length. The head is blue and there is a row of diamond-shaped white spots down the middle of the back instead of a continuous white band (Fig. 10). These markings are sufficient to distinguish it from the apple tent-caterpillar.

When the larvae are full grown they become quite restless and wander from tree to tree, up and down fence posts, trees, etc. This period of wandering is ended by the caterpillar spinning a cocoon in some more or less protected place and transforming to the pupa which lasts for about two weeks. The moths emerge during the latter part of June and the early weeks of July. They resemble the moth of the apple tent-caterpillar in general shape, size and color, but they can be readily distinguished by the fact that the diagonal

lines across the fore wings are dark instead of light. The life cycle is completed by the laying of the eggs in the last week of June and during most of July.

Control Measures.— It is only rarely that this insect becomes so numerous as to invade ornamental trees upon lawns and in private grounds. It is usually confined to open

Fig. 9. Forest tent-caterpillars collected into a characteristic group upon the trunk of a plum tree. (V. H. Lowe, Geneva, N. Y. Agri. Exper. Sta., Bull. 159.)

woods, roadside trees in country districts, or to sugar groves. It is only in the latter case, then, that it ordinarily attracts much attention.

Where control measures are warranted much can be accomplished by pruning off the twigs bearing the egg masses and burning them. Advantage may be taken of the fact that the caterpillars collect in masses upon the tree trunks. They

can then readily be seen and destroyed by crushing, by spraying with kerosene or any of the stronger contact insecticides (see p. 115) or by collecting in a vessel containing kerosene.

The caterpillars are quite susceptible to arsenates and can usually be readily killed by spraying the foliage with arsenate of lead (2½–4 lbs. to 50 gallons of water). This poison must be applied before the caterpillars are half grown and of course the earlier it is used the more foliage will be saved.

Much damage in future years can be prevented by systematic and thorough collecting of cocoons during the latter part

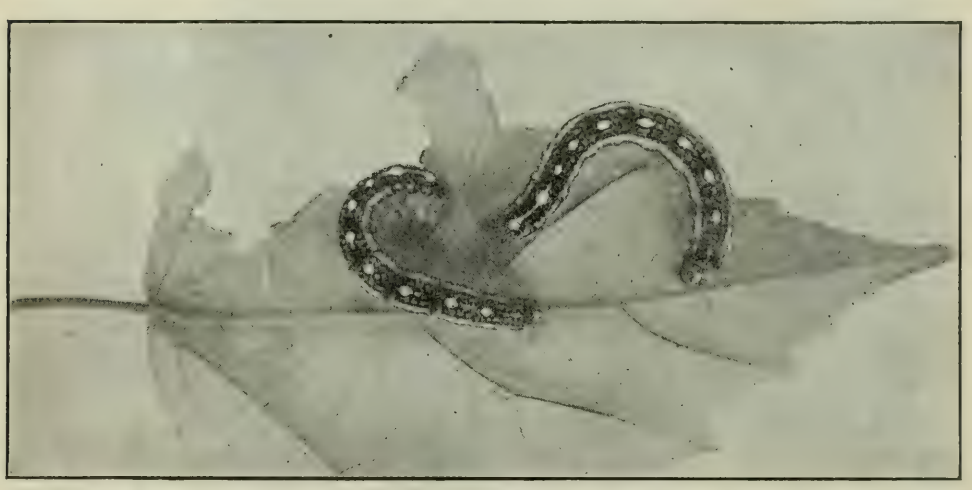


Fig. 10. Two forest tent-caterpillars upon a leaf, showing the characteristic markings. Compare with apple-tree tent-caterpillar in Fig. 6. (W. E. Britton, Conn. Agri. Exper. Sta., Bull. 177.)

of June. By offering a bounty for these cocoons and by offering prizes for the largest number collected, school children can be induced to compete and very effective work often results. It should be realized, however, that the damage for the season is already done when the cocoons are constructed and this is a measure designed only to prevent damage the following season.

Trees not infested can be protected from caterpillars during their wandering stage by banding with strips of cotton batting tied to the trunk at the middle and folded over so

that both sides extend downward. Bands of sticky flypaper or of paper smeared with crude petroleum mixed with tar or with some heavy greasy substance are also effective.

3. THE WHITE-MARKED TUSSOCK MOTH

(*Hemerocampa leucostigma* Sm. & Abb.)

The caterpillars of the white-marked tussock moth are the most common insects attacking the leaves of shade trees in most of the cities and towns of New York State. Their attacks are not confined to the leaves of any particular species of tree but they appear to attack practically any variety of shade tree or ornamental tree including several conifers, showing little preference or discrimination. According to the writer's observations they are, however, more injurious to such trees as the horse-chestnut, maples and elms than to others.

The insect passes the winter in the egg stage (Plate I, Fig. 1), the young caterpillars appearing in the later weeks in May. They immediately begin feeding on the under surfaces of the leaves, eating the parenchyma or body of the leaf, leaving only the veins and the upper epidermis. Thus the leaf is skeletonized and if it happens to be an elm leaf, the results of the feeding of the very young caterpillars is not readily distinguishable from the work of the elm leaf-beetle. As the larva grows larger, it begins to eat the entire thickness of the leaf and when nearly full-grown eats all of the leaf but the midrib and principal veins.

The larvae may often be seen suspended from the leaves by a silken thread which they secrete. As they approach full-growth they apparently become restless, often leaving the tree upon which they have lived up to this time and migrating to other trees. It is at this stage of their life history that their spread from tree to tree mainly occurs.

The larval stage endures for a period of 4 or 5 weeks and when full-grown the caterpillar reaches a length of 1½ inches. At this time (Plate I, Fig. 2) it is strikingly pretty in its coloration. The general color is grey and the

PLATE I.

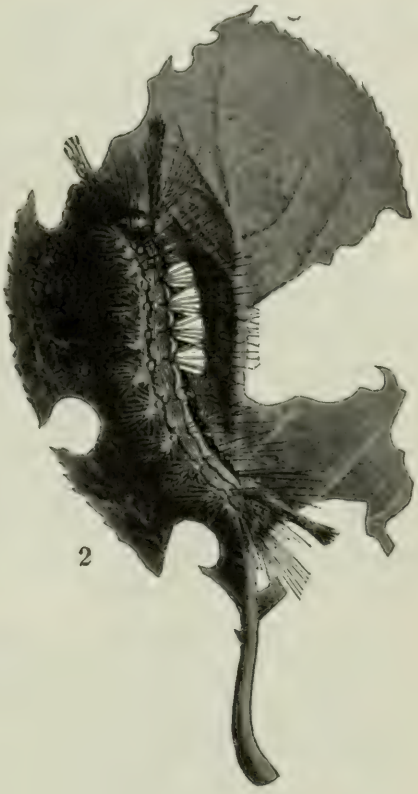
(W. J. Schoene, Geneva, N. Y. Agri. Exper. Sta., Bull. 312.)

Fig. 1. Egg mass of tussock moth upon cocoon from which female has emerged.

Fig. 2. Caterpillar of the tussock moth on an apple leaf.

Figs. 3 & 4. Egg masses, cocoons and adult females of tussock moth.

1



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back is ornamented with a series of four brush-like tufts or tussocks of white hair and behind these two bright colored red elevations. At each side is a velvety black band bordered with yellow. The head is a brilliant red and extending forward each side of it is a pencil of stiff black hairs. A single similar structure of hair extends backward from the posterior end.

When full grown the caterpillar fabricates a grayish cocoon, constructed with silk with which are mixed numerous hairs derived from its body. These cocoons are usually spun in crevices in the rough bark. The pupal stage endures for a period of from ten days to two weeks. The adults of the two sexes arising from the cocoons at the end of this time are very different. The male moth is winged and active in its habits, while the female (Plate I, Figs. 3, 4) is entirely wingless and scarcely ever leaves the surface of the cocoon from which it emerges.

The female deposits her eggs upon the outside of the cocoon quite soon after emerging (Plate I, Figs. 1, 3, 4). The eggs are numerous (often over 300) and are covered with a very conspicuous white frothy mass of material secreted by the female. These masses are a half inch or more in diameter and are very conspicuous objects upon the bark of trees in badly infested locations.

Thus the entire life history from egg stage to egg stage is completed in from six to eight weeks. In central New York the eggs of the new generation are laid principally in July. Usually in this locality the eggs laid do not hatch till the succeeding spring. There is thus only one complete generation each year, although occasionally a few eggs hatch and give rise to a small second generation. In southern New York, however, two generations is the rule and an occasional third generation occurs.

Control Measures.— This insect can be readily controlled by two distinct methods. Perhaps the most satisfactory remedy consists in the collection and destruction of the egg masses. In New York City this is done as a part of the regular routine work of the year. Laborers are here

employed to do this work, but in other cities and towns very effective results have been accomplished by placing a bounty on the egg masses and by offering prizes for those collecting the largest number. In this way school children can be interested and such keen competition aroused that really effective results are accomplished. The egg masses are so conspicuous that with care all can be collected.

In regions of the State where more than one generation occurs each year the question of control is somewhat more difficult. Here the collection of egg masses in the fall or early spring should be supplemented by similar measures taken at the time when the eggs of the first generation are on the trees. If the infestation is at all serious, however, it will be better in such cases to control the pest by spraying at the time when the first generation is just hatching in May and supplement this by fall or winter collection of the egg masses.

The tussock moth can be controlled readily by spraying the trees with arsenate of lead used at the rate of 4 lbs. to 50 gallons of water. As the caterpillars appear at approximately the same time as the larvae of the elm-leaf beetle, both of these pests can be readily controlled by the same spraying, when they occur on elms. As a usual thing, unless the tussock moth is unusually numerous, the use of sprays is unwarranted, as its numbers can be so readily reduced at a smaller cost by collecting and destroying the egg masses.

Quite frequently it happens that trees which have been ridded of all egg masses may be adjacent to other trees in which these measures have not been taken. Such trees can be prevented from becoming reinfested by the banding with some material which will prevent the ascent of the larvae. Perhaps the simplest way is to fasten a band of cotton batting around the tree by tying a string about the middle of it and then turning the upper part down over the string. Or the tree may be banded with tanglefoot fly paper or if the bark is thick a band of tree tanglefoot may be applied directly to the bark.

4. THE MOURNING CLOAK BUTTERFLY OR SPINY ELM CATERPILLAR

(*Euvanessa antiopa* Linn.)

The casual observer frequently meets in the first warm days of spring a butterfly with dark purple wings bordered with yellow. This is the mourning cloak butterfly. In the fall as it goes into hibernation it is a striking and handsome insect but in the spring it is often battered and the wings

Fig. 11. Female mourning cloak butterfly laying eggs on twig of elm. (C. M. Weed, N. H. Exper. Sta. Bull. 67.)

badly mutilated from winter exposure. In some localities the butterfly is abundant and its young or caterpillars are occasionally so numerous on poplars and elms as to cause serious anxiety. It is widely distributed, living in Europe, Asia and America.

Reddish, ribbed eggs are laid in ring-like masses around small twigs and branches in the latter part of May (Fig. 11). In about two weeks the small, blackish caterpillars emerge

from the eggs and at once proceed to devour the new and fresh foliage of the tree. They feed in companies and rapidly defoliate branches. On completing their growth in June or

Fig. 12. Spiny elm caterpillars at work on twig of elm. (C. M. Weed, N. H. Exper. Sta. Bull. 67.)

early July they appear as large, blackish caterpillars, two inches in length, with a row of red diamond-shaped spots on the back and armed with numerous branched black spines (Fig. 12). They now leave the tree or shrub on which they

have been feeding and scatter about, seeking some sheltered situation. Having found this, each caterpillar transforms into an inactive, spiny grayish-brown chrysalis. Two weeks

Fig. 13. Twig defoliated by spiny elm caterpillars, showing the cast skins of the larvae. (C. M. Weed, N. H. Exper. Sta. Bull. 67.)

later the beautiful, conspicuous butterflies appear. These probably deposit eggs for a second brood, although in New Hampshire according to both Weed * and Sanderson † there

* New Hampshire Agri. Exp. Sta., Durham, Bull. 67, 1899.
† Elementary Entomology, Boston, 1912.

is apparently but one generation. The moths hibernate in secluded, out-of-the-way places, coming out the ensuing spring.

Control Measures.— Special control is usually not necessary. Where the caterpillars are doing serious injury, spray individual trees or branches with arsenate of lead, 3½ pounds to 50 gallons of water.

5. THE ELM LEAF-BEETLE

(*Galerucella luteola* Müll)

The elm leaf-beetle is undoubtedly the most serious enemy of the American elm in many regions of New York State. This destructive insect is a native of Europe and was introducted by accident in Baltimore, Md., some time before 1837. In its original home its natural host plants are the English and Scotch elms and in this country the leaves of these trees continue to be its favorite food. However, if these species are lacking, it readily attacks the leaves of the American elm and the corky elm, and breeds successfully upon them.

In New York it has been especially injurious in the cities and towns along the Hudson where thousands of trees have been killed by its work. It is also well established in several of the cities of the central part of the State such as Elmira, Ithaca, Oswego and more lately in Syracuse where it was discovered by the writer in June, 1914. In all of these cities it has become firmly established and in many cases has been very injurious, but apparently its attacks upon the trees have never been so fatal as has been the case in the Hudson valley.

The elm leaf-beetle lives upon the leaves of the elm trees in all the active stages of its existence. It passes the winter as an adult beetle in garrets, out-houses or in any protected location. It is a small beetle slightly more than ¼ inch in length. The prevailing color is orange or greenish yellow with a dark strip upon each of its wing-covers and character-

Plate II

The Elm Leaf Beetle. (Courtesy of Dr. E. P. Felt, State Entomologist of New York.)

1. Cluster of eggs, much enlarged.
1a. Single egg as seen in side view.
2. Recently hatched larva, much enlarged.
3. Full grown larva or grub, much enlarged.
4. Pupa, much enlarged.
5. Overwintered beetle, much enlarged.
6. Young brightly colored beetle.
7. Leaf, showing egg-clusters, skeletonizing work of larvae, cast larval skins, and holes made by the adults in feeding.
8. Leaf skeletonized by grubs.
9. Characteristic work of adults.

. H. Joutel, 1900

ELM LEAF BEETLE

(Courtesy of E. P. Felt, State Entomologist of New York)

istically arranged black spots upon its thorax and head (Plate II, Fig. 6). Very often the adults which have lived over the winter show a darker coloration, so much so that the parts normally yellow or orange become dirty green or even nearly black in color (Plate II, Fig. 5).

The beetle comes from its winter hiding places in April or May, at about the time when the leaf-buds of the elm are just opening. It feeds upon the tender leaves making small irregular holes in them (Plate II, Fig. 9) for a variable period of time before depositing its eggs. Normally, however, the adult female begins depositing her eggs in the latter part of May, and continues for several weeks. The eggs are oblong oval in shape tapering toward the free end and are bright orange yellow in color (Plate II, Figs. 1, 1a). They are deposited upon the lower surface of the leaves in irregular rows or clusters varying in number from five to thirty. Each female is said to lay over 500 eggs but never all in one place.

The eggs hatch in from five days to a week and the young grubs (Plate II, Fig. 2) immediately attack the under side of the leaf skeletonizing it (Plate II, Figs. 7, 8). They eat voraciously, feeding only upon the under parts of the leaf, leaving the upper epidermis and the veins untouched. The upper epidermis then dies leaving transparent areas in the leaves which are quite characteristic of the work of this species. The leaves, when badly skeletonized, turn brown and fall from the tree. On reaching full growth (Plate II, Fig. 3), which occurs late in June or early in July, the larvae crawl down the tree seeking for a place to pupate. This occurs under any sort of partial shelter as under scales in the rougher bark, in the grass or under-ground.

The adults of the new generation emerge in July and very soon deposit their eggs for the second generation. This second generation is completed before the advent of cold weather and as a usual thing it is the adults of this generation, emerging in late summer or fall, which winter over. In many seasons a partial third generation of the grubs may occur but these very seldom reach maturity, at least in any except the most southern parts of the State.

When these beetles are numerous, the elm trees attacked may lose all of their leaves twice in the same season. If this takes place for several years it is nearly certain to result in the death of the tree.

Control Measures.— In the control of all insects with this character, a thorough knowledge of their life histories and habits is necessary in order to combat them most successfully. As has been pointed out by Dr. Felt,* this is the case of the elm leaf-beetle, which involves an even more careful study than usual, because of the great variation in the life history of the species in different localities and in different seasons in the same locality. Where control measures have been undertaken after accurate study of the insect they have been much more successful than in cases where such local and seasonal study has not been made.

If elm trees are sprayed early in the spring when the adults are still feeding upon the new leaves and before the eggs are laid, many of the beetles on eating the leaves will be poisoned before they have a chance to deposit their eggs and thus much damage will be prevented. This should be followed up with later spraying just when the larvae of the first generation are hatching and for a third time when the larvae of the second generation are beginning to appear. It will be thus readily seen why a careful study of local conditions each year is necessary, for if spring opens up only a little later than usual, the beetles may not begin laying till two weeks later than usual and the development of the larvae of the first generation may be delayed still further by cold damp weather after the eggs are laid.

The spray which has proved of most advantage in controlling this insect is arsenate of lead used in the proportion of 4 lbs. to 50 gallons of water. For the larvae this should be applied to the under surface of the leaves, as it is on this surface only that the grubs feed. In the first spray this is not necessary as the beetle eats the entire thickness of the leaf and gets the poison whether it is on the upper or lower

* N. Y. S. Mus. Bull. 109, 1907.

surface. If the two early sprays are thoroughly and properly applied the third one will not be necessary.

The type of spraying outfit one should use must depend entirely upon local conditions. If the trees to be sprayed are large and numerous, it will perhaps be cheaper in the long run to do the work with a high pressure apparatus such as those used for the gipsy moth work in Massachusetts. The first cost of these, however, is rather large and if the trees are small or of moderate size a cheaper power spray will perhaps prove just as satisfactory. With such a machine good results may be accomplished when the spraying is done from a tower or from ladders and when an extension rod is used (see page 122). However, the cost per tree is then likely to be considerably greater. In applying the poison, extreme thoroughness is the primary requisite for success. If some leaves are left untouched, the grubs will leave the sprayed leaves and migrate to those unsprayed, as they are quite sensitive to poison and avoid it if possible.

No other method of control so far devised can be depended upon to be anywhere near as effective as spraying. However, other measures may be used to supplement this chief means of control. Advantage may be taken of the habit which the larvae have of crawling down the tree and pupating in crevices of the bark or on the ground. If the rougher bark is scraped from the tree the grubs will be forced to take refuge in the ground and can then be killed by spraying them with some contact insecticide (see page 115) or by treating them with boiling water. This measure, however, can be applied only after all the damage has been done by that generation and even if it were as effective as spraying with arsenate of lead, the latter method would have preference.

In cases where a new infestation is found in a locality for the first time, the writer wishes to urge that strenuous measures for its control be taken at once. It will usually be found more economical in the long run to establish a control of the insect at once and perhaps to exterminate it, rather than to delay control measures until more serious damage has been done.

6. THE ELM LEAF-MINER

(*Kaliosysphinga ulmi* Sund.)

One of the most frequent and characteristic injuries to the leaves of English, Scotch and especially to Camperdown elms is done by the larvae of a small sawfly. These larvae work between the upper and lower surfaces of the leaves, mining

Fig. 14. Leaves showing the work of the elm leaf-miner. (G. W. Herrick, Cornell Agri. Exper. Sta. Bull. 333.)

irregular burrows through the parenchyma of the leaf, and for this reason they are called leaf-miners. The leaves of the Camperdown elm especially are frequently so badly mined (Fig. 14) by the larvae of this sawfly that a large

per cent. of them turn brown and fall from the tree. The writer has observed several cases where small or medium sized Camperdown elms were in a dying condition, apparently from the repeated attacks of this insect.

The adult of the elm leaf-miner is a black rather wasp-like insect about 1/8 inch long (Fig. 15). These dusky winged insects emerge from the ground where they have spent the winter in the latter part of May. They fly to the leaves of the elm where they may often be seen in immense numbers. Here the females lay their eggs, placing them well down into

Fig. 15. Adult of the elm saw fly, much enlarged.
(G. W. Herrick, Cornell Agri. Exper. Sta. Bull. 333.)

slits made in the upper surface of the leaf by their saw-like ovipositors.

The eggs hatch in from 6 to 10 days and the minute larvae immediately begin to burrow through the parenchyma of the leaf, mining out irregular galleries (Fig. 14) and causing the upper and lower epidermis of the leaves to die and turn brown. Several larvae often occur in each leaf and in such cases the leaf is nearly entirely destroyed and falls from the tree.

When the larvae are full grown, which occurs about July 1st, they break through the epidermis of the leaf, fall to the ground and burrow into this for a distance of about an inch. Here they construct for themselves a brown parchment-like cocoon in which they spend the rest of the summer and all of the next winter, the adults emerging the following May.

Control Measures.— As a usual thing the work of this insect is more unsightly than it is really injurious. However, occasionally they are so numerous that small trees especially Camperdown elms are nearly completely defoliated by them year after year. In other cases they are sufficiently numerous to render unsightly what should be an object of beauty. In either event measures should be taken for doing away with the pest.

The only method of control which seems to offer a reasonable chance of success is one recommended by G. W. Herrick.* He found that the young larvae are killed if the leaves are sprayed when the small mines first begin to appear, with a mixture of "Black-leaf 40," (1 pint to 100 gallons of water in which is dissolved 5 lbs. of soap†). The "Black-leaf 40" is a tobacco derivative having a considerable power of penetration and when applied in this way, it soaks through the outer epidermis of the leaf and kills the larva within. This method of combating the leaf-miner in order to be effective must be properly timed. The leaves must be sprayed as soon after the larvae have hatched as possible.

Another possible way of controlling this insect is by attacking it after it has entered the ground. The upper inch or two of the soil under trees which have been badly infested may be removed and replaced with fresh soil, or the removed soil may be so treated as to destroy the larvae in their cocoons, and then returned. The mere turning over of the soil with a spade will bury many of the cocoons so deep in the earth that the adults will never be able to reach the surface. However, the author believes that the chief reliance should be placed on spraying with the nicotine solution as described above.

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* Cornell Agri. Exper. Sta. Bull. 333, 1913.

† If smaller quantities are desired mix "Black-leaf 40," 1 oz., water 6¼ gals., soap 5 oz.

B. BORING INSECTS

Boring insects are of many sorts, attack different parts of the tree and behave in a variety of different ways. The leaf-miners already mentioned are in reality borers working in the green tissue of the leaves. Borers may also attack the bark or the sapwood or the heartwood. Some attack only the trunks of trees, others are found only in the roots, others only in the smaller branches or twigs, while still others may attack trunk, larger limbs or even small limbs without any apparent preference.

Of all the borers those living in the inner living bark, the cambium, or the outer living part of the wood, the sapwood, are naturally the most injurious. Their work in these living tissues often results in the partial or complete girdling of the tree, the result being apparent either in the death or at least in the decreased vitality of the latter. Trees are often completely killed in a very short time by the girdling effect of borers in the cambium.

Other borers work entirely or nearly entirely in the inner sapwood and heartwood of the tree. The work of these is not so immediately fatal as in the case of cambium borers, but the burrows in the wood weaken the trees and allow decay fungi to enter, so that trees thus affected are often blown down during storms.

As a usual thing boring insects cannot be controlled by spraying. Therefore, the wisest measures to be used against borers are those of prevention. A certain amount of immunity may be obtained for the trees in most cases (but not in all) by maintaining the health of the tree at its maximum so it will be less attractive to most insects and will be better able to withstand the attack of all. Trees suffering from the attack of borers must often be sacrificed either wholly or in part in order to destroy the insects then in them before they emerge and attack healthy trees. Very often by attempting to save a fatally infested tree for a few

years longer, all of the similar trees in that vicinity become infested and are likewise lost.

Some sorts of boring insects may be combatted by injecting carbon disulphide and plugging all openings to the burrow. This, however, is worse than useless in cases where the burrows cannot be closed completely or where they are so filled with borings as to interfere with the free distribution of the gas. In such cases the judicious use of the knife is perhaps the best measure which can be taken.

On the following pages are discussed a few of the most common and injurious boring insects attacking shade trees in New York.

7. THE BRONZE BIRCH-BORER

(*Agrilus anxius* Gory.)

The white birch is one of the most beautiful and popular ornamental trees planted on our lawns and in our private parks. However, of recent years the mortality among white birches, especially the cut-leaf variety, has been so great that it is very doubtful if it is wise to continue to plant them. The death of such large numbers of this beautiful tree is due to the work of a flat-headed borer which spends its larval stage in the inner bark and sapwood of birches. Usually the first indication noticed of the presence of these pests in a tree is the dying of the tree at the top. Such dead tops should be examined immediately to determine whether death is due to drought or to insect work. If the birch borer is the cause of death its work will be evident upon removal of the bark. The inner bark will be found to be riddled by numerous winding, zigzag burrows made by the flat-headed borers (Fig. 16). Limbs attacked the preceding year will also show the characteristic holes made in the bark by the adults on emerging from the tree. These openings are nearly semicircular in outline and their very characteristic appearance is shown in Fig. 17.

A careful examination will often show signs of the presence of the insect before the top begins to die. The indications to be looked for are peculiar rusty reddish brown spots on the bark of branches, these spots occurring over places where the burrows have approached rather near to the surface of the bark. These can be best found in the fall or winter. Another sign of the borer's presence is found in irregular ridges in the bark running either cross wise, diagonally or spirally. These ridges are made by the tree in an attempt to overcome the injury done by the insect and are caused by the overgrowth of the burrows by new woody tissues.

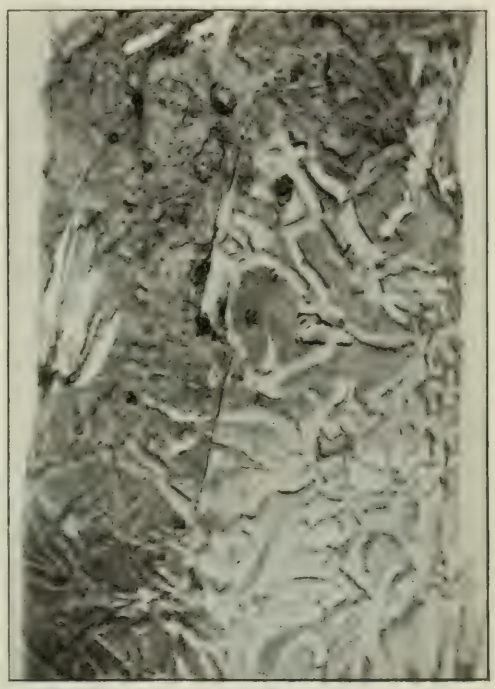

Fig. 16. Portion of the trunk of a dying white birch with bark removed, showing the winding burrows of the larva of the bronze birch-borer. One-half natural size. (Original)

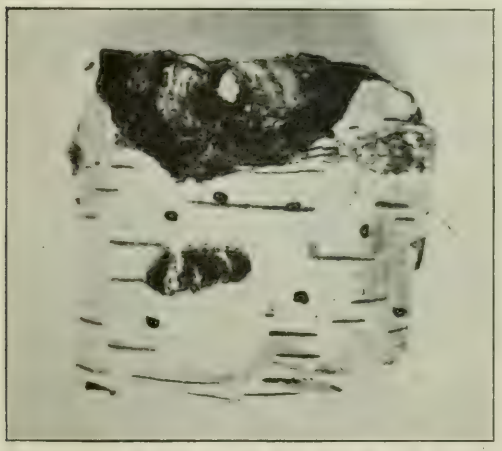

Fig. 17. Portion of the bark of birch showing the characteristic semicircular exit holes made by the adult beetle on emerging from an infested tree. One-half natural size. (Original)

The general appearance of the larvae or flat-headed borer is shown in Fig. 18. It is creamy white in color, the mouth parts and the spines at the opposite end of the body being brown. It is slender with a flattened prothorax (usually spoken of as the head). It is very minute at the time it hatches but when a borer

has reached full growth it is about three-fourths of an inch long. The adult which emerges in the latter part of May and in June, is a slender greenish-bronze beetle from 2/5 inch to nearly ½ inch long (Fig. 19). In the adult stage it does no appreciable harm but may occasionally be seen feeding upon the leaves of poplars, willows, elms and birches.

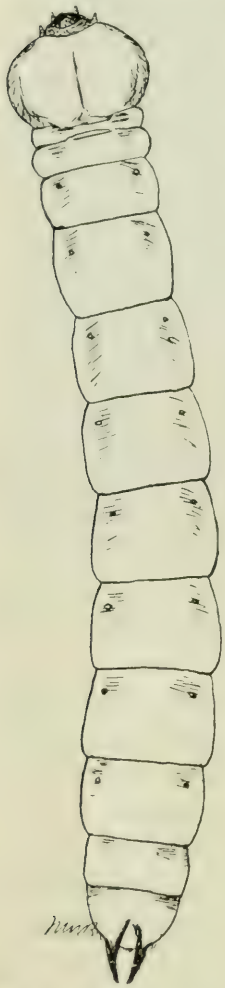

Fig. 18. Larva of bronze birch-borer. About six times natural size. (Original)

Control Measures.— After these borers once get into a tree in any considerable

Fig. 19. Adult of bronze birch-borer. About six times natural size. (Original)

numbers it has been found impossible to save it by any means thus far devised. Experience has shown that after the tree begins to die at the top from the attack of these borers, noth-

ing can save it, although judicious pruning away of the more seriously infested parts will prolong its life. However, in most cases this pruning, even if it prolongs the life of the tree for a year or so, must be so severe as to destroy its symmetry and beauty. If the owner of infested birches has other uninfested trees which he wishes to protect, or if he is public spirited enough to wish to protect the trees of others from attack, he must not hesitate to take preventive measures as soon as he discovers the trees are infested. These measures to be effective must be prompt and drastic. Nothing can be done to prevent the early death of the tree if infested, and this tree must be cut and burned to save other trees from a similar fate. These measures must be taken before May 1st of the spring following the attack, in order to destroy the borers before they transform into beetles and emerge. In the case of this particular tree pest it is not practicable to destroy the borer by probing with a flexible wire because the burrows are so tortuous. Neither is it practicable to cut out the grub with chisel or knife on account of the winding course of the burrow and because of the immense numbers in which the insects occur in the trees.

8. THE FLAT-HEADED HEMLOCK BORER

(*Melanophila fulvoguttata* Harr.)

This flat-headed borer is constantly found living under the bark of dying hemlock and spruce in various regions of the State. In the Adirondack forests practically every hemlock which has been blown down, uprooted or felled during the winter months serves as an excellent breeding place for this beetle. In this extensively forested region it apparently finds a sufficient number of trees which are down or dying from various causes in which to breed, so that comparatively healthy trees are seldom infested. In more thickly settled regions, however, where the timber has been largely cut out

and its host trees much reduced, it often does a considerable amount of damage. This is especially true where the natural stand of timber has been much thinned out to form open groves. In these cases it is a question whether the openness of the stand so weakens the remaining trees as to make them susceptible to the attack of this insect, or whether the scarcity of broken or dying hemlocks compels the beetle to breed in healthy trees. However, the fact remains that hemlocks in the open and in groves which have been over-thinned are more subject to attack than those occurring under more natural conditions.

The grubs of this beetle are somewhat similar in general appearance to those of the bronze birch-borer but are larger and not quite so slender (Fig. 20). The prothorax, which is the wide portion popularly spoken of as the head, is marked upon its upper surface by an inverted V. The spines at the end of the body are absent in the hemlock borer. These grubs make winding shallow burrows between the inner bark and sapwood (Fig. 20). When the tree is attacked by them in large numbers, these burrows cut off the flow of sap and the tree soon succumbs. The borer passes the winter under the bark of infested trees and the adults emerge early in the summer. In the Cranberry Lake region full grown larvae and pupae were taken during the latter half of June 1915. Specimens taken from the bark of both spruce and hemlock during August of the preceding year included numerous examples of all sizes from less than one-fourth of an inch to one inch in length. These observations would indicate that the adult likely emerges at any time during the spring and summer. The adult beetle (Fig. 21) is dark brownish-bronze in color with three yellow spots on each wing cover. It is from three-eighths to one-half of an inch long and about one-third as broad.

Preventives.— It is doubtful whether anything can be done in the way of controlling these insects after they have once entered the tree. Much in the way of prevention can,

however, be done. Trees known to be infested should be felled and so disposed of as to destroy the continued brood

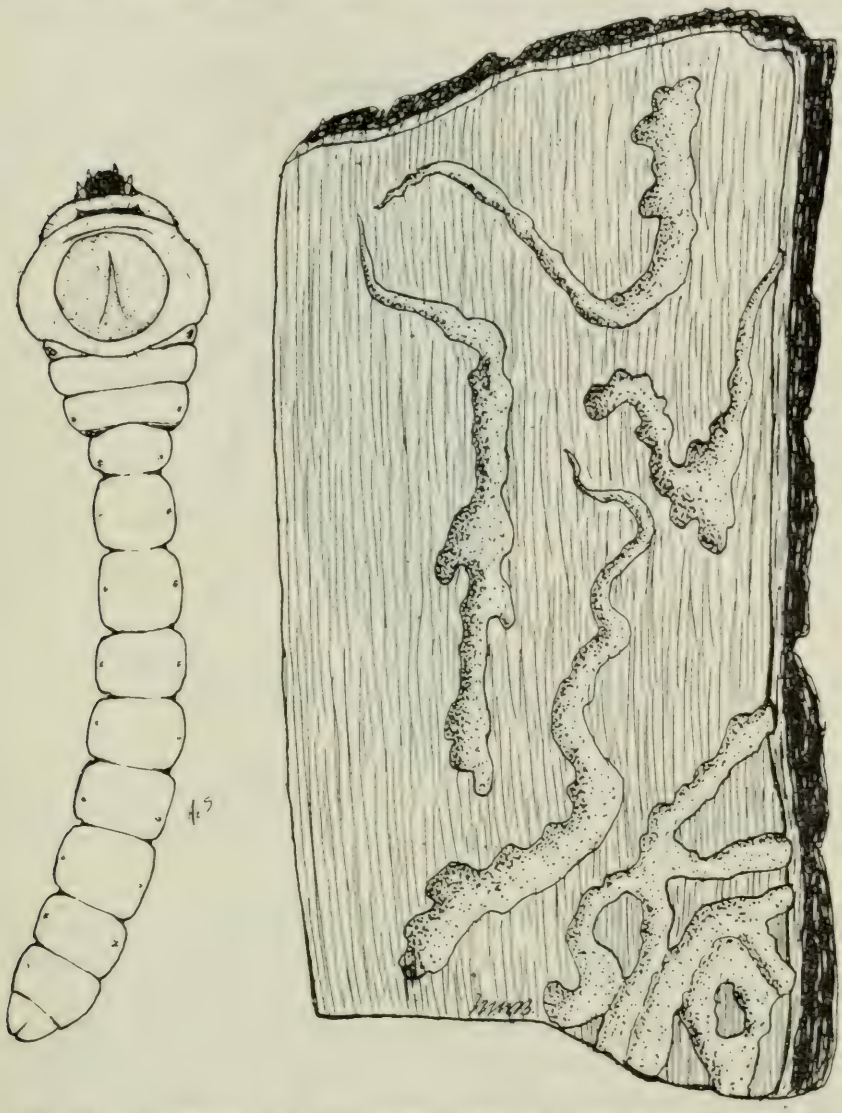

Fig. 20. Larvae of the flat-headed hemlock borer and its work in the inner bark of hemlock. Larva magnified about four times. (Original)

before it has a chance to emerge. This work can best be done in the fall or winter and the method recommended is to fell the trees, strip off the bark and burn it. The wood can be

utilized in any manner desired. In addition the region should be carefully inspected and all injured, sickly, dead or felled trees should be removed thus doing away with breeding

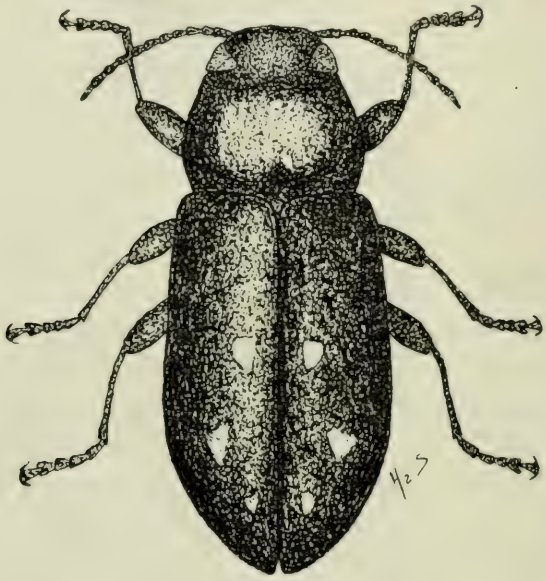

Fig. 21. Adult of the flat-headed hemlock borer. About six times natural size. (Original)

places and preventing undue increase in the number of these injurious beetles.

9. THE ELM BORER

(*Saperda tridentata* Olivier.)

In some regions of the State the elm borer is very prevalent and quite destructive. The American elm seems to be its favorite host, and as this tree is, all things considered, probably the most popular and valuable shade tree in the State, any of its enemies are worthy of attention. The borer in question seems to attack, preferably at least, trees which have been weakened by the work of other insects such as the elm leaf-beetle or which are injured or sickly from other causes. Whether perfectly healthy, vigorous trees are ever

attacked or not appears questionable to the author. However, there can be no doubt that in many cases the actual death of trees which otherwise would be able to survive is due to the work of this borer.

The larva is a round-headed borer about one inch in length and is of a white or yellowish white color. The body is only slightly flattened and is thickest just back of the head. The burrows of the borer under the bark are extremely winding and involve both the inner bark and the sapwood. The adult

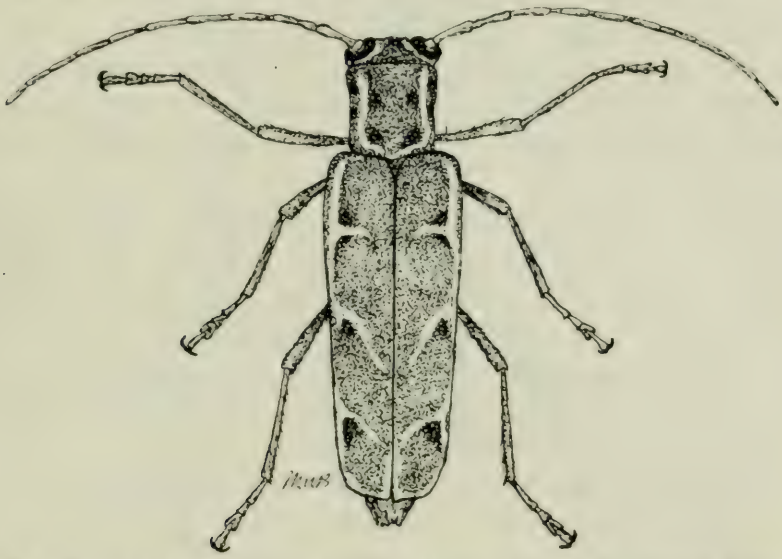

Fig. 22. Adult of the elm borer. About three times natural size. (Original)

insect may be seen upon the wing or depositing their eggs throughout the entire summer (June to September). These beetles are grey or brownish-grey in color with the prothorax and wing-covers ornamented with red or orange red lines and with black spots as shown in Fig. 22.

Its presence in the tree is very difficult to detect until its work has proceeded to such an extent that the tree is beginning to show signs of dying. The first signs to appear usually consist in the yellowing and dropping of the foliage on one or more limbs. If the tree is then examined carefully, "sawdust" derived from the borings will be found in the

crevices of the bark. Later indications are in the form of dying and dead patches in the bark of the trunk or larger branches.

Control Measures.— Trees infested to such a degree that they show signs of dying should be cut and burned between the first of September and the first of May following. In other words, if the tree is found to be fatally infested during the summer months nothing will be gained by destroying it at once, whereas if it is left till September it will act as a trap tree by offering a suitable place for other beetles to deposit their eggs. The trees may be burned as soon as cut or they may be used for firewood, but in the latter case all of this wood must be used before May as otherwise the contained grubs will give rise to beetles which will lay their eggs in new trees.

If the trunk of the tree is sound and only a few limbs are infested, these may be removed and burned. This should be done as soon as the infestation is discovered. If limbs are uninfested and only a part of the bark of the trunk is killed, the diseased parts should be removed, including all the parts decayed or discolored by fungus, and the wound painted two coats with a pure white lead paint.

Preventive measures are of doubtful expediency, due to the extremely long period of time (May to Aug.) during which the laying of the eggs may occur. Measures which have been found efficient against very closely related pests are as follows: The bark of trees which have as yet not been attacked may be kept moist during the egg-laying season with a wash prepared as follows: To one gallon of soft soap add one gallon of hot water and one pint of crude carbolic acid. Mix thoroughly and allow to stand over night. Dilute this next day by adding eight gallons of soft water and apply to the trunk and the bases of the large limbs. Or trees may be kept thoroughly coated during the summer by means of a brush, with a mixture of two gallons of thick whitewash, to which is added one pint of crude carbolic acid and about four ounces of lead arsenate and enough lamp-black to color it grey so it will be less conspicuous on the tree.

10. THE LOCUST BORER

(*Cyllene robinae* Drury.)

The black locust is one of the most valuable trees for the farm wood lot, for when conditions are right it furnishes a plentiful supply of post timber both for home use and for the market. However, this valuable tree has a most serious enemy in the locust borer — such a destructive enemy that it has made the successful rearing of black locust apparently

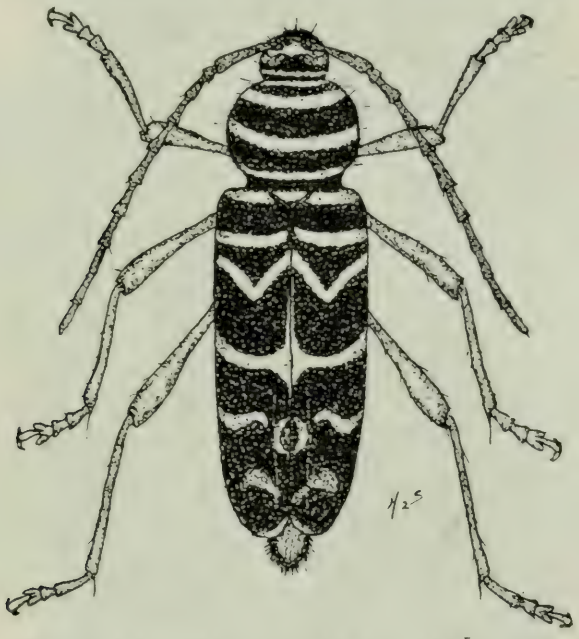

Fig. 23. Adult of the locust borer. About three times natural size. (Original)

impossible in many parts of the country. It is deadly to the locust not only in the wood lot and in plantations but is equally deadly to this species when used as shade trees. For this reason this insect is of nearly equal interest to the dwellers in the city and in the country.

The adult insect is a handsome beetle slightly over half an inch in length. It is black in color with both wing covers and thorax marked with irregular yellow bands as shown in Fig. 23, those on the middle of the back being shaped like a letter " W". They fly only in September and October, are

quite active in their habits and at this time are found especially upon the flowers of the golden rod where they appear to feed voraciously upon the pollen. The females deposit their eggs during September and October in cracks in the bark and in crevices under strips of the outer bark. They are not placed in special punctures made in the bark by the

Fig. 24. Several eggs of locust borer deposited under the bark in an old injury. About twice natural size. (H. Garman, Ky. Agri. Exper. Sta.)

female but in any crevice which will partly cover and conceal them. Often six or eight are placed in one crevice (Fig. 24).

On hatching, the larva, which is a round-headed borer, burrows into the outer bark and makes a small oval cavity in the bark where it passes the winter in a dormant condition.

The location of this short burrow can often be detected by the pellets of excrement extruded from the entrance. In the spring the larva begins burrowing in earnest and feeds voraciously upon the sapwood and heartwood of the tree until it pupates some time during August. It emerges in September as an adult of the new generation. The general appearance of the larva is shown in Fig. 25.

Trees which are infested or have been infested by these borers can be readily recognized. If they have been attacked

Fig. 25. Larvae of the locust borer; enlarged and natural size. (H. Garman, Ky. Agri. Exper. Sta.)

year after year, they often possess trunks which are deformed and the main limbs also are often distorted or killed. If such a tree is felled and examined, the trunk and main branches will be found to be riddled by successive generations of locust borers (Fig. 26). Quite frequently trees are killed outright by the work of the borers but perhaps more often the work of the borers year after year in the trunk or larger branches so weaken these that either the entire tree or its main branches may be broken by the wind. In plantations of black locust which are being reared for post timber, serious damage is done even though the trees may not be killed out-

right, as the burrows in the wood render it valueless or at best much decrease its value for posts or any other purpose.

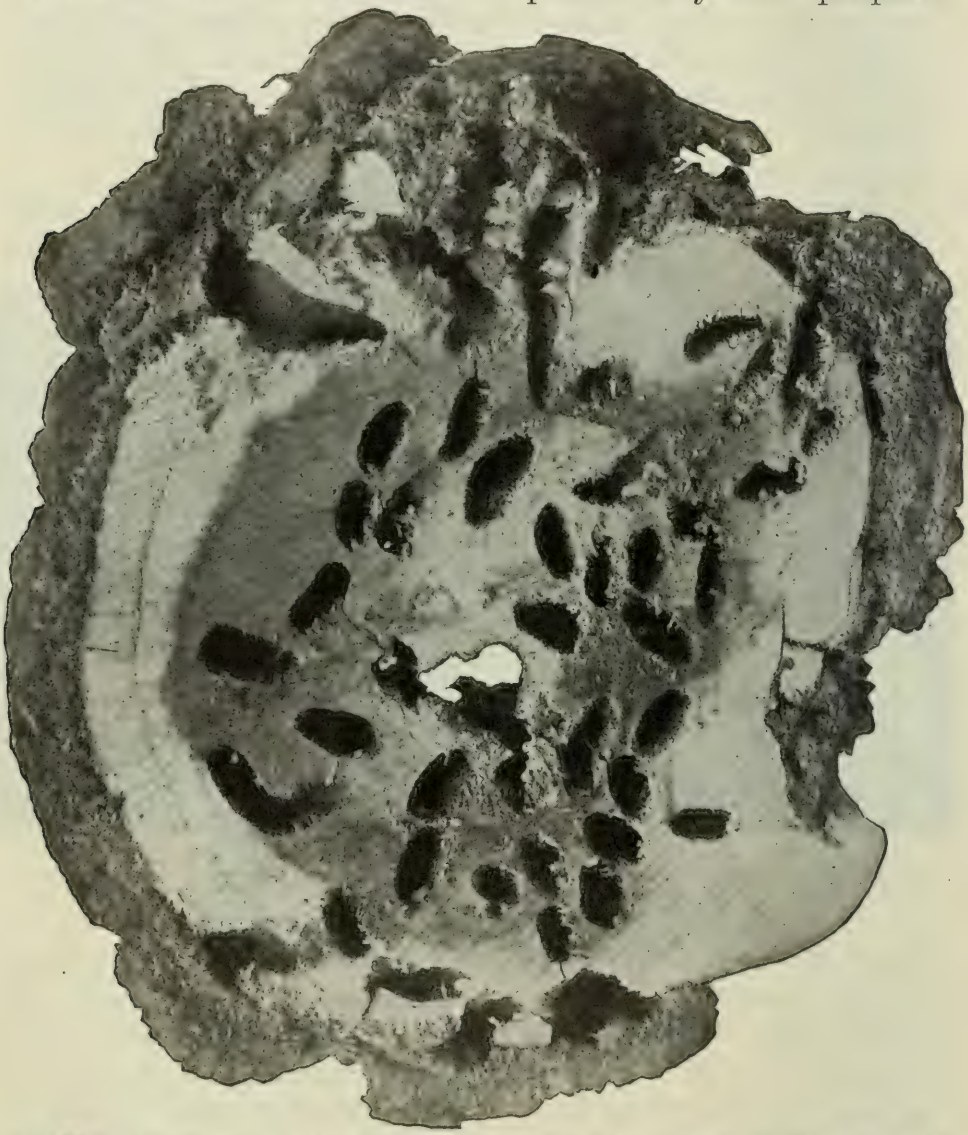

Fig. 26. Cross section showing injury by the locust borer in the sapwood and heartwood of locust. Natural size. (W. E. Britton, Conn. Agri. Exper. Sta.)

Remedies and Preventives.— Valued trees whether in plantations or elsewhere should be examined in the fall for signs of the recently hatched larvae. Such signs consist of

excrement [illegible]ed from the burrow in the outer bark. If the tree is found to be infested, most of the larvae can be killed during the fall and winter (between Nov. 1st and Apr. 1st) by spraying the trees with kerosene oil emulsion (see p. 115) used in the proportion of 1 gallon of emulsion to 2 gallons of soft water. Trees should be examined again during May and June and those found badly infested, as evidenced by the exudation of sap and the extrusion of "sawdust" from the burrows, should be cut during the early summer (before Aug. 15) and so disposed of as to kill all of the contained larvae before they have a chance to emerge. This may be done either by burning the entire tree or by submerging the more valuable parts till the larvae are drowned (several weeks) and burning all refuse.

The use of poisoned baits (consisting of a mixture of honey or syrup and some arsenate) which may be smeared upon the tree has also been recommended. To the writer, however, this seems of doubtful expediency as it is believed that such a bait would attract the beetles in larger numbers and it is probable that many eggs would be laid before the poison proved fatal. It is certain that attempt at control by this method would result in the death of many honey-bees and these are too valuable to be ruthlessly destroyed on the mere chance that a poison bait may prove effective against an injurious form.

Still another way of combating this insect is by taking advantage of the fact that the adults feed upon the golden rod. Here they can be collected in immense numbers in a locality where the locusts are badly infested. If all golden rods except a limited number in certain known localities are kept down and these localities are visited systematically and all beetles collected and destroyed it is perfectly practicable materially to reduce the numbers in any locality and just as materially to reduce the amount of damage to the locusts. If this duty is performed by children, the cost will not be prohibitive.

It is recommended that farmers or others who contemplate establishing a plantation of black locust for commercial purposes (i. e., the production of post timber) should first make

a careful examination of the locusts within a radius of several miles. If a large percentage of the black locusts show the results of attack by the locust borer, the plantation should be abandoned, temporarily at least. If the cooperation of land owners over a radius of several miles can be obtained it would seem to be entirely feasible, practically to exterminate this beetle by carefully inspecting all locust trees twice a year for several years, and disposing of every infested tree before the borers could transform to beetles. Then after the plantation is established, if this system of management is continued, if all breeding places in the plantation are destroyed, and if in addition the adults are systematically collected during their feeding season, the writer believes that black locust can be successfully reared even in a locality in which the locust borer was originally plentiful. Only a practical trial can determine the cost of the system of close supervision recommended above but it is believed that it would not be prohibitive.

11. THE SUGAR MAPLE BORER

(*Plagionotus speciosus* Say.)

One of the most striking characteristics of many cities and towns of New York is the extreme prevalence of sugar maple trees badly injured and deformed by this very injurious insect. It is so generally prevalent in almost all parts of the State that we wish to urge strongly the advisability of planting the streets of our towns and cities with other varieties. If a maple tree is desired experience has proven that it is much wiser to plant the Norway maple. This species is a somewhat slower grower but is much more resistant to insect attack, and will usually remain a source of beauty and of pleasure for many years longer.

This very injurious round-headed borer often kills sugar maple trees outright and a large percentage of the roadside trees of the cities, villages and country roads of New York show the characteristic and more or less serious injuries wrought by this pest (Figs. 27, 28). Furthermore, the

insect appears to prefer healthy trees and most often seems to attack those apparently in full vigor. The signs of the work of this borer appear in the shape of dead limbs, of dead areas of bark on the trunk or larger branches and in transverse ridges or elevations just under the bark. (Figs. 27, 28). This latter condition is caused by the attempt on

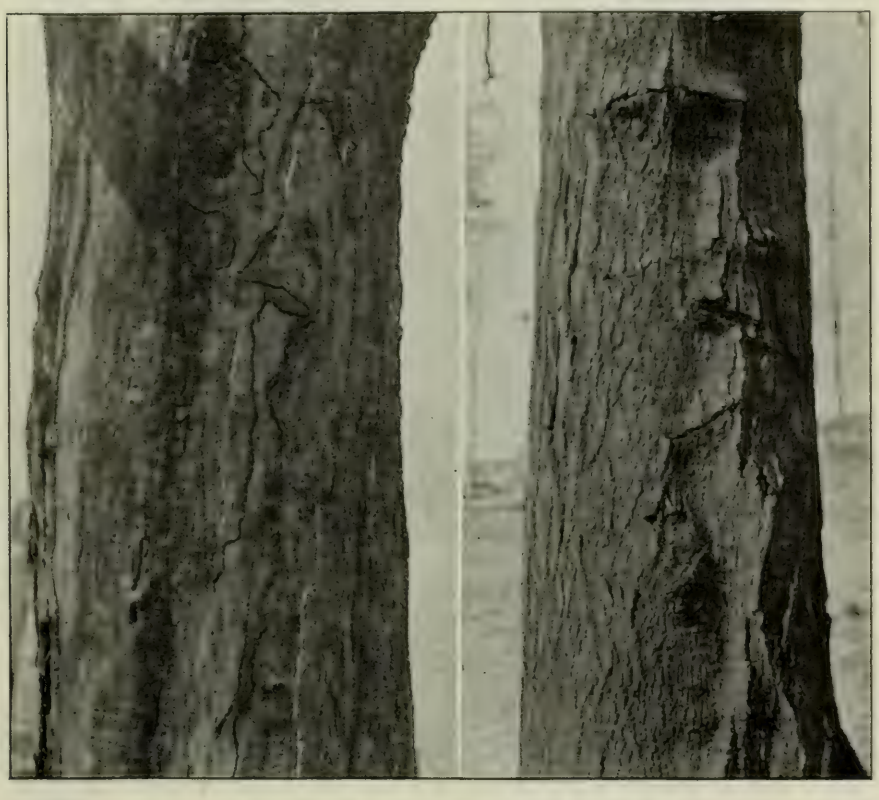

Fig. 27. Showing the work of the sugar maple borer in the trunk of large maple trees. The tree to the left had been attacked several years previously, and the bark on about half of its circumference killed. In the tree at the right the work of the borer has not proved so serious. The ridges and splits in the bark are due to overgrowth of the burrow by new sapwood. (Original)

the part of the tree to heal the injury done by the burrowing larva by covering the injury with an overgrowth of new tissue. This forms a ridge and forces the bark outward at an angle or causes it to break off and expose the wound underneath.

The grub of the maple borer (Fig. 29) is a round-headed borer which when full grown often reaches a length of nearly two inches. The eggs are laid during July and August upon the trunk and larger branches of maples. The female shows a preference for laying in sunny places and seems to place

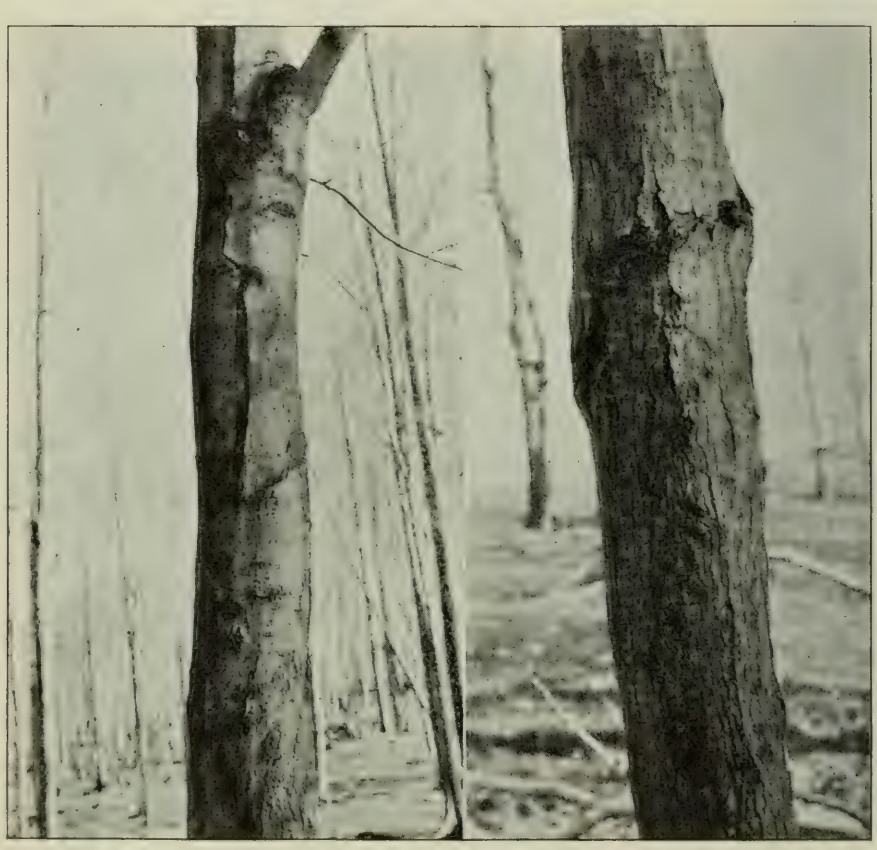

Fig. 28. Showing more recent work of the sugar maple borer. In the tree at the left the burrow shows the characteristic longitudinal course which becomes diagonal on reaching the first limbs. In the tree at the left the burrow half girdles the tree but is healing over.

her eggs most frequently on the trunk near the bases of the larger limbs. This often results in the partial or complete girdling at the base of the limb, as the larva usually bores diagonally upward and on meeting such an obstruction as the base of a limb attempts to go around it (Fig. 28). The first winter is spent in the sapwood, and on resuming activ-

ities in the spring and summer following, the insect continues to mine either between the bark and sapwood or in the outer sapwood. The burrows during this second summer form very serious wounds in the tree as they are one-half inch or more in width (Figs. 27, 28) and about two-thirds as deep. As a usual thing the burrow has an upward direction but

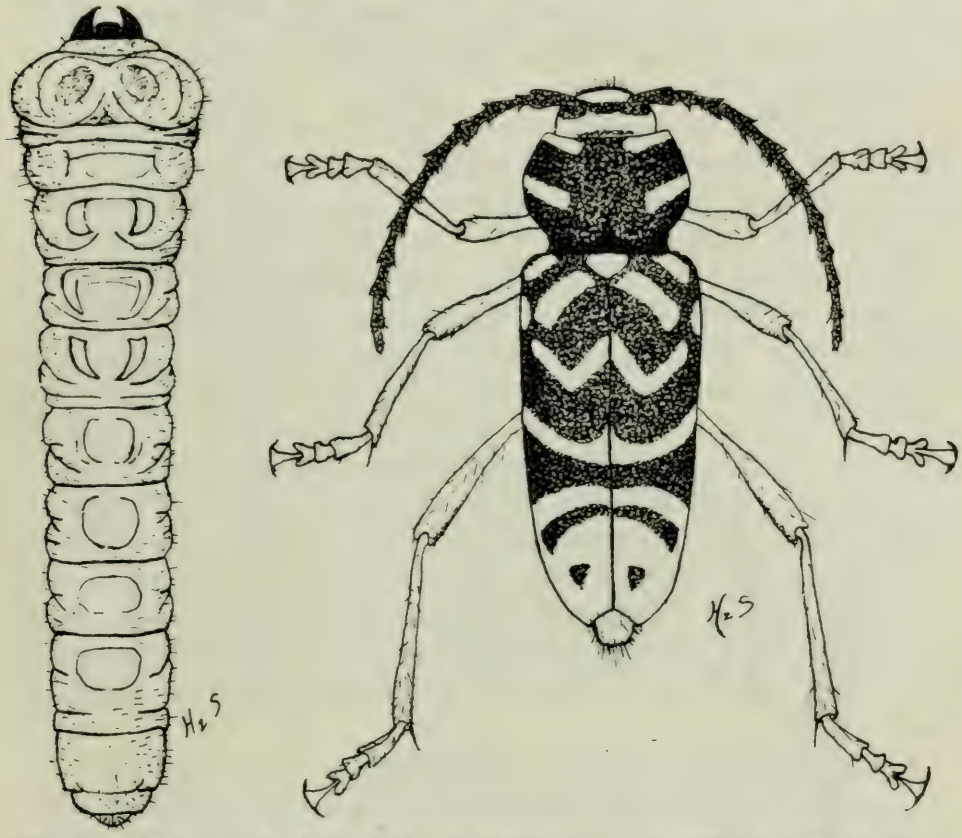

Fig. 29. Larva and adult of the sugar maple borer. Twice natural size. (Original)

sometimes may take a diagonal or nearly a transverse course, thus partially girdling the tree. As a usual thing only a relatively small number of larvae occur in a tree at one time but occasionally they may be quite numerous and in such cases the tree is doomed. Trees may be killed by as few as three or four larvae provided the direction of the burrows is such as to girdle the bark completely.

At the approach of the second winter the nearly full grown larvae bore deeper into the heartwood and there hibernate, the adult emerging the following June or July (Fig. 29). The female deposits her eggs during July and August. This causes a discoloration of the bark, and the larva upon hatching and beginning its boring causes the sap to flow slightly and also throws out a quantity of frass and excrement which often adheres and extends in small masses from the point of entrance.

Control Measures.— Trees which are badly infested should be cut and burned during the winter or spring after the infestation occurs before any of the adults can emerge. Trees which are especially valuable should be examined carefully in spring and fall of each year for signs indicating the presence of borers. In the fall these signs consist of discoloration in the bark and exuding sap where the eggs have been laid, and in the fine " sawdust " and pellets of excrement cast out by the young larvae. Often also, both in the spring and in the fall, considerable quantities of coarser " sawdust " may be found in the crevices of the bark and at the base of trees, indicating the presence of larger borers. If sawdust is present, find the openings from which it is extruded, cut away the bark and follow the burrow till the larva is located. Be careful to injure the tree as little as possible and to make the injury clean cut. Cover the wounds with two coats of good paint.

Some authorities have recommended the injection of carbon disulphide into the burrows. This is a volatile substance which readily kills insects and is very effective when all of the openings to the burrow are tightly sealed. The objection is that one can never know whether the insect has been killed or not. Therefore the more radical measure is recommended. An interesting fact brought out by a study of the history of this insect is that it was formerly a rare insect whereas now it is common. This is merely another instance showing the effect of man in upsetting the balance of nature. Conditions in the natural forests were not favorable to the life of the maple borer and it became common only

when man established more favorable conditions by planting sugar maples in the open as along roadsides and on lawns. It is a species which only rarely deposits its eggs in trees in dense growths or in groves in which underbrush is plentiful. Therefore the best prevention of this insect in sugar groves is to allow the underbrush to grow.

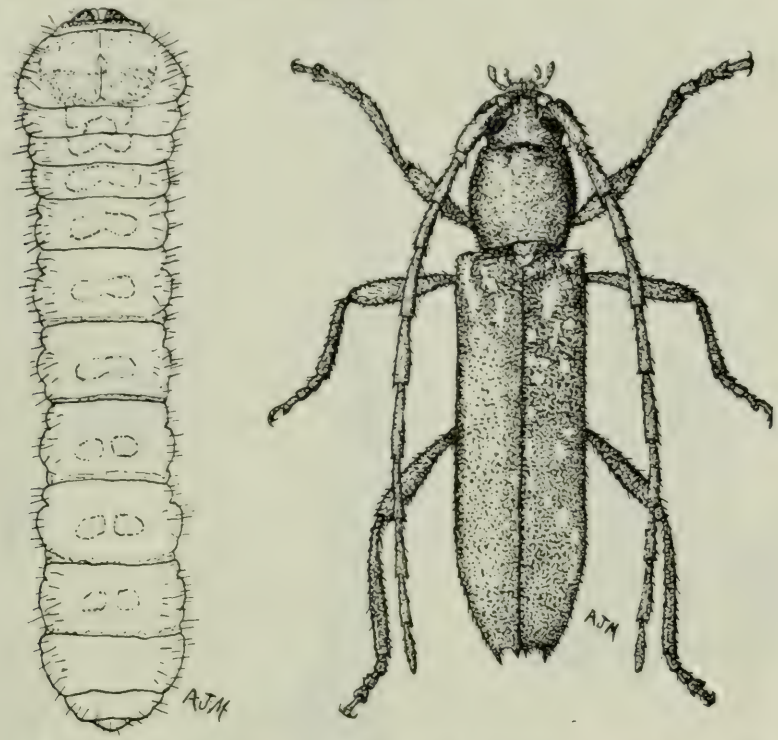

Fig. 30. Larva and adult of the twig pruner. About four and one-half times natural size. (Original)

12. THE TWIG PRUNER

(*Elaphidion villosum* Fab.)

The twig pruner is one of the most curious and interesting of the boring insects as regards its habits. The adult is a slender brown beetle a half inch or more in length (Fig. 30). The wing-covers often appear to be marked with yellowish or ashen grey spots due to the unequal distribution of the hairs covering the back. The wing-covers are each armed at the end with two spines.

The female beetle deposits her eggs one at a time in the smaller twigs of a living oak, hickory, maple or chestnut tree most commonly, although more rarely any one of a large number of other trees, shrubs or vines may be chosen. On hatching, the larva which is a round-headed borer (Fig. 30),

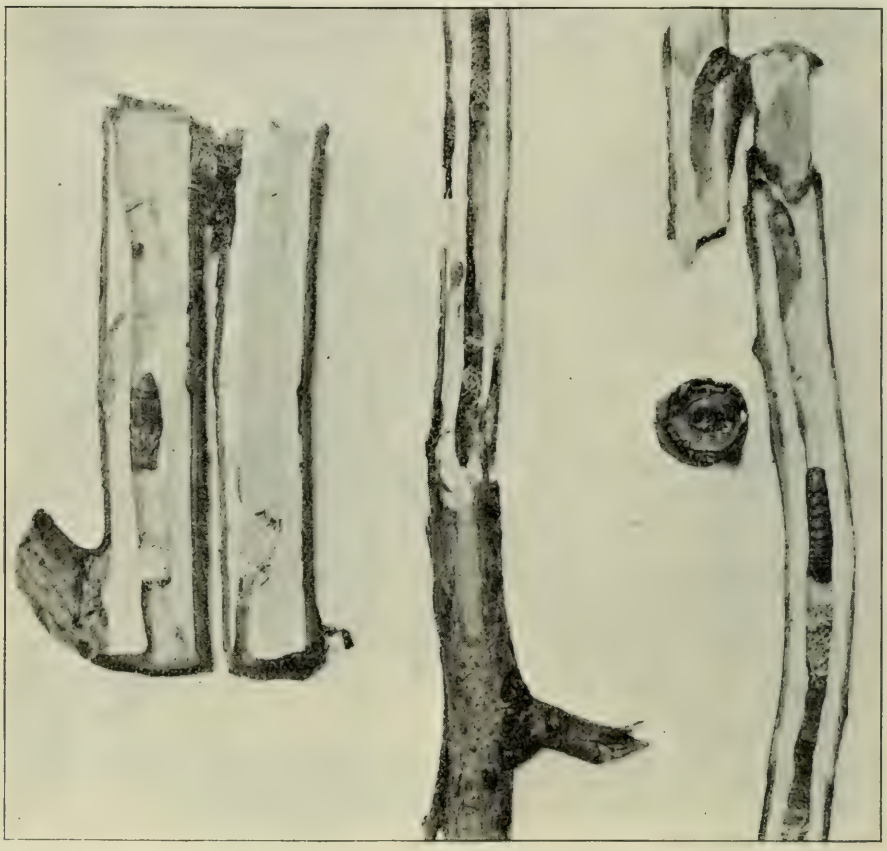

Fig. 31. Several twigs showing the burrows made by the twig pruner in hickory. Note the plugs of "excelsior" and "sawdust" at the severed end. A larva is seen in one burrow and a pupa in another. To the right is shown the end of a severed twig with the central burrow plugged with excelsior-like frass. About three-quarters natural size. (Original)

burrows through the outer part of the wood just under the bark, following the grain and working toward the base of the small limb. As the borer grows, it works to the center of the twig making a slightly oval burrow through the axis.

When the larva reaches full growth, which occurs in early fall (September), it gnaws a circular groove in the outer wall of the burrow and extends this farther and farther outward until only a few wood fibres and the bark remain. It then retreats up the burrow and plugs the opening with "sawdust" and excelsior-like chips.

The twig is usually broken by the first high wind and falls to the ground, the larva being in its winter quarters inside (Fig. 31). If the severed twig is examined it will usually be found to be as cleanly cut off as if done by a sharp knife. The larva transforms to a pupa (Fig. 31) either late in the fall or in the succeeding spring and emerges as an adult in June.

The amount of damage done by this interesting insect depends upon its prevalence. However, the injury is usually not great, the result in even the worst cases observed being merely an overpruning of the tree. This may destroy the symmetry of the tree or even decrease its vitality, but no cases have ever been observed where trees were killed or even seriously weakened by the work of the twig pruner.

Control.— This insect is one of the easiest to control of any of the tree pests. They may be combatted effectively by collecting the pruned off twigs in the fall and burning them, thus destroying the contained grubs. This to be effective, however, must be thorough, which means that all of the dwellers in a neighborhood must cooperate.

13. THE MOTTLED POPLAR AND WILLOW BORER

(*Cryptorhynchus lapathi* Linn.)

This peculiar and striking looking snout-beetle (*Curculionidae*) has become one of the most common and perhaps the most disastrous enemies of willows and poplars in the northeastern United States. It was originally an inhabitant of Europe, where it is a well known pest, and was introduced into this country probably about 40 years ago. Since that time it has been reported as doing damage in nearly all the

northern states as far west as North Dakota. It attacks practically all species of native and cultivated willows, poplars and alders and also breeds to some extent in dwarf birch and red birch. Its principal injuries have been to poplars and willows in nurseries, to basket willow in plantations and

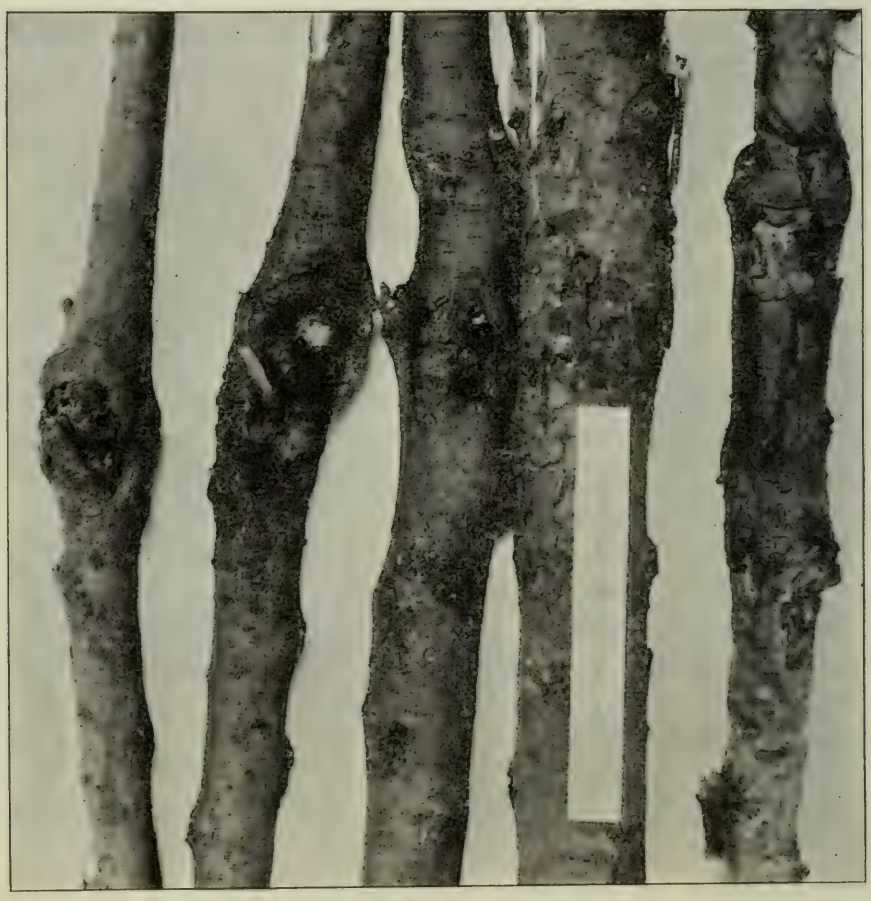

Fig. 32. Showing the dead areas in the bark of willow and the gall-like swellings due to the work of the larvae of the mottled willow and poplar borer. About one-fourth natural size. (Original)

to the various species of willow and poplar when used as shade trees or as wind breaks.

Indications of the work of this borer are seen in dead or dying limbs, and in the presence of irregular swollen places and of dead patches of the bark upon the limbs or trunk

(Fig. 32). These latter are often cracked open, sometimes exposing the wood beneath and often surrounded by swellings under the bark due to the attempt on the part of the tree to grow over and heal the wounded area.

Most of the adults emerge during July, August and September. Some, however, emerge in October and the writer has recently found that still others pass the winter as full-

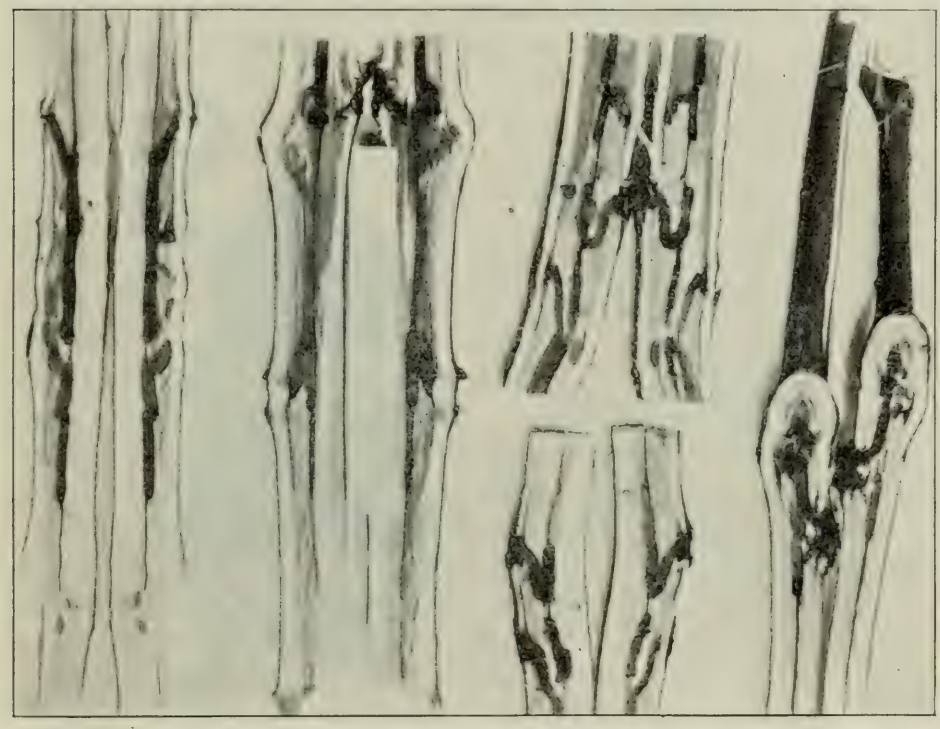

Fig. 33. Showing the burrows of the willow borers in the wood and the chambers in which they pupate. About one-fourth natural size. (Original)

grown larvae, pupae or young adults in burrows in the wood. However, the great majority of the adults emerge in late summer or fall. They are quite easily recognized on account of their unusual appearance (Fig. 34). They are rather broad snout-beetles about one-third of an inch long, dark brown in color, mottled with grey and with the posterior part of the wing-cover gray, yellow or pink in color.

The adults of both sexes feed voraciously upon the inner bark or cambium of the younger shoots of the willow, in so

doing making punctures in the outer bark. After feeding thus for a week or two the females lay their eggs in the older part of the tree, preferably in wood of two to four years' growth. Most of the eggs are deposited during August and September and hatch in from 18 days to three weeks. The larvae begin to feed upon the inner bark or cambium and so continue till cold weather puts an end to their activities for the season. Usually the insect passes the winter as a small immature larva just under the bark. With the coming of

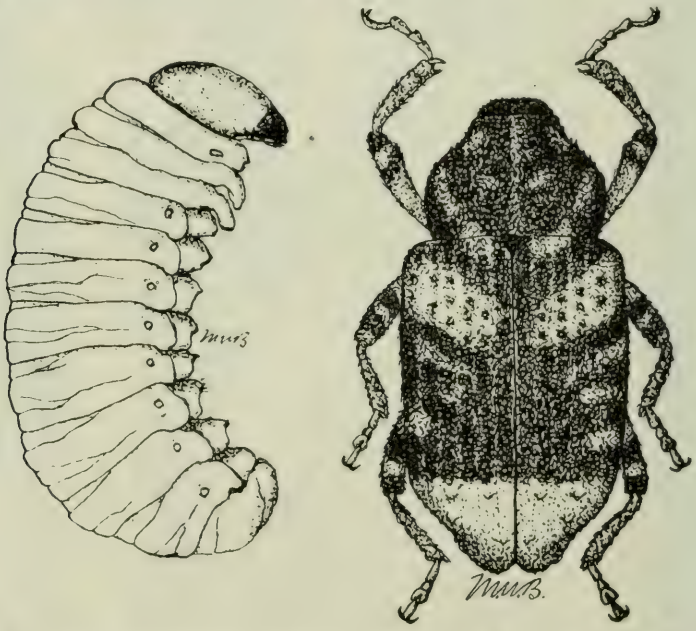

Fig. 34. Larva and adult of the mottled poplar and willow borer. About six times natural size. (Original)

spring, activity is resumed, the larva continuing to mine the bark with irregular channels until nearly ready to pupate. It then bores into the wood usually at an upward angle for a half an inch or more, or in branches of an inch in diameter, until the pith is reached (Fig. 33), then extends its burrow upward (occasionally downward). Before the larva pupates he packs the gallery in the wood, except for a small chamber at the end, entirely full of finely shredded wood fibre. The larva then pupates and the adult emerges about two weeks later. This is the typical seasonal life cycle

but it is subject to considerable variation as previously mentioned.

Methods of Control.— As with practically all boring insects the main reliance for control measures should be placed upon cutting infested limbs or entire trees and burning them before the contained brood have a chance to emerge and infest new hosts. This can best be done in early summer, as at that time the larvae are quite active and their presence is made very apparent by exudations of "sawdust" or sap or both. It would be well also to examine the nursery or plantation for evidences of larval work in the fall, as the insect may have a strain the adults of which do not emerge till early spring as is true of some of those infesting native willows near Syracuse.

That there is a possibility of controlling this pest by two other sorts of treatment is shown by the experiments of W. J. Schoene * with the use of a stomach poison and those of R. Matheson † using contact insecticides. Schoene's experiments demonstrated that it is possible to control this beetle by spraying the food plant during the last two weeks in July with bordeaux mixture containing three pounds of lead arsenate to fifty gallons of water. The treatment must be thorough so as to cover all parts of the bark with the poisonous mixture. The most serious objection to this method is on the basis of the impracticability of spraying nursery trees.

Matheson finds that when trees infested with this borer are carefully painted either with pure carbolineum or with emulsion, either in December or in the April following, the contact insecticide penetrates to such an extent that the larvae working in the bark are killed. The carbolineum emulsion used was prepared as follows: 1 lb. sodium carbonate, 1 quart hot water, 1 quart carbolineum avenarius. These experiments seem very conclusive but it should be realized that this treatment is yet in the experimental stage, and it must be put to practical test before it can be recommended unreservedly.

* New York Agri. Exp. Sta., Geneva, Bull. 286, 1907.
† Journ. Econom. Ent., vol. 8, pp. 522, 525, 1915.

14. THE WHITE PINE WEEVIL

(*Pissodes strobi* Peck.)

The white pine is the most valuable and popular of our native eastern conifers and on account of its rapidity of growth has in the past been the tree chosen in making plantations where a quick return on the investment was desired. Yet at present the wisdom of making plantations of this beautiful and desirable tree in many regions of our State is open to serious question. This is due to the extreme prevalence of the white pine weevil. The insect is by all odds

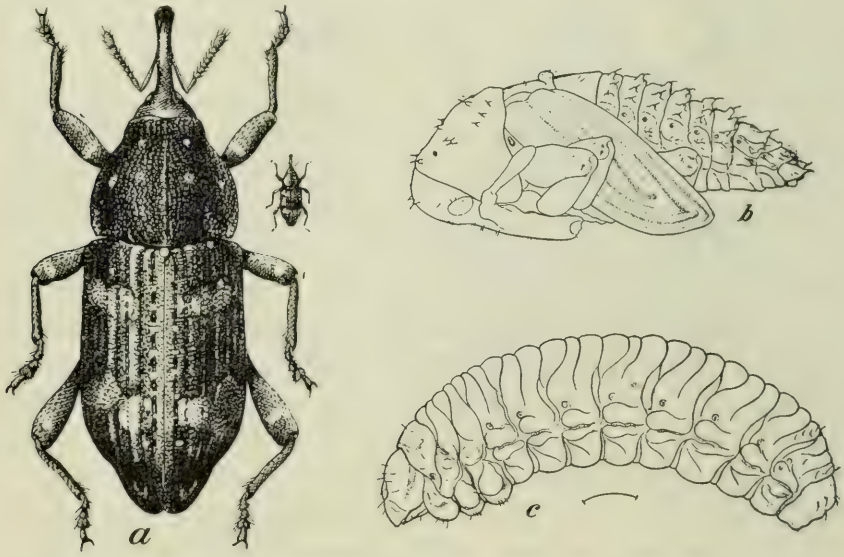

Fig. 35. Life history stages of the white pine weevil. *a*. Adult much enlarged (smaller figure natural size); *b*. Larva; *c*. Pupa. (A. D. Hopkins, Bureau of Entomology.)

the most serious enemy of the white pine in New York and adjacent states and in addition often attacks other species of pines and spruces.

The white pine weevil is a small brown beetle about one-fourth of an inch long with grey or white markings (Fig 35). It differs from ordinary beetles in the possession of a long snout comprising about one-fourth of the body length. These insects become active early in the spring and begin laying

their eggs in the previous year's growth of the terminal shoot of the pine, during the latter part of April or early in May. Laying is continued at a diminished rate throughout May, June and July, although relatively few beetles oviposit during the latter month. The height of the laying period varies with the latitude and with the season, but in the vicinity of Syracuse is usually during the first week in May. The eggs are usually laid singly, each in a small excavation made by the mouth parts of the female beetle and the location of each egg puncture is indicated by a droplet of pitch which exudes and hardens over the wound. The upper part of the last year's growth just beneath the whorl of terminal buds is the position most favored by the parent beetle in ovipositing.

At the end of a week or ten days the eggs give rise to small white grubs which at first feed exclusively upon the inner living portion of the bark. As they grow the larvae work downward, often eating the entire inner bark as they proceed. Just before they complete their full growth the grubs burrow into the wood of the terminal, most often near the lower part. Here either in the pith or in the wood itself, they construct small oval chambers about one-third inch long known as "chip cocoons" (Fig. 36). In these cocoons the larvae transform to pupae principally during late June and July. The adults emerge principally during July but some emerge during August and early September, and conclusive evidence is at hand which shows that some of the adults of the later *crop — i. e., those arising from eggs laid in July — do not emerge until the following spring. However, the great majority of the adults leave their larval hosts during late June and July and do not deposit their eggs till the succeeding spring.

The work of the larvae in the living terminal of the white pine soon causes the new growth above it to wilt and die. This terminal usually dies back to the next whorl of limbs

* No reference to a second generation is intended here, as but one generation a year occurs. However, some infested leaders do not wilt till late in July or in August and from some of these the adults do not emerge till the following spring.

below the point of attack, but occasionally the larvae, when numerous, are forced from lack of food to pass this whorl and continue their feeding in the bark of the growth of the

Fig. 36. Work of the larvae of the white pine weevil in the terminals of white pine and Norway spruce (the leader to the left). The terminals here are in several cases killed back farther than one year's growth. (Original)

year before. In this way two years' growth and occasionally three years' growth is killed (Fig. 36). The killing of the leader in this manner, whether of one or more than one year's

growth, throws the vitality of the tree into the next lateral shoots below the injury and these contend for leadership. This results in the production of a forked or branched top, the tree produced being known among woodsmen as a stag-horn pine. This either decreases or entirely destroys the commercial value of the tree besides detracting from its beauty. The new leaders may in turn be attacked — the result being the production of a stunted bushy growth of no timber value. Instances have been observed by the writer where this had been carried so far that 75 or more leaders were striving for supremacy.

The white pine weevil shows certain decided preferences in attacking trees. It prefers the white pine to any other species, but occasionally will also attack pitch pine and jack pine and occasionally does serious damage to plantations of various spruces, especially the Norway spruce. It also shows a decided preference for certain size of trees — rarely attacking the terminals of trees less than 4 feet or more than 20 feet high. It lays its eggs most frequently in leaders which have made more than the usual amount of growth the past year. The weevil also shows a decided preference for trees growing in pure stands and in the open. For this reason plantations of white pine or Norway spruce are often attacked seriously and disastrously while young native white pine growing under cover in nearby wood lots are nearly entirely ignored by the beetle in ovipositing.

Remedies and Preventives.— It is very important before plantations of white pine are made that the entire locality be examined carefully for the presence of this little pest attacking the native white pines. If native pines showing the effect of past or present work of the weevil are numerous, as is likely to be the case if this tree is at all abundant, it is not advisable to plant white pine or Norway spruce. If, however, the pines in a radius of several miles show no signs of the work of the pine weevil, the author believes that white pine may be planted with a fair chance of its escaping serious damage provided the plantation is systematically inspected

and thorough measures taken when any evidence of the work of the insect is found.

Plantations which have never suffered from the work of the pine weevil should be carefully inspected at least twice during the summer (late in June and again in July) for wilted leaders showing the work of the larvae. These leaders, when found, should be carefully removed and collected. They may be burned thus destroying all of the developing weevils, but by so doing numerous parasitic enemies of the weevils will also be destroyed. For this reason Dr. A. D. Hopkins* has recommended that infested shoots be collected and placed in tight barrels covered at each end with ordinary wire screen. In this way the parasites being smaller will escape through the meshes, while the beetles will be unable to escape. By the time cold weather begins all of the weevil will have emerged from leaders collected in July and will have died. The screens may now be removed from the barrels but these and their contents should be left till the following June to allow the escape of the larger parasites which develop later. The writer wishes to add to Dr. Hopkins recommendations that infested leaders which begin to wilt after August 1st should be either burned at once, or screened until midsummer following, as some of the beetles from these later broods will not emerge till the following spring.

In the case of plantations where an infestation is well established or in a region in which the weevil is numerous, still more careful measures must be adopted. In addition to the control measures recommended above, an attempt should be made to prevent as far as possible the beetle from laying its eggs in the leaders. This involves the collecting and destroying of the beetles while they are on the leaders preparing to oviposit. Dr. E. P. Felt † recommends collecting the weevil with an insect net 15 inches in diameter. When the leader is tapped sharply, the insect at once lets go with its feet and drops into the net. The writer has found by

* U. S. Dept. Agriculture, Bureau of Entomology, Circular No. 90.
† 29th Rep. State Entomologist of N. Y. 1913.

practical experience that the insect is often lost when the leader is jarred by the net. A better method is to hold the net against the side of the lower part of the leader and then tap the upper part on the other side with a stick. Where the trees are six feet or less in height it is also recommended that a light pan or pail containing a small quantity of crude petroleum or even kerosene be used instead of a net. This material acts as an efficient contact insecticide and the beetles are thus collected and killed at one operation. This collection of the adults should be repeated at intervals of about ten days during the period when most of the eggs are laid — i. e., from the beginning of warm weather in April until the adults disappear from the leaders about the first of June. Three or four collections should be thus made and this should be followed by treatment of the infested leaders as recommended in a previous paragraph. If these measures are carried out *conscientiously* and *thoroughly* for several years at the end of that time the pine weevil will be entirely under control,— but the work must be thorough.

Experiments in the use of materials which will act either as repellants or as poisons have been performed by Dr. W. E. Britton* and Mr. B. H. Walden. These experiments showed that when the leaders were sprayed either with lime sulphur (commercial lime sulphur, one part in eight parts of water) or with lead arsenate solution (at the rate of 6 lbs. lead arsenate paste to 50 gals. water) before the eggs were laid, they enjoyed a certain degree of immunity. This treatment is not applicable to commercial plantations on account of the expense, but in the case of plantings for ornamental purposes where cost is not the main item it might be used with advantage.

Observations made by the writer at the Great Bear Springs Plantation near Fulton, N. Y., lead him to hope that a system of planting may yet be devised which will make it possible to rear commercial white pine in any part of the State. Most of the pine at Great Bear Springs is planted

* Eleventh Report of State Entomologist of Conn., 1911, pp. 307–309. Fourteenth Report of State Entomologist of Conn., 1914, pp. 173–176.

in blocks of pure white pine, Scotch pine or western yellow pine of many acres each. In another place a small block of about a dozen rows of white pine occurs between two large blocks of Scotch pine, and in still another place white pine and Scotch pine are planted in alternate rows.

Last year the work of the weevil was serious in all of the large plots of white pine while the other two species were untouched. In the small block of white pine surrounded by Scotch pine, only a relatively few leaders were affected. Where alternate rows of white pine and Scotch pine occur none showed any evidence of attack. The two species of pine were planted at the same time but the Scotch pine soon outstripped the white pine in growth and last spring was several feet higher. The white pine was doubtless protected either by the higher denser growth of the other species or the odor of the Scotch pine predominated and did not attract the beetles. It is probable the former furnished the principal reason as it is well known that young pines occurring as undergrowth in natural mixed stands enjoy a certain degree of immunity from weevil attack. A number of experimental projects are being considered by The New York State College of Forestry the object of which is to discover a system of planting which will, in a measure at least, protect the white pine from weevil attack during its vulnerable period.

15. THE HICKORY BARK BEETLE

(*Eccoptogaster quadrispinosa* Say.)

In many parts of New York State one of the most familiar elements in the landscape consists in hickory trees either killed or injured by the work of the hickory bark beetle. Although some hickory trees die from the attacks of other insects and from other causes, in a very large per cent of those dying suddenly, this insect is the guilty cause. In several sections of the state, hickory trees (with the possible exception of those growing in dense groves) seem to be doomed to destruction unless prompt and efficient measures are taken to save them.

The adult of the hickory bark beetle (Fig. 37) is a small black or dark brown bark beetle about one-fifth of an inch long. In the vicinity of Syracuse the beetles usually begin about the middle of June to emerge from the trees attacked the previous year and continue to come out during July, some even appearing as late as the middle of August. They immediately fly to living trees and feed voraciously upon the young twigs and the petioles of the leaves, thus showing

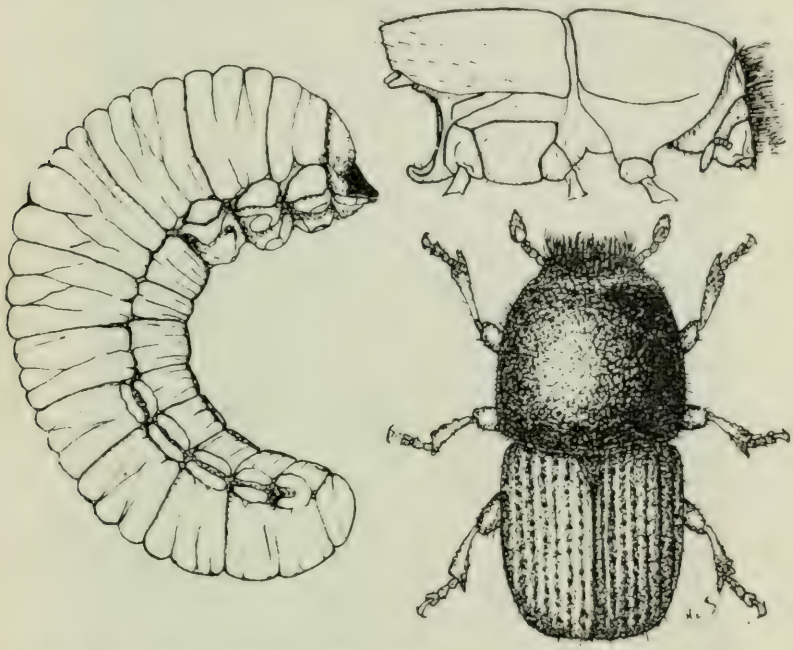

Fig. 37. Larva and adult of the hickory bark beetle. Larva about nine times and adults about eight times natural size. (Original)

their preference for the young tender growth of the tree. They make cavities in these structures (Fig. 38) often eating nearly through the sapwood, causing the leaves to wilt and often weakening the twig to such an extent that it is readily broken by the wind and falls to the ground. These feeding habits of the adults do considerable injury to the tree but do not cause its death. Were this the worst habit of this insect, the tree would survive its attacks — at least for a period of many years.

After feeding for a variable length of time, how long has never been determined, upon the twigs and leaf petioles, the adult beetle reaches sexual maturity. In building their brood chambers the beetles attack the bark of the trunk and larger branches of either healthy or unhealthy hickory trees. Immense numbers usually concentrate their efforts upon one tree, by their concerted attack producing its death and thus providing suitable food for the developing larvae. The

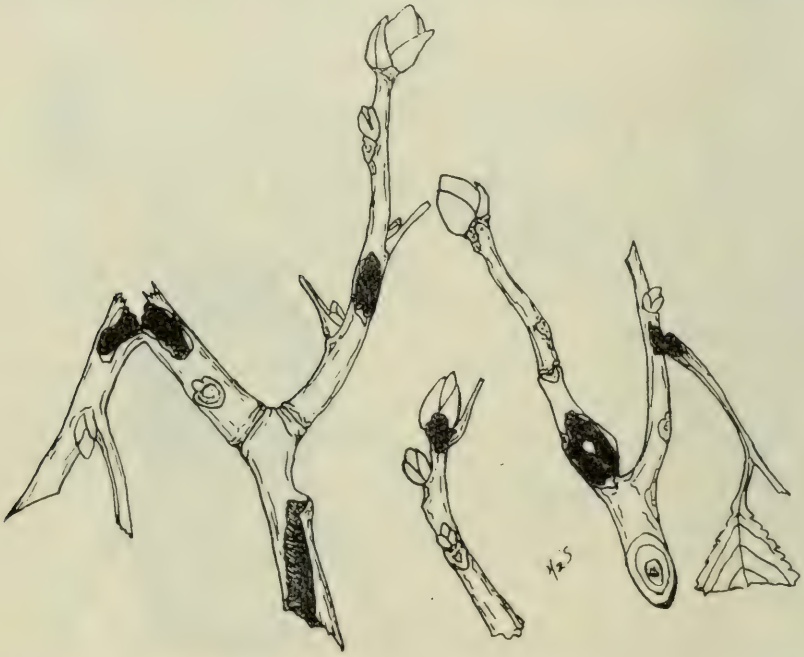

Fig. 38. Work of adults of the hickory bark beetle in the twigs. (Original)

female makes a longitudinal, vertical egg-gallery from one inch to two inches or more in length. This usually extends upward from the point of entrance. In each side of this (Figs. 39, 40) she excavates small niches and in each niche deposits an egg and plugs the opening with frass or "sawdust." The number of eggs laid by the females varies considerably. Careful counts of the larval galleries arising from 67 brood-burrows show that the number of larvae varied from 17 to 63, the average number being 29.37.

After hatching from the eggs the larvae bore through the living cambium on the surface of the sapwood at right angles to the egg-gallery. The galleries extend for a distance of three inches or more and, as the trunk and larger branches of each tree is attacked by many broods at the same time, the flow of sap is cut off in a very few days and the tree is

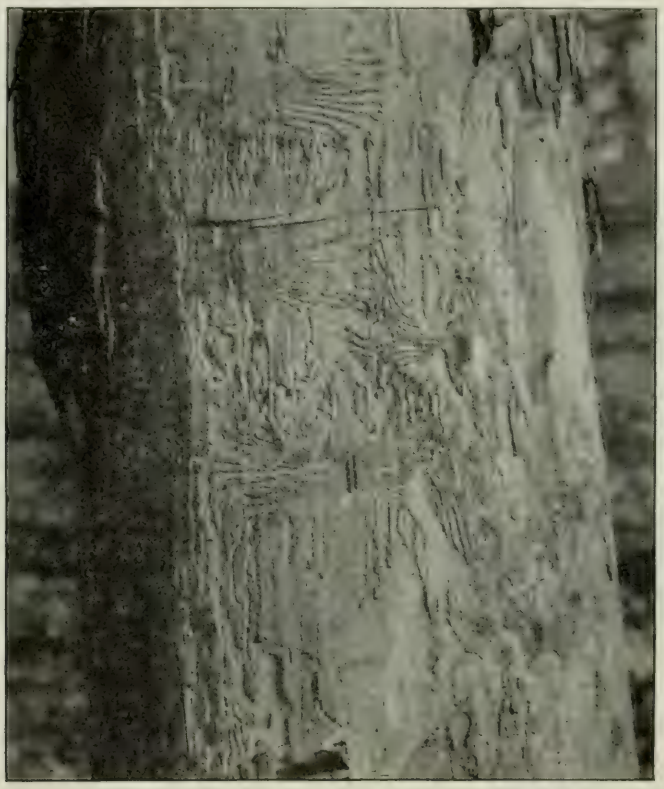

Fig. 39. Trunk of tree killed by the hickory bark beetle with part of bark removed showing brood burrows. (Original)

killed within a very few weeks. The attack of the brood upon the inner bark begins in the locality of Syracuse about the middle of July and continues up until the latter part of August. Living adults have been found in their egg-galleries as late as October 1st, although most of the beetles have laid their eggs and died before September 1st.

The great majority of the larvae are practically full grown (Fig. 37) and have taken up their winter quarters in the inner part of the outer bark by the advent of cold weather. Here they pass the winter well protected from both cold and excessive moisture. They transform to pupae in the outer bark during May and June of the following year

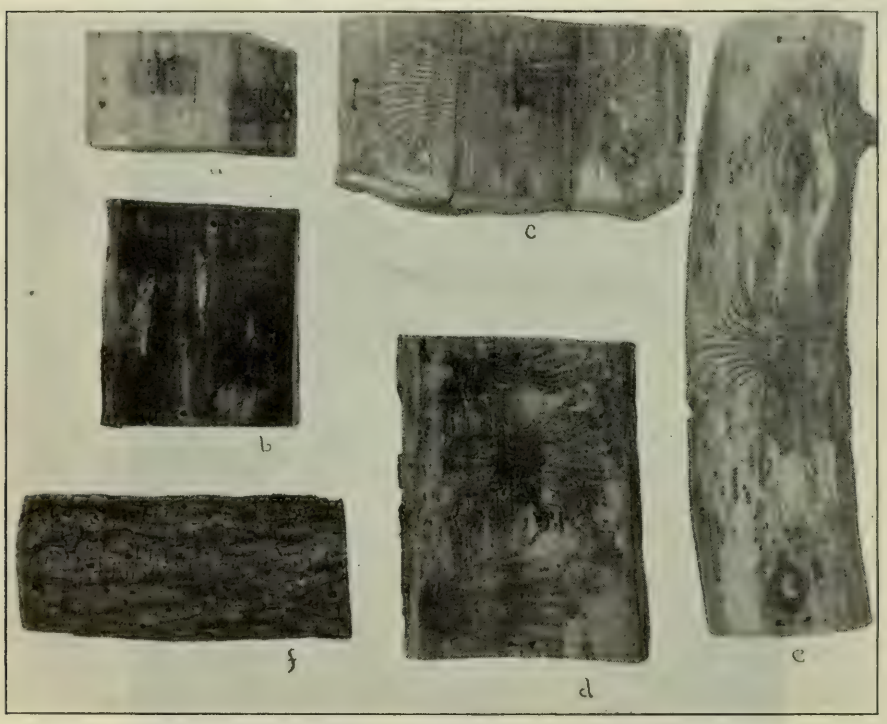

Fig. 40. Various phases of the work of the brood of the hickory bark beetle. *a*. Appearance of the engraving made on the sapwood and in the bark (*b*) by the young larvae. *c* and *d*. The engraving on surface of sapwood and in the bark, when the larvae have reached full growth and have entered the outer bark for hibernation. *e*. Engraving on sapwood of a thinner barked limb. In such cases the sapwood is deeply grooved while in the thick barked trunk it is barely etched. *f*. "Shot holes" in the bark made by the young adults in emerging. Slightly less than one-third natural size. (Original)

and emerge to start a new generation in June and July. The various dates mentioned here hold good only for Syracuse and vicinity — farther south the different stages would appear earlier.

A very interesting infestation of this destructive bark beetle has been under observation for the past three years. This occurred in a hickory grove of 3.9 acres about 1½ miles south of the college, on a hill with a western exposure. About 70 per cent. of all the trees on the tract are hickories. The grove is a typical example of pasture-woodlot conditions. The stand of the trees is sparse, all underbrush has been religiously removed and the ground is covered with a growth of grass which is pastured closely. From a forestry standpoint conditions could not be worse, as the absence of undergrowth and the close pasturing allows the sun to dry out the soil in the summer and gives the cold more ready access to the roots in winter. The location is very much exposed to winter blasts, as the prevailing winds here are from the southwest. In addition the grove is on a rather steep slope and the soil is such that this drains readily and dries out quickly.

The condition of this hickory grove was first noticed in September, 1913. At that time a dozen or more trees were found to be infested — some dead, others only partly dead. Three or four trees were also seen which had been killed the previous year. The trees noted as infested or killed at that time comprised about 50 per cent. of the southeast acre of the tract — none of the trees showing the effect of the brood except at this corner of the grove.

On August 25 of the following year (1914), the hill was a scene of desolation. Trees killed the previous year were still standing and were distinguishable for a mile or more. On nearer approach many trees killed that year and having all the leaves brown showed the work of the beetles which had been earliest in establishing their breeding burrows. On closer examination it was determined that still more trees had been more recently attacked and the leaves of those were just beginning to wilt and turn yellow. The ground under all of the trees, recently dead, dying and those not attacked by the brood, was strewn with broken leaves and twigs, showing the work of the adults in feeding, while many broken and wilted twigs due to the same cause still adhered to the trees.

On September 23, those trees which a month previously had

shown the earlier evidences of dying, were now entirely dead with the leaves all brown, and many more trees which at that time showed no indications of attack were evidently dying. A careful count was made of all living, dying and recently dead trees upon the tract of 3.9 acres with the following results.

Total number of hickories living, dying and recently dead	146
Living hickories	35
Dying and recently dead hickories	111
Per cent. of trees killed in our season	76.+

This past summer (1915) the work of devastation has practically been completed, and at present less than a half dozen living hickories remain on this tract and these showed very evident signs of the beetles' attack in the presence of "sawdust" in the crevices of the bark and of the entrance galleries under the outer scales. There can be no doubt that had the past season been a normal one, not a living hickory would have remained. The unusually cool weather and especially the very frequent rains of the past summer apparently acted as a partial check upon the hickory bark beetle as well as upon other bark beetles. Numerous instances were observed where the larvae had hatched and had carried their burrows only a fraction of a centimeter and then had been apparently drowned in their burrows. It was also noticeable that the egg-galleries were as a rule much shorter this year than usual and the number of eggs laid was correspondingly smaller.

However, while the hickory bark beetle in this locality was undoubtedly checked during the past summer, many broods succeeded in establishing themselves during the short intervals of comparatively normal weather and a number of trees were killed. The beetles also succeeded in spreading from this center of infestation for a mile or more in several directions. The most noteworthy dispersion was in a northerly direction which is readily explained by the direction of the prevailing winds at the season when they are on the wing. In this dispersal they left untouched a grove of hickories

directly in the course of their spread although trees in three directions from this grove were attacked, some of them as near as 200 feet.

The reasons for this are believed to be as follows:— The grove consists of a dense stand of sturdy young trees with a close crown top which shades the forest floor and keeps the ground moist and in good condition. In other words, the forest conditions are excellent. The denseness of the crown and the presence of considerable underbrush apparently renders conditions not to the liking of this beetle. The writer believes that the fact that the trunks of the trees are always shaded acts as a deterrent to prevent the beetle from building its brood burrows and ovipositing. It is also believed that the denseness of the stand acts as a protection in that it does not allow enough freedom of flight, it being a well known fact that this species is quite clumsy on the wing and is easily knocked to the ground by obstructions.

Control Measures.— Early in the history of this infestation an effort was made to have the interested parties undertake control measures. The owner of the grove, however, is non-resident and could not be reached. The lessee, a dairyman, could not be interested to the extent of attempting to control the pest, although the seriousness of the infestation was presented to him. Another infestation, a smaller one, which occurred about two miles distant, was controlled at the advice of the writer by cutting the infested trees, converting them into stove-wood and burning before the emergance of the new generation of beetles. Such control measures can only be of temporary effect, however, unless they are carried out over a large area. This usually necessitates the cooperation of a number of independent owners and complete cooperation in such matters is very difficult to secure.

Regarding the control of the hickory bark beetle, the writer's observations indicate that the only practical measures are those recommended by Dr. A. D. Hopkins (1912) in Circular 144 of the Bureau of Entomology. Infested trees must be cut before May 1st following the attack (in central New York this may usually be delayed till nearly June 1st),

and so disposed of as to destroy the contained brood. Mere barking of the trees is not sufficient as the larvae are in the outer bark and can be readily destroyed only by burning the bark or by submerging it in water for a considerable time. Other methods consist in utilizing the wood and burning all refuse or in converting it into stovewood and using for fuel before the following summer. Numerous experiments with insecticides and repellents have been tried but in the opinion of the writer none of these have been successful enough to warrant their recommendation. A seriously infested tree is doomed and must be so disposed of as to prevent others from suffering the same fate.

16. LEOPARD MOTH

(*Zeuzera Pyrina* Fab.)

The leopard moth, an old world insect, occurring in southern Sweden, central and southern Europe, Algeria, Morocco and southwest Africa, was imported into the United States prior to 1879, in which year it was first observed in Hoboken, N. J. Not until 1894 were workers thoroughly aware how destructive this insect enemy is to our most valuable shade trees. Fortunately its ravages in America have thus far been confined to cities, so that the distribution is not general. This limitation is doubtless partly due to the numerous unhealthy and weakened trees in city streets and in city parks, which furnish just the proper conditions for attack by this pernicious pest. At present its distribution includes Massachusetts, Connecticut, Long Island, eastern and southeastern New York and New Jersey.

The host trees and shrubs include a long list, chief among which are the maples, elms, ash, linden, mountain-ash, beech, birch, walnut, oak, chestnut, poplar, alder, aspen, privet, lilac and honey-suckle. The insect will attack most woody plants, evergreens excepted.

The adult moth (Fig. 41) is a spotted insect as its common name indicates. The female is much the larger, being heavy

bodied and a feeble flier. The male is slender, possesses stout wings and has broad feathered antennae (See Fig. 41). Moths appear from May to September. The female soon after emergence deposits her oval, salmon colored eggs in the crevices and crannies of the bark. Two to four eggs

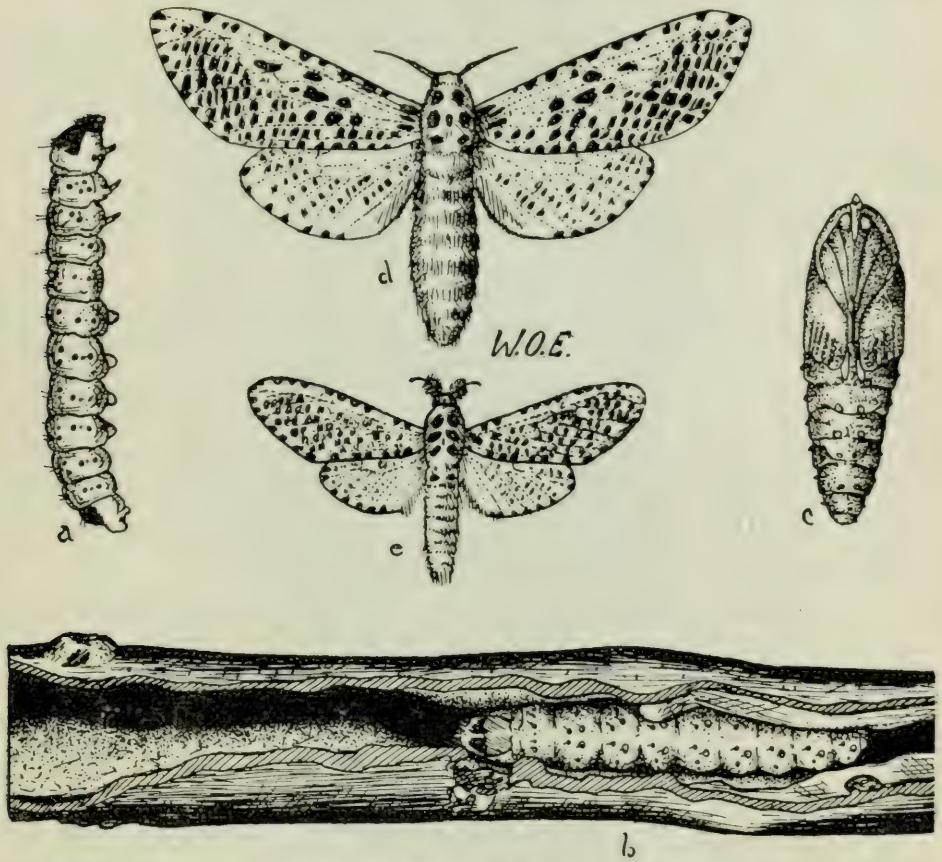

Fig. 41. Life history stages and work of the leopard moth. *a*. Larva lateral view. *b*. Larva in burrow. *c*. Pupa. *d*. Adult female moth. *e*. Adult male moth. Natural size. (Original)

may be placed in a group. The females lay a large number of eggs, 800 having been observed in a particular instance. These hatch in 10 to 15 days, the larvae entering the small branches mining them out and leaving only a shell where once was a vigorous stem. Later they go to larger ones and continue their feeding in a similar manner. For the most

part they confine themselves to the sapwood or to the layers of wood directly beneath the bark. Frass and pellets of excrement, indicative of their work, occur directly under the branch infested. Where the larger larvae have worked just under the bark, this splits open the next season, leaving a large unsightly scar (Fig. 42).

No parasites have been recorded as assisting in the control of this moth in the United States. Birds, however, perform a very important part in keeping the suburban districts partially free from the insect. Insectivorous birds driven from the city, by the English sparrows, to outskirting villages unquestionably play an important role in checking the moth's dispersal.

Control Measures.— Prune the infested trees while in foliage, once in the spring and again late in the summer, and burn the prunings *at once*. If they are not burned promptly the larvae will migrate from the prunings to new trees. When the trees are in leaf one can readily see the extent of the larval operations because of the wilted portions where the insects are at work. When pruning, cut the trees several inches back of the extent of the injury.

In the case of young and rare trees and others which show only a few larval burrows in the bark, carbon disulphide may be used as recommended on page 117 of this bulletin.

Too much stress cannot be placed upon keeping the trees in a thrifty condition. Hampered by the lack of freedom for growth and by a badly watered and poorly ventilated root system, city trees do not possess the hardiness, nor the resistance to enemies which trees in rural districts develop. In many cases the leaves are always gathered in the fall, their valuable nitrogen content thus being lost and the tree is left to draw its nourishment from an already depleted soil. Care should be exercised with transplants and fertilizers always used so that they may develop into sturdy trees prior to insect attack. Chances of recovery are greatly augmented thereby.

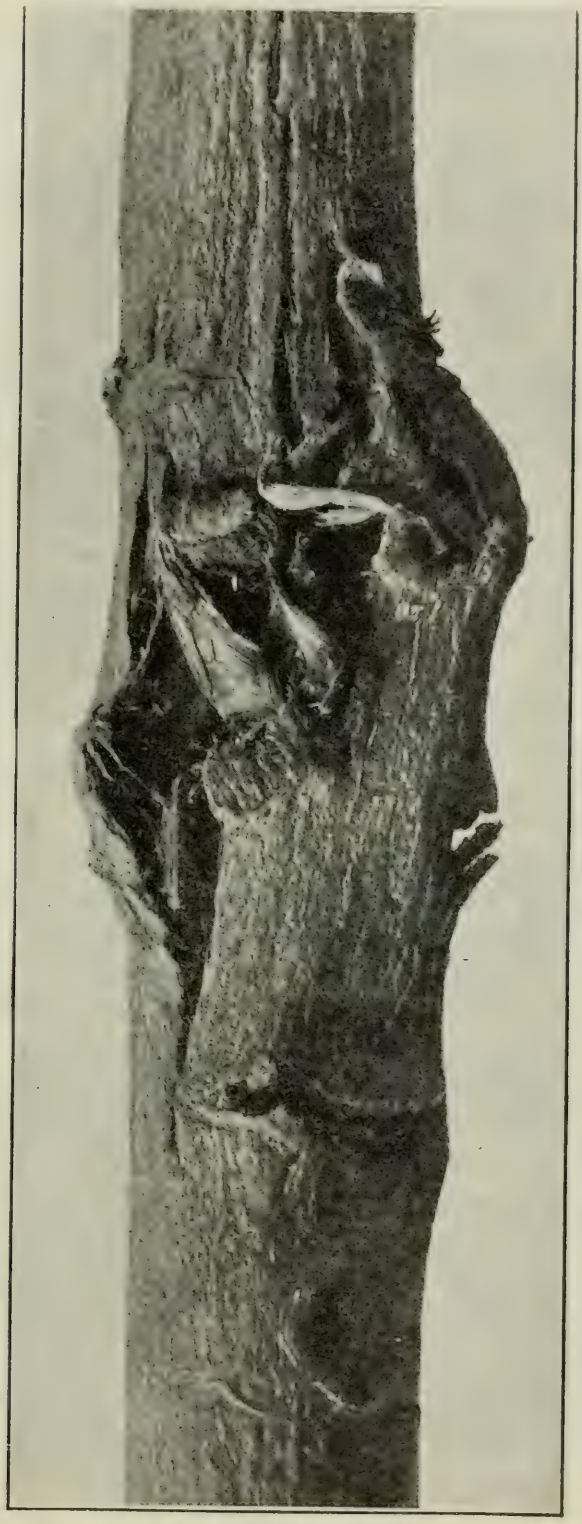

Fig. 42. Work of the leopard moth in branch of maple. About natural size. (L. O. Howard and F. H. Chittenden, Bureau of Entomology.)

17. THE PIGEON TREMEX OR BROWN HORN-TAIL

(*Tremex columba* Linn.)

The pigeon tremex or brown horn-tail is a wasp-like insect an inch and a half or more in length (Fig. 43). It possesses two pairs of wings which when spread have an expanse of two inches or more. The prevailing color of the body is dark brown and the cylindrical abdomen is marked with circular bands of yellow. The abdomen of the female ends in a horn-like projection from which the insect receives one of its common names. This horn-like structure is used by the insect in boring a hole through the bark and into the wood of trees, in which the eggs are deposited. The larva is cylindrical in form, has six short legs upon its anterior segments and its body ends in a short spine-like structure (Fig. 43). This larva bores in the sapwood and heartwood of dead or dying trees such as the maple, elm or hickory. Its burrows are quite characteristic as they are circular in section and are completely packed with fine borings and pellets.

The insect is really not notably injurious but it is found associated with dead and dying trees so frequently and such numerous inquiries are made concerning it that it is thought wise to include an account of it in this bulletin. The pigeon tremex attacks only dead trees or the dead parts of living trees. Quite frequently, however, the eggs are laid in the wood while it is still sappy and this often results disastrously to the female depositing the eggs, as in that sort of wood her horn-like ovipositor often becomes jammed and she is unable to release herself and perishes. The remains of these insects consisting of part of the abdomen with the ovipositor (horn) still sticking in the tree are often seen, the rest of the insect doubtless having been snapped off by some bird.

The larva works entirely in the wood and never mines the cambium. It therefore does not kill trees directly but may

hasten their death in two ways. It may carry its burrows into living sapwood thus spreading disease fungi which may complete the destruction of the tree or its numerous burrows may so weaken the tree that this is broken by the wind. In either of these two ways the horn-tail is occasionally injurious

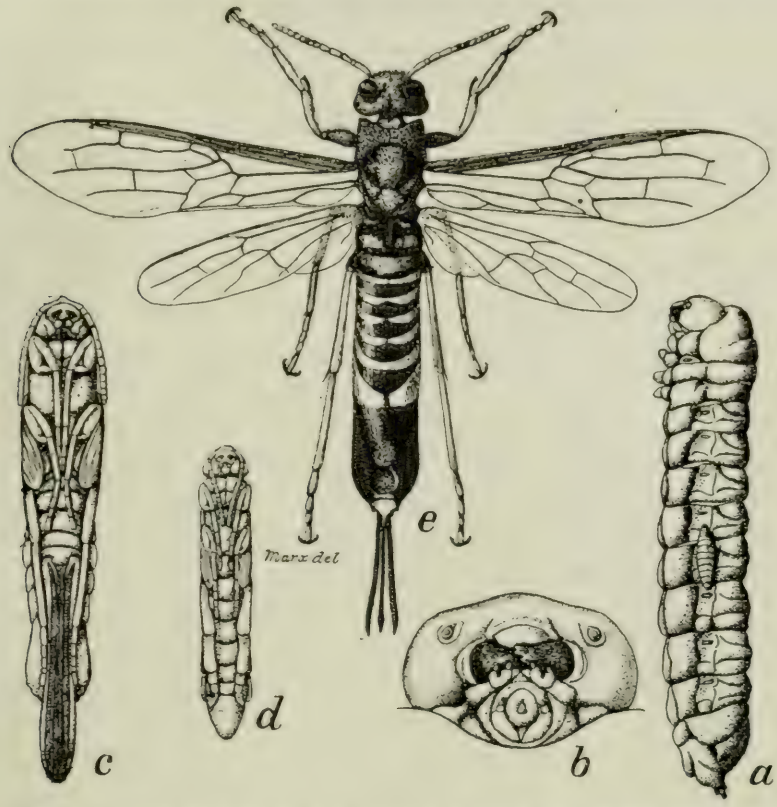

Fig. 43. Life stages of the pigeon tremex or brown horn-tail. *a*. Larva. *b*. Head of larva. *c*. Pupa of female. *d*. Pupa of male. *e*. Adult female. Slightly enlarged. (Riley, Bureau of Entomology.)

to maples which have been partly killed by the sugar maple borer or to elms attacked by the elm borer.

Remedies and Preventives.— The best measure to be taken against this insect is that of prevention. Trees if kept in a vigorous, healthy condition will not serve as a breeding place for this insect. Valuable trees attacked by such insects as the sugar maple borer or the elm borer or other pests

should receive early attention. The bark over dead areas should be removed and the wounded place painted with two coats of good white-lead paint. If the wood beneath has begun to decay, all the decayed parts should be removed, the wood sterilized with a solution of corrosive sublimate and the cavity filled with Portland cement.

C. SAP-EATING INSECTS

While sap-eating insects show a great diversity of form and habits, they all acquire their food in a manner essentially similar — i. e., by piercing the outside tissues of the plant and sucking the sap from the underlying layers. The amount of sap which is thus withdrawn from the tree is doubtless very large and it is only occasionally that our attention is called to how great this may be. It is only in extreme cases that the work of sucking insects results in the death of a tree but wherever these little pests are present the tree must be weakened more or less.

As the food of such sucking insects is obtained from beneath the surface of the leaf or bark, these pests cannot be controlled by stomach poisons covering the surface of the parts attacked. They must be reached in some other way than through their food. The best way to reach them has been found to be by spraying with some substance which kills the insect on contact. A contact insecticide to be successful must possess one or more of three properties. It must be corrosive — i.e., have the property of "eating through" the protective covering of the insect (as lime sulphur); it must have the power of penetrating the breathing pores of the insect and causing a fatal irritation within the body of the insect (as oil emulsions, miscible oils and tobacco derivatives); or it must smother the insect by stopping up the spiracles (as the various soaps, dusts, etc.). In all cases success depends upon actually covering the body of the sucking insect with the spray material. In other words it is necessary to "hit the sucker."

SCALE INSECTS (Coccidae)

Perhaps no other single group of insects has received such universal attention as the scale insects. They are of importance economically since many of them seriously injure and others kill outright many valuable trees. As regards struc-

ture and habits, scales are curiously specialized in unusual ways. They are flattened, circular or oval in shape and they may vary in color from a white to a deep reddish-brown or black. In most cases the mature females are quiescent, that is, after selecting their feeding positions on the tree or plant, they never move. Their bodies are soft and degenerate, lacking organs of special sense and of locomotion. The males unlike the females, have wings, functional legs, eyes and antennae, but their mouth parts are either absent or feebly developed, so they never take food after maturing. These winged forms are rarely seen and then only at times by scientists or by others who make a special effort to see them. Notwithstanding the fact that scale insects are of such importance, comparatively few people ever recognize them. They are small, obscure and deviate so much in form and appearance from the normal type that they bear no resemblance to ordinary insects.

The destructiveness of scale insects to vegetation is directly due to their numbers. A hundred or even a thousand would never seriously impair the life of a tree, but when they occur, as they sometimes do, in countless millions there is little wonder that the host is injured. It has been estimated that, at Washington, D. C., the progeny of a single female San José scale in a season would number 3,216,080,400 individuals, if all were to survive. However, the death rate is tremendous and a balance is maintained, largely by natural and artificial agencies. Were this not true, in a short time scale insects or plant lice, or other insects with enormous reproductive powers, would soon reach such inconceivable numbers that all living things would succumb to their attack.

Some of the more pernicious scale insects may actually kill trees, others may be so kept in check by parasites and predacious enemies that they never become sufficiently numerous to injure materially the health of the tree. However, all scales are more or less injurious, their presence indicating an unthrifty condition, and when abundant the myriads of little beaks pumping out the sap and poisoning the tissues either kill the tree or materially weaken it. Aside

from their feeding habits many scale insects indirectly injure plants by the excretion of honey-dew. This sweet substance furnishes a medium for the growth of fungi which gives to the leaves a blackish appearance. The fungous growths clog the breathing pores or stomata and therefore seriously interfere with the respiration of the tree.

18. THE SAN JOSÉ SCALE

(*Aspidiotus perniciosus* Coms.)

This notorious scale of Chinese origin, first appeared in the United States at San José, California. Its destructiveness was noted in 1880, in which year the United States Department of Agriculture began its campaign against the pest. In 1893 the insect obtained a footing in the east in New Jersey, Virginia, and New York, and since then it has been constantly and stubbornly fought.

Dr. Britton of the Connecticut Agricultural Experimental Station has compiled a list of 70 or more host plants which include those trees and shrubs *commonly* attacked. The commonest of these hosts are the hawthorne, dogwoods, poplars, quinces, mountain ash, willows, roses, lilac, basswood, and elms. It also occurs on birches, catalpa, hackberry, virginia creeper, maples, pecan, honey-suckle, mulberry, black walnut, smoke-tree, horse-chestnut, white ash, honey-locust, spirea and arbor-vitae.

When the trunk and branches are badly infested, the scales lie thickly together, even overlapping, and forming a sort of grayish scurf over the smooth bark. By rubbing or crushing this, a yellowish, oily liquid issues from the injured bodies of the insects. If a single female is examined with care (Fig. 44, a, b), one will see that it is covered with a circular grayish to black scale. This is convex and is composed of concentric rings in the center of which occurs a polished red or yellow tubercle or "nipple." The male (Fig. 44d) is much smaller, more elongate, with the "nipple" distinctly eccentric.

The San José scale winters over in an immature condition (Fig. 44f). When the tree resumes activity in the spring, the soft-bodied insects beneath the small, dark gray scales begin feeding. During the latter part of May the two-winged males emerge from their scales, mate with the females, and die. In another month the females are mature and by the latter part of June, in central New York, they are giving birth to small, yellowish and active living young (Fig. 44e). The activity of the larvae may last from 1 to 36 hours or more. Finally they settle down, establish themselves and

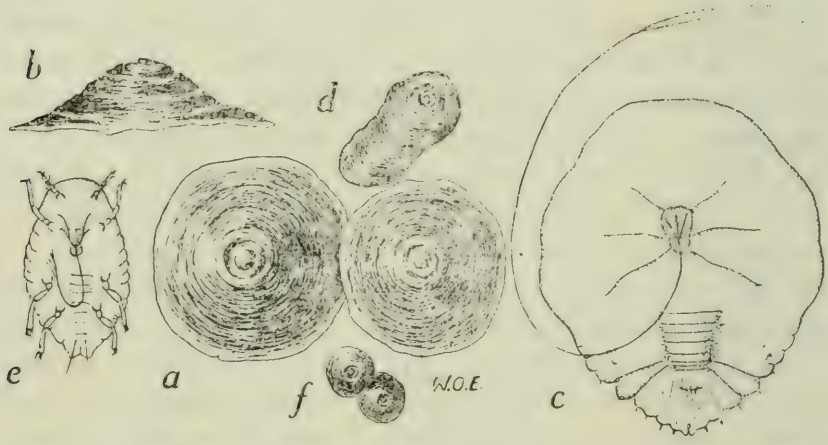

Fig. 44. The San José scale insect. *a*. Adult female scales as seen from above. *b*. Same, from side. *c*. Body of female removed from under the scale and much enlarged. *d*. Male scale. *e*. Newly born larva, much enlarged. *f*. Young scales. Magnified about 20 dia. except *c* and *e* which are much more enlarged. (Original)

secrete the characteristic scale-like coverings. There may be four or five generations in a single season.

The insect is transported to uninfested areas on nursery stock. The majority of the states, however, have rigid inspection laws which, together with the practice of fumigation by nursery men before the shipment of stock, assist in preventing a wider distribution of this pernicious scale. Doubtless birds, insects and other agencies, as winds, are potent factors in dispersing the active young to new trees.

Control Measures.— Many parasitic and predaceous enemies attack the San José scale. However, the combined

work of all the enemies of the insect has not been sufficient to overcome its enormous fecundity. Spraying must be resorted to. Spray with lime-sulphur at winter strength (see p. 116) after the leaves have fallen, and again in late winter or in early spring before the tree resumes activity. Lime-sulphur should be applied to shade and ornamental trees only in parks, on highways and in large estates, because it is very offensive. It not only has a disagreeable odor but it will also stain and discolor dwellings, in many instances chemically combining with the paint on buildings.

Where conditions are such as to make the use of lime-sulphur undesirable a 20 per cent kerosene emulsion may be used during the dormant season or a 10 per cent kerosene emulsion solution may be used while the tree or shrub is in leaf. Excellent results may be obtained by the *proper* use of miscible oils.

19. THE OYSTER SHELL SCALE

(*Lepidosaphes ulmi* Linn.)

The oyster shell scale is widely distributed in America, occurring from New England to the State of Washington. It is likewise common in the old world being practically cosmopolitan. The scale is conspicuous and easily recognized, its common name suggesting its character. It lives on a wide variety of host-plants; especially on apple, ash, poplar, willow, maple, horse-chestnut, elm, lilac, red-twigged dogwood, currant and many others.

The female scales (Fig. 45, a) are those ordinarily observed, the males (Fig 45, b) being considerably smaller. They are 1/8 inch in length, similar to an oyster shell in shape, and brown to black in color. They may even appear ash gray, notably in the spring after exposure to winter weather. The yellowish, delicate, soft-bodied and legless insects live beneath the scales throughout life, excepting the males which when mature are winged and emerge from the anterior ends of the scales.

Maturing in the fall, the females lay their eggs and die as frosts and cold weather approach. Therefore when a scale is turned over during the winter one will find the dead body of the female and 50 to 100 or more, white oval eggs (Fig. 45, c.) These hatch in May and June. The yellow aphid-like young (Fig. 45, d) wander about for a few hours, but soon settle down and at once begin to feed by sucking the sap from the host. The scale is secreted in the form of numerous fibers which later coalesce, assuming the characteristic oyster-shell appearance. There is probably one generation a year in New York, but farther south a complete second generation has been recorded.

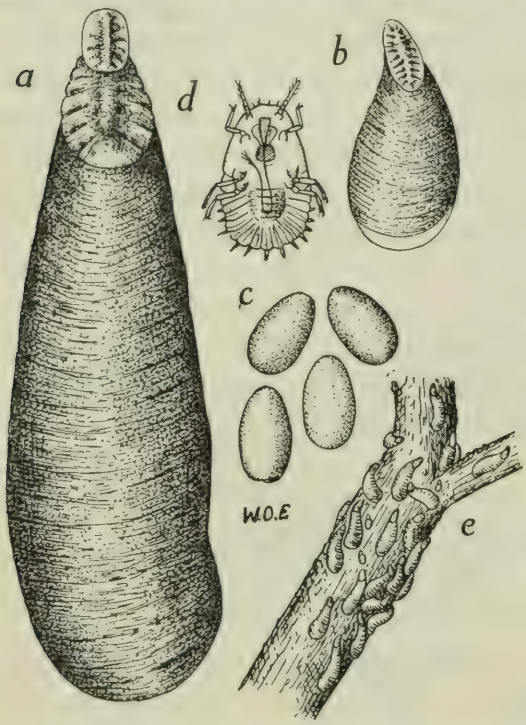

Fig. 45. The oyster shell scale. *a*. Adult female scale. *b*. Male scale. *c*. Eggs *d*. Newly hatched larva, greatly enlarged *e*. Female scales on bark of twig. Enlarged about 20 dia. except *e* which is approximately natural size. (Original)

The distribution to uninfested shade trees and ornamentals is largely during larval activity. Winds and birds doubtless aid in the distribution. It is conveyed to new centers and distant places on infested nursery stock.

Control Measures.— At the time the eggs are hatching and the larvae are active 10 per cent kerosene emulsion is effective. However if not applied at the proper time the young will have secreted so much protective scale that the emulsion will penetrate slowly. Instead of the kerosene, "Black Leaf 40" (¾ of a pint to 100 gallons of water with an addition of 3 to 4 pounds of soap) may be used. Lime-

sulphur (33 degrees Beaume) properly applied as a dormant spray, 1 part to 9 of water, is efficient. Where trees are sprayed for San José scale, this scale is also controlled at the same operation.

20. PINE LEAF SCALE

(*Chionaspis pinifoliae* Fitch.)

This is a native scale insect occurring from Maine to California. It is found principally on white, pitch and Austrian pines but other species of pines and spruces are also attacked.

Transplants are apparently more susceptible to attack than naturally grown trees. At times the scales are so abundant that they whiten the evergreens and obscure the natural color of the foliage.

The pine leaves turn pale and brownish and where infestation is severe, the branches may die.

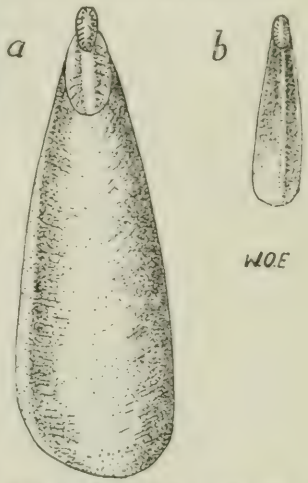

Fig. 46. The pine leaf scale. *a*. Adult female scale. *b*. Male scale. Enlarged about 20 dia. (Original)

The female scale (Fig. 46, a) is pure white in color and in shape is a rather narrow oval which is wider posteriorly. The male (Fig. 46, b) is smaller and is somewhat narrowed. The scale passes the winter as eggs, which number 25 to 75 to each female scale. These eggs hatch from the middle to the latter part of May, the active young settle down, secrete their scale, the females completing their growth by the middle of July or the 1st of August. Probably there is usually but one brood in central New York, but further east in Massachusetts Mr. Cooley writes of two broods of this scale. However, he found it impossible to separate the generations, as scales in all stages of development were taken throughout the summer.

Control Measures.— Special control is usually unnecessary. Spray with 10 per cent kerosene emulsion in May at the time most of the eggs are hatching or while the young are active; "Black Leaf 40" applied at the same time, ¾ pint to 100 gallons of water, is effective.

21. THE SCURFY SCALE

(*Chionaspis furfura* Fitch.)

This is a native insect, occurring over practically the whole of the United States and is one of the commonest on shade trees and shrubs. It is especially most abundant on plants of the family *Rosaceae,* but attacks many others as well. The hosts include mountain-ash, elm, horse-chestnut, walnut, willow, red-twigged dogwood, hawthorn, apple and pear.

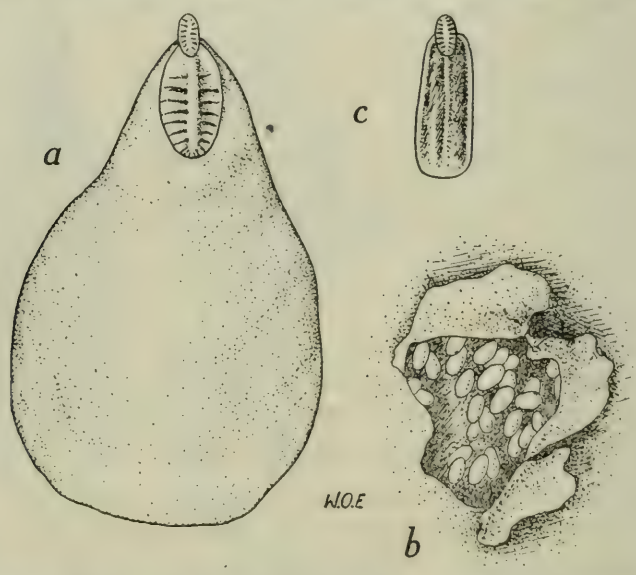

Fig. 47. The scurfy scale. *a*. Adult female scale. *b*. Eggs. *c*. Male scale. Enlarged about 20 dia (Original)

The female at first is a pure white but on exposure becomes dirty and grey. It is 1/10 inch long, irregularly oval, with the characteristic cast skins at the head end (Fig. 47, a). The male is smaller (Fig. 47, c), long, narrow and has three prominent longitudinal ridges on its upper surface. On reaching maturity the latter part of August or the 1st of September, the female lays 60 to 80 purplish eggs (Fig. 47, b) which hatch in the following spring,— about the middle of May in central New York, the exact time obviously depending on an early or late season. The larvae are active and fre-

quently become so numerous as to give a scurfy appearance to the infested portion of the tree and from this characteristic it receives its common name.

Control Measures.— This scale is not regarded as especially pernicious but if infestations occur year after year without check the resultant injury may be appreciable. To control, spray with 10 per cent kerosene emulsion when young appear, or with "Black Leaf 40," ¾ pint to 100 gallons of water. Lime-sulphur applied as a winter spray is dependable.

22. THE ROSE SCALE

(*Aulacaspis rosae,* Bouche)

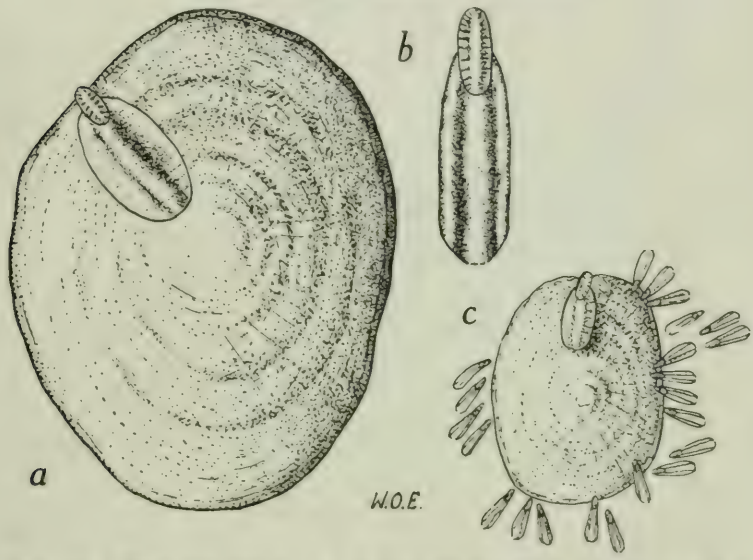

Fig. 48. The rose scale. *a*. Adult female scale. *b*. Male scale. *c*. Female scale surrounded by male scales. Enlarged about 20 dia. (Original)

The rose scale is practically cosmopolitan, occurring in Europe, Asia, Australia and America wherever roses are grown. In addition to its attack upon rose bushes, blackberry and raspberry are often infested and frequently this insect is found doing serious injury in greenhouses.

The female (Fig. 48, a) is snowy white, nearly circular, with two cast skins near the head end of the insect, while the male (Fig. 48, b) is shorter, narrower, and three-ridged.

Observations on the life history of this scale in New Jersey indicate that the insect may hibernate in all stages from the egg to the gravid female. As a rule, however, the wintering forms are either young scales or full-grown females. The same conditions apparently hold for Canada. After April breeding is practically continuous throughout the summer. There may be two generations of the insect in New York, while farther south three or even more broods may occur.

Control Measures.— While these scale insects often occur in considerable numbers upon roses, especially on *Rosa rugosa,* it is very rarely that the plants are ever killed. However, their presence indicates an unhealthy condition and this can usually be remedied by spraying with 10 per cent kerosene emulsion, whale oil soap, or "Black Leaf 40" solution, mixed as recommended on page 117. Winter application of lime-sulphur is also effective.

23. THE ELM BARK LOUSE

(*Gossyparia spuria* Modeer.)

The elm bark louse is a scale insect accidentally introduced into this country from Europe prior to 1884. It has become widely distributed throughout the country upon nursery stock. It attacks elm trees of any age, but is especially injurious to young or recently transplanted trees. It quite frequently causes the death of limbs and occasionally of entire small trees.

The adult female (Fig. 49, 1, 2) is a small insect about 1/10 inch long, of a grey to brownish color and the oval body is bordered with a white woolly secretion of wax. These females gather in crevices in the bark on the underside of the limbs. They are often very numerous and form masses readily seen from the ground. It is in these positions that the females lay their eggs, usually during June or July, and later die. The larvae arising from these eggs are minute yellow dots. These are quite active and can be readily seen upon the bark and upon the leaves. Many of the larvae migrate to the leaves, take up their position on the under

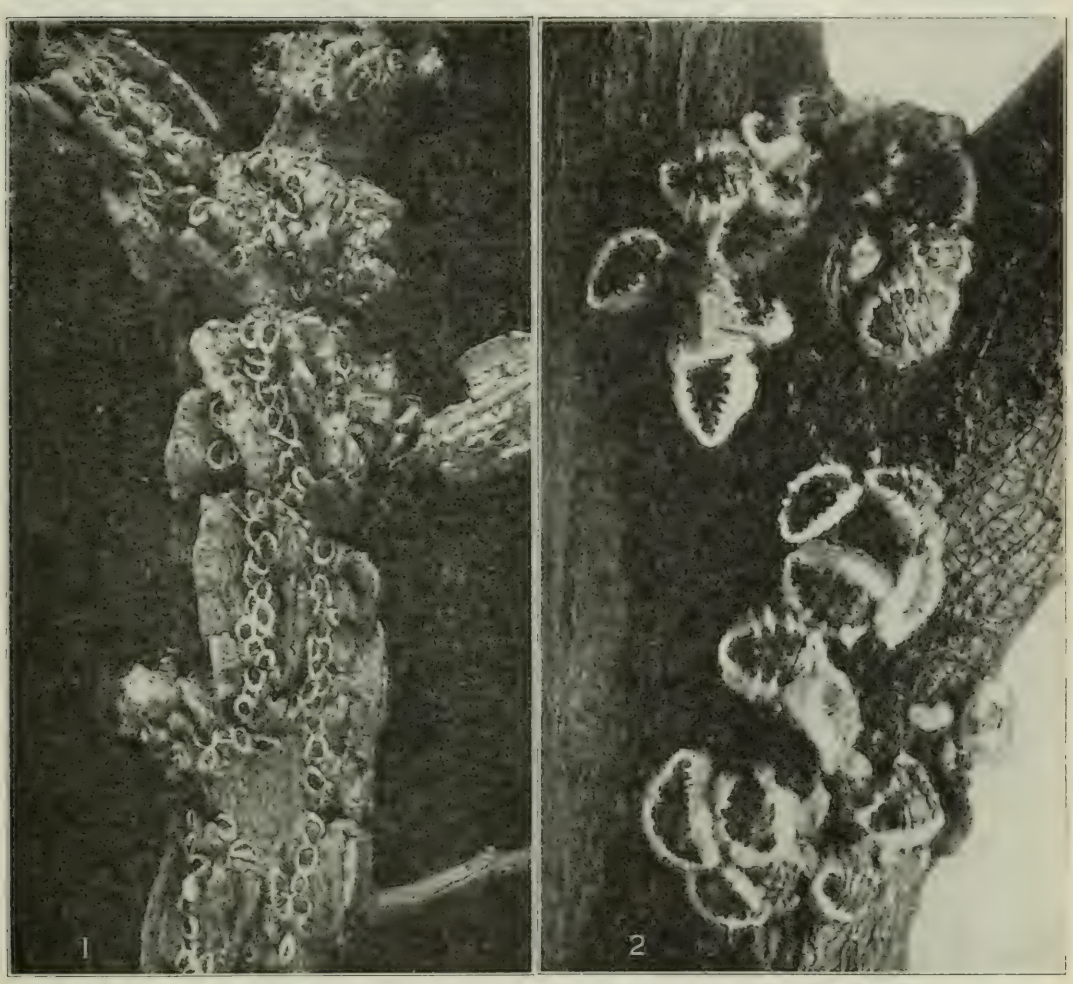

Fig. 49. The elm bark louse. 1. Dead females in winter on corky elm (natural size). 2. Living females in summer. Enlarged 4 dia. (S. B. Doten, Nevada Agri. Exper. Sta.)

side near the main veins (Fig. 50, 1, 3) and insert their beaks. They suck great quantities of the sap from the tree by means of these minute sucking tubes. On the approach of cold weather the larvae migrate from the leaves back to the bark where they pass the winter as half-grown larvae (Fig. 51, 1, 2), protected by the secretion of numerous waxy filaments which cover the body with a layer similar to wool.

Early the following spring activity is resumed. It is at this stage of their existence that the females especially are most injurious. That great quantities of sap is lost by the tree, is shown by the amount of honey dew excreted. This is often so great that walks are kept constantly moistened by it and in a proper light the small droplets falling to the ground from badly infested trees can be distinctly seen.

Control Measures.— There is but one generation of this insect a year and as Prof. S. B. Doten* has worded it: "If all the females could be destroyed at the beginning of the season there would be no generation." The control of this insect is not difficult and if infested trees occur in places where all parts can be readily reached by the stream from a garden hose, it is not expensive. The elm bark louse in any stage of its existence will be readily washed from the tree when hit by the full force of the stream from a garden hose. According to Prof. Doten quoted above, this scale insect can be controlled by the thorough use of the garden hose twice a season. The trees should receive the first thorough washing just before the leaves begin to show (in New York this would be in May) and again just before the young scales begin to appear (late June or early July). Too much stress cannot be laid on the *necessity of hitting with force every part* of the tree. If a six or eight foot extension is employed more thorough work can be done. This consists of a six or eight foot length of galvanized iron pipe of slightly smaller bore than the hose. This is inserted between the end of the hose and the nozzle and by its use parts of the tree otherwise inaccessible can be reached.

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*Agri. Exper. Sta., Univ. of Nevada, Bull. 65.

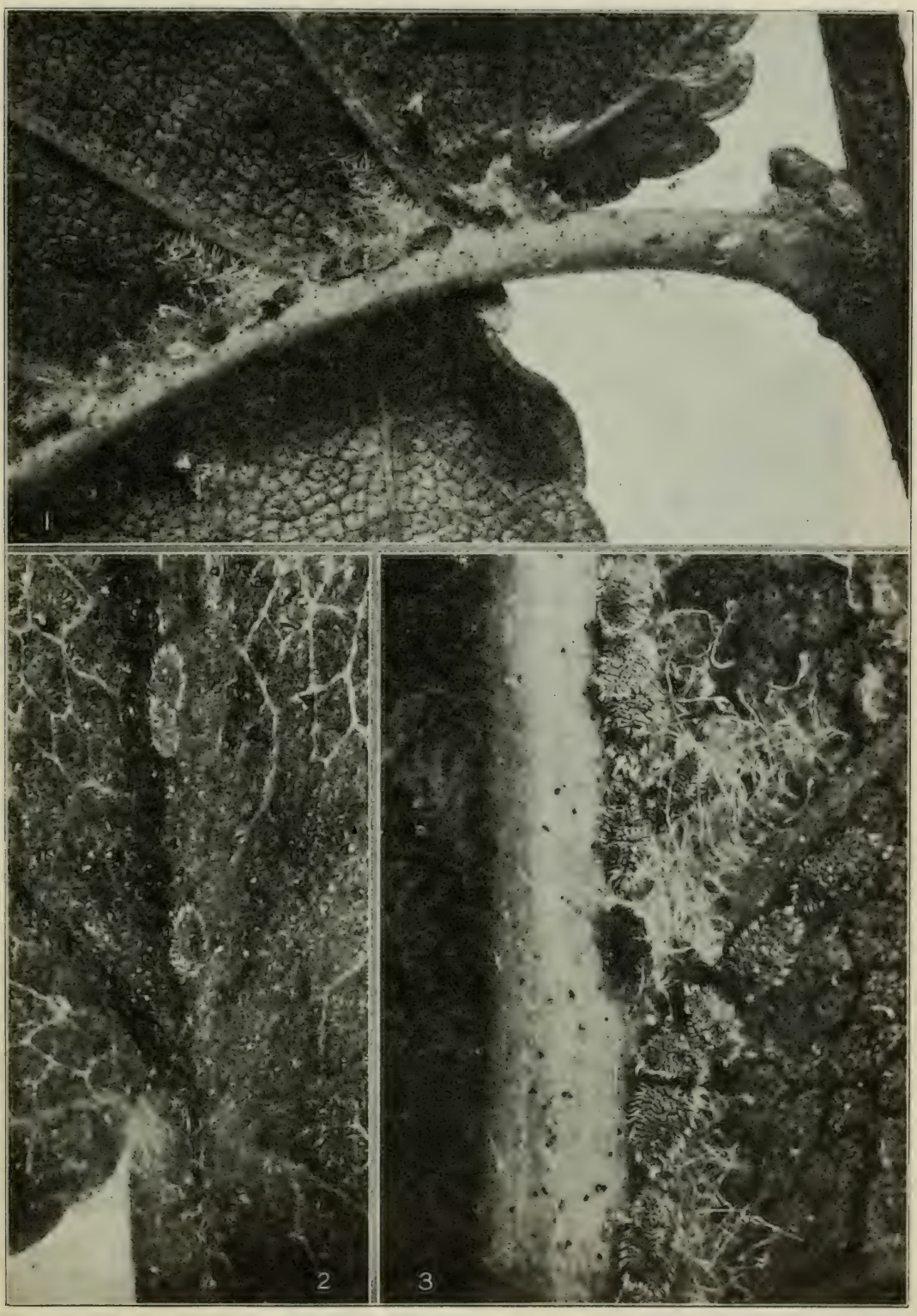

Fig. 50. Larvae of the elm bark louse in summer condition. 1. Larvae grouped along midrib on under surface of leaf (x8). 2. Recently hatched larvae on upper surface of leaf (x16). 3. Larvae along midrib (x16). (S. B. Doten, Nevada Agri. Exper. Sta.)

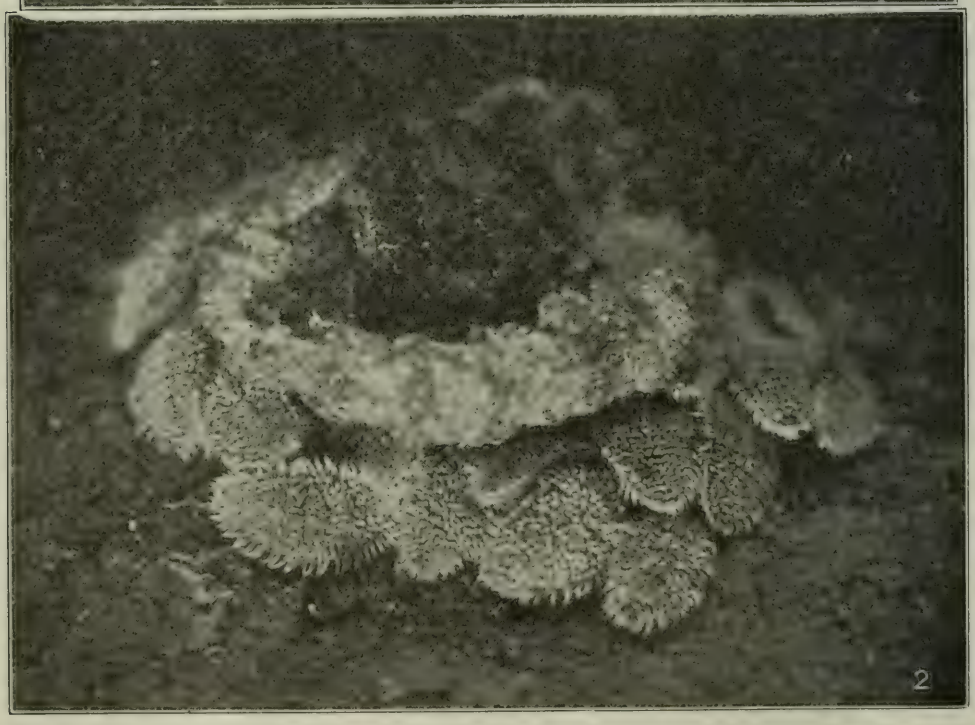

Fig. 51. Hibernating larvae of the elm bark louse. 1 and 2. Larvae in winter condition around and under dead females (x16). (S. B. Doten, Nevada Agri. Exper. Sta.)

The scale can also be controlled by thorough application of a contact insecticide such as 10 per cent kerosene emulsion. This can be applied as a spray but on small trees it is recommended that it be applied by scrubbing the tree with a stiff brush frequently dipped in oil emulsion. Oil emulsion is most effective when applied in the early spring just after the scales have resumed activity or later, just after the young have hatched.

24. THE COTTONY MAPLE SCALE

(*Pulvinaria innumerabilis* Rothu.)

This conspicuous native scale insect is distributed throughout the State from Long Island to Buffalo. At times it occurs in such great numbers as to do noticeable injury to some of the maples. The favorite host is the soft or silver maple, but it also occurs upon the Norway maple and box-elder. It has been taken on 47 trees and plants including the oak, linden, willow, elm, honey-locust, black locust, black walnut, poplar, beech, virginia creeper, spirea, dogwood, etc.

The egg-sacks, formed by the deposition of eggs in a mass of white, waxy, cottony secretions, are found on the limbs and branches during late May and June. The eggs are a reddish-yellow in color. A single female rarely deposits less than 500 eggs and most frequently 2,000 or more, Forbes having found in Illinois the average number to be 3,410 eggs. In the latitude of Albany and Syracuse, the young appear the latter part of July. They may remain in the ovisacks for a few days but sooner or later migrate to the tender shoots and twigs. Many settle along the mid-ribs on the under surface of the leaves. Growth proceeds slowly, the females becoming only half-grown by fall. The larvae migrate back to the branches before the leaves fall and here they hibernate, completing their growth in the spring. There is but one generation.

Interesting among the predacious enemies of this scale is that of a moth whose caterpillars feed on the scales, eggs

and larvae. Lady-bird beetles and hymenopterous parasites do effective work in keeping this insect down.

Control Measures.— Spray 10 per cent kerosene emulsion in the summer just when the young are emerging; on hibernating scales use 25 per cent emulsion. Both sprayings should be effective if properly applied.

25. THE BLACK BANDED SCALE

(*Lecanium nigrofasciatum* Perg.)

This scale insect is apparently a native and is rather abundant over the eastern half of the country. Writers regard it as the most injurious of the Lecaniums found on soft and sugar maples. Other trees, however, are attacked — namely sycamores, poplars, hawthorns and several ornamentals of infrequent occurrence.

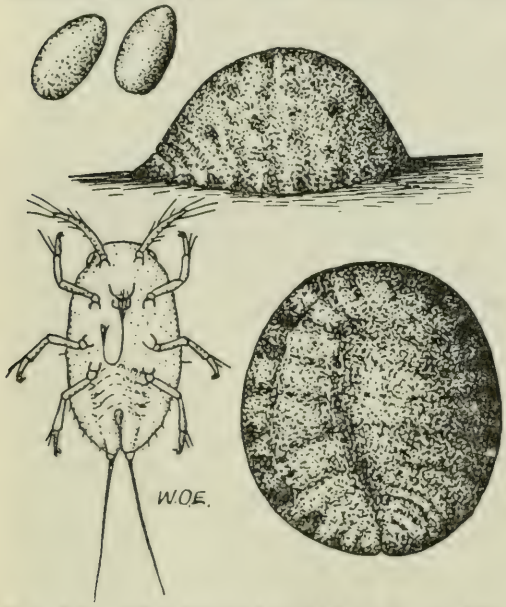

Fig. 52. The black banded scale or terrapin scale. (Original)

The female scales are hemispherical, reddish-brown, marked with black lines and normally are covered with a delicate waxy bloom, which when rubbed causes the scale to appear highly polished. The female, slightly smaller than the so-called tulip scale, is 1/4 of an inch long and is one of our largest species.

Eggs occur in May. The young appear in June and many establish themselves on the tender branches and on the petioles and midribs of the leaves. Those on the leaves migrate back to the branches in the late autum where they hibernate, completing their growth in early spring.

Control Measures.— This species is ordinarily held in check by hymenopterous parasites. When the infestation and injury are marked, apply 10 per cent kerosene emulsion at the time the young are migrating either to or from the leaves.

26. THE TULIP TREE SCALE

(*Toumeyella liriodendri* Gmel.)

The tulip tree scale is distributed over the northeastern United States, west to Michigan and southward. When numerous, the scales seriously injure the tulip tree, especially in nurseries. Besides the injury incident to its feeding, the scale secretes a great quantity of vile smelling honey-dew. This furnishes a medium for the growth of a black fungus which often does considerable damage to the leaves by clogging up the stomata, thus interfering with the transpiration of the tree.

The females are the largest of our scale insects, measuring about ⅓ inch in diameter. They are light brown, knotty and very convex. Apparently in the latitude of central and southern New York the insect hibernates in the larval stage, the larvae appearing late in August and during September. There is but one generation a year.

Control Measures.— A thorough spraying with 10 per cent kerosene emulsion late in September just after the young have appeared, has been found to be quite effective. Or in late autumn after the leaves have fallen scrape off as many scales as possible and apply 20 per cent kerosene emulsion.

27. PLANT LICE

(*Aphididae.*)

Much has been written regarding these delicate, inconspicuous and soft-bodied insects. They are of interest on the one hand because of their habits and enormous reproductive powers and again because of the toll they collect from vegetation of all kinds. The millions of tiny beaks continually

drawing off the sap obviously weaken the plant. The steady withdrawal of the vitality causes many succulent plants and hardier shrubs to succumb to their attack. Fortunately, however, the mortality among aphids is high. A sudden change in temperature, or wind, or rain, kills millions of them. Yet withal, on account of their enormous powers of reproduction and their adaptability, aphids are able to stand the stress of the struggle and perpetuate their kind.

There are many and various kinds of plant-lice which differ widely from each other, either in bodily structure, or in feeding habits, or in their unique methods of procuring protection from their enemies. Thus some aphids are wholly leaf-feeders; others are subterranean and live throughout their lives on the roots of plants, frequently causing serious nodular swellings and malformations; while still others produce galls on the twigs or branches or leaves of hardy trees. Many of the plant-lice are covered with a waxen "wool" which protects them to some extent from external agencies. These are known as the woolly aphids and they include some of our most destructive forms.

Many aphids excrete a sweet watery substance popularly known as honey-dew. This is really undigested portions of the plant juices which are passed through the aphid's body. This sweet substance is often produced in such quantities as to cover the leaves of the tree and quite frequently the walks under badly infested trees are kept moist by its constant dropping. The withdrawal of so much sap must produce a very serious injury to the tree but in addition there is another injury which is often quite striking. The "honey-dew" covering the leaves offers an excellent culture medium for the development of certain fungi. So that quite frequently leaves are covered by a black fungus and killed by it.

The sweet "honey-dew" often also serves to attract ants which have a decided liking for sweets of all kinds. In return for this sweet substance, ants often care for and give protection to the feeble-bodied and defenseless aphids. In many cases a very interesting relation certainly exists between ants and aphids.

While each species of aphid is likely to present differences of its own, a fair example of the life-history of a plant-louse through a season may be given in the following generalized way: Aphids pass the winter in the form of eggs, deposited in the fall by the true, wingless females. In the early warm days of spring these hatch into the so-called wingless stem mothers which without fertilization lay eggs or give birth to living young. This new brood matures into a generation of wingless females, which reproduce without fertilization and which bear their young alive. As many as 8 to 11 successive generations may occur in a season. In the course of the season, one or more generations may arise of which either all or part of the individuals may be winged. The winged forms fly away to other trees or plants and there found new colonies. In the fall a brood of true winged males and wingless females appear and after mating each female ordinarily deposits a single large egg and in this condition the winter is passed.

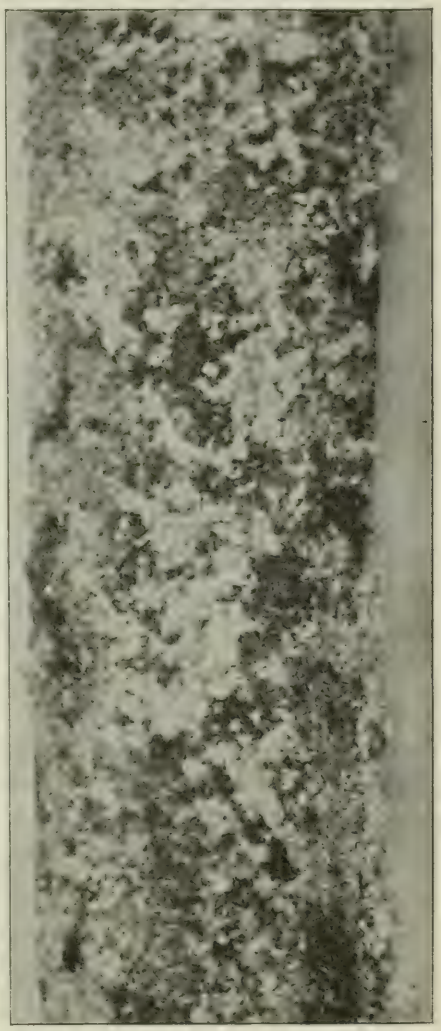

Fig. 53. The woolly aphids of pine bark (*Chermes pinicorticus*). Natural size. (Original)

Some of the forms most injurious to shade trees are: The elm-rosette aphis which migrates from the apple and which is often called the woolly apple aphis, causes some injury to elms as there are two forms, one living on the branches and

another on the roots. A closely allied species produces the elm-leaf curl which so commonly occurs on many of our elms, and still another species occurs upon the bark of elms. The Pine Bark aphid lives on white pine and probably on Scotch and Austrian pines (Fig. 53). The box-elder plant louse does considerable injury to this tree, especially by secreting a large amount of honey-dew in which grows an injurious black fungus.

Control Measures.— Since these insects feed by sucking the juices from plants, a stomach poison sprayed onto the surfaces of leaves will not control them. Rather an insecticide must be used which will kill on contact, either by closing up the breathing organs or by corroding the body-covering. This holds good for all sucking insects; one must hit them with a spray which kills on contact. To control plant-lice use a 10 per cent kerosene emulsion. "Black Leaf 40" at the rate of one part to 800 or 1,000 parts of water has proven of equal value. Whale oil soap mixed as recommended on page 116 of this bulletin is very effective.

A strong stream of water from the ordinary garden hose has been used with a measure of success against plant-lice. The aphids washed from the tree or plant are unable to get back to the host. It is well worthy of trial in cases where the infestation is localized to several branches of the tree. It should be emphasized, however, that the full strength of a solid stream of water should strike the infested part in order to knock off a high per cent of the aphids.

III. SPRAYS AND SPRAYING APPARATUS

After learning the manner in which insects feed either by denuding branches of their foliage or by withdrawing the sap from the host or again by boring into the tree, the next important step is to adopt proper measures for their artificial control. This in most instances means the selection of insecticidal remedies. Therefore it will at once be seen that it is of much importance to know of what spraying materials are composed, how they are mixed for use and finally how and under what conditions they may be applied without injury to the tree.

Any one insecticide obviously cannot be employed for all purposes. Thus an inert arsenical poison is perfectly harmless to a sap-eating insect which always evades a surface film of poison by drawing out the juices from within the plant. Consequently sprays are divided into several groups. Each group of materials is only effective when used against a particular set of insects. They are: (1) stomach poisons, (2) contact sprays, (3) repellants, (4) fumigants.

1. STOMACH POISONS

Poison-sprays are effective only against insects which defoliate or which chew their food. To be efficient as a poison it should be insoluble, suspensible and adhesive. One which is partially soluble and which settles rapidly is in large measure valueless. The poison which goes into solution burns the foliage the resultant injury frequently exceeding that of the insects. In all cases the water serves merely as a carrier of the insecticide and serves likewise to spread the material over a greater area. When the water evaporates, a thin film of poison remains on the leaves. This is a protection to the tree for a longer or shorter time depending on the poison used and how applied. On a rough leaf the particles will lodge in the numerous depressions and may

remain for months whereas on a smooth leaf, a heavy rain or a strong wind may remove the greater part. The finer the material the better it settles into the crevices of the leaves and because of this Paris green is the poorest and arsenate of lead the best of poisons on the market. The addition of soap to an arsenical increases both suspensibility and adhesiveness.

Arsenate of lead.— This is sold in two forms, as a paste and as a powder, the exact chemical composition varying according to process of manufacture and purity of the materials used. It is made from arsenate of soda and lead acetate or lead nitrate. Owing to the small percentage of soluble arsenic, the paste is used at from 2 to 6 pounds to a 50 gallon barrel of water, the ordinary usuage in shade tree work being 3 pounds to the barrel. It is the best poison in general use today. Owing to competition among producers the price has varied considerably. Usually, it can be purchased in 100 pound lots at 12–14 cents or at 20 cents a single pound package. If properly applied, it should give good results.

The powdered form of lead arsenate does not mix as readily with water as does the paste. Consequently it has not had the extensive use by the public. Apparently also it does not stay in suspension as well as the latter and very little is known regarding its adhesiveness. The powder is twice as strong as the paste, being used 1½ pounds to 50 gallon barrel of water, but 2½ pounds may be used without injury to the tree.

Paris green.— Paris green was first used to combat insects in 1868. It thus is an old remedy and previous to the introduction of lead arsenate, was the mainstay for the control of all leaf-feeders. It is a coarse, green, crystalline powder manufactured by the union of copper oxide, arsenic and acetic acid. It settles rapidly in water, contains soluble arsenic and is easily washed off by rains. Paris green is soluble in ammonia, hence it should never be used in ammonical combinations. The usage is 3–8 ounces to a 50

gallon barrel of water. When mixing stir up the poison to form a thick, even paste and add an equal amount of quick lime to absorb soluble arsenic.

London Purple.— This is a by-product from the manufacture of aniline dyes. The percentage of soluble arsenic is high and therefore when used as a spray, a liberal quantity of lime should be added. The poison costs 10 cents a pound but is not nearly as effective as Paris green. It is used frequently in mixing poisoned bait for cutworms which occur in gardens, greenhouses and nurseries.

2. CONTACT INSECTICIDES

Contact insecticides are used exclusively against insects which suck the sap from plants by inserting fine needle-like mouth parts into the tissues and which cannot be injured by the inert arsenicals on the foliage. Sucking insects must be reached by a contact insecticide in order to kill them. Therefore it can readily be seen that to practice economy and yet effectively to control, one must use care in the selection of sprays and also must have them properly applied.

Kerosene emulsion — Kerosene emulsion should be prepared as follows:

Hard soap ½ lb. (or for limited use)	Soap 2 oz.
Water 1 gal.	Water 1 qt.
Kerosene 2 gals.	Kerosene 2 qts.

Dissolve the soap in soft water, using heat. *Remove from the fire* and add the oil while the soap solution is warm. Agitate the mixture vigorously until a creamy white emulsion appears. This can be done very well by churning with a bicycle or a bucket pump. This is the stock solution and it should be diluted before being applied. For scale insects in the winter time, spray a 25–20% emulsion, i. e., 1 part in 4 or 5 parts of water; in the summer time to control plant lice and for use against scale insects apply a 10% emulsion, 1 part to 10 parts of water. In damp, rainy weather the emulsion should never be applied at the strength used on a bright, sunshiny day. The kerosene, owing to its slower

evaporation, has an injurious effect on the foliage in muggy and wet weather.

Miscible oils.— These are composed largely of mineral oils. However, they generally contain a small quantity of vegetable oil and a small amount of alkali. Frequently they are referred to as " soluble oils " and appear on the market under various trade names. They have a wide use and are easily diluted, readily applied and will kill many injurious insects; but they are primarily designed for use against scales. One should be very cautious in applying them.

Lime-sulphur.— There are a number of good commercial lime-sulphur washes on the market. They are valuable in combating scales and in addition have excellent fungicidal properties. A commercial lime-sulphur wash, as a rule, tests 33° Beaume, which refers to its specific gravity. The value of this insecticide as a spray is proportional to its specific gravity or density. The dilution for 33° Beaume lime-sulphur when used as a dormant spray is 1 gallon of the wash to 8¼ gallons of water; for summer work 1 gallon to 42 gallons of water. Further information regarding lime-sulphur sprays may be had from Bulletins 329–330, New York Agricultural Experiment Station (Geneva). Always apply the lime-sulphur at dormant strength late in winter before the tree resumes its activity.

To much stress cannot be placed on the cautious use of lime-sulphur solution. It is very seldom advisable, if at all, to spray lime-sulphur on shade trees after the foliage has appeared as it stains and discolors the leaves. This ruins their appearance as ornamentals for the season, not to mention the offensiveness of the spray to the passing public. Application of insecticides is a difficult task under most city conditions especially so if various householders operate individually. Operations should always be carried out with the utmost regard for the rights of others.

Whale-oil soap.— For scale insects this may be applied in the winter at the rate of 1½ to 2 pounds to 1 gallon of water. In the summer the maximum strength should be 1 pound to 4 gallons of water and an even greater dilution is effective

against plant lice. It is similar to kerosene emulsion in its insecticidal qualities.

Tobacco extracts.— Two liquid tobacco extracts are manufactured and sold under the trade names of "Black Leaf 40" and "Nico-fume." The former contains 40% active nicotine and 60% inert ingredients, the cost being $10.75 per 10 pound gallon, 2 pounds for $2, 1/5 lb. at 75 cents and 1 oz. at 25 cents. It is ordinarily diluted for plant-lice 1 part to 800 to 1000 parts of water (or ¾ of a pint to 100 gallons of water) plus 3 to 5 pounds of soap. If wanted in smaller quantities mix 1 oz. to 7 or 8 gallons of water plus 5 oz. soap. When used with lime-sulphur a precipitate appears and the insecticidal value of the tobacco extract may be modified by such a combination although this has not been accurately determined.

"Nico-fume" likewise contains 40% nicotine but it is much more volatile. It is used in greenhouses by vaporizing one ounce of the extract to 2,000 cubic feet. It can also be used as a spray. The cost is $10.50 per 8 pound gallon.

Carbolic wash for borers.— This is valuable as a preventive against borers laying their eggs on valuable trees but should properly be called a repellant rather than a contact insecticide. Use 1 pint of crude carbolic acid (or ½ pint chemically pure carbolic) to which add 1 gallon of soft soap thinned by the addition of 1 gallon of hot water. Allow the mixture to stand over night then dilute with 8 gallons of soft water. The usual method of application to the trunk is by brush. However, it may be sprayed but this is not usually economical.

Carbon disulphide.— This is a clear, highly volatile liquid giving off fumes heavier than the air. It is sold in 25 to 100 pound lots at 10 to 12 cents, single pounds selling from 15 to 20 cents depending on the purity of the sulphide. This chemical is highly inflammable and its vapor uniting with air is explosive so that when being applied fire should never be near. The operator must not smoke. The gas is deadly to all insect life. It has come into somewhat general use against borers in valuable shade trees and has been success-

fully used in New York city against the leopard moth and also in Washington, D. C., against the carpenter worm.

It is injected into the openings of larval burrows and these are immediately closed with various substances such as putty or grafting wax. For introducing the poison a machinist's long-nozzled oil-can may be employed on large trees, although glass syringes have been found very serviceable, since it requires only a very small amount of the disulphide, a teaspoonful of the liquid being sufficient for each burrow, and by using glass syringes the quantity can be gauged. After application, plug the openings with grafting wax as this has been found by workers to give best results. Difficulties naturally arise in the use of this material. It is often impossible to plug all the holes in infested trees, since there may be several ventilation openings to the same gallery and unless they are all plugged, the operation is unsuccessful. Then too, many of the burrows are wholly or partially filled and blocked with sawdust so that distribution of the vapor is not uniform. In the case of valuable shade-trees, the writer believes, nevertheless, that by careful application some measure of success may be attained.

B. SPRAYING APPARATUS

Hand atomizers.— Hand atomizers can be bought in most any hardware store at small cost. They are not adapted to extensive use, but may be employed to advantage in spraying house plants or a few valuable low-growing garden plants.

Bucket pumps.— Of bucket pumps there is a big variety on the markets. The pump should have an air-chamber so that a steady pressure may be maintained. Many concerns are selling such outfits at from five to ten dollars. These are mounted in large galvanized iron buckets with a foot-rest on the pump and a clamp which fastens the pump to the bucket. This type is useful for spraying shrubs and small ornamental trees in private yards. It also gives satisfaction when used in a limited way in nurseries.

Knapsack pumps.— The best type of knapsack pump (Fig. 54) has a portable copper tank, a lever handle for pumping, an agitator and brass valves and seats. They are heavy to carry when filled with spray and consequently this limits their use. The cost is from eight to fifteen dollars. They are far superior to the bucket type for some sorts of work.

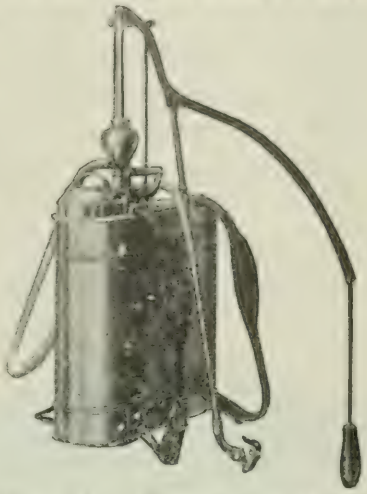

Fig. 54. Knapsack sprayer. Note the agitator, pump, air chamber, handle and straps for carrying. (The Deming Co.)

Barrel pumps.— A good barrel pump (Fig. 55) should have the following points in its favor. It should maintain a pressure of 85 to 100 pounds to the inch; the air chamber should be within the barrel; the cylinder, plunger and the working parts should be of brass; it should have a good mechanical agitator; and should possess valves with durable seats and cages. This pump may be used to good advantage in spraying small shade trees and transplants but may also be employed to spray any other low-growing vegetation. The cost is from fifteen to twenty-five dollars.

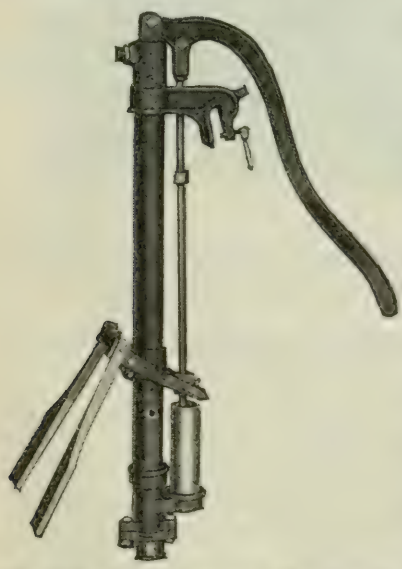

Fig. 55. Barrel pump. Desirable type for trees and shrubs of the yard. (The Deming Co.)

Power outfits.— For the spraying of shade trees on an extensive scale, for city work and for woodlands a power outfit means not only economy and efficiency but is a necessity. Apparatus more or less suitable are of many makes and degrees of efficiency, but these naturally fall into two types.

(1) *Orchard types.*— The very best sprayer of this class consists of tank, gasoline engine, and

tower mounted upon a strong and durable truck. Naturally the gas-engines vary according to the purchase price of the outfit. The best gas-engines, 2 or 3 cylinders, meet the demands for spray work and are able to maintain a uniform potential pressure of 100 to 175 pounds. Most of the pump manufacturers and many gas-engine companies are selling these engines with truck, tank and tower complete for from $250 to $400. Such outfits (Fig. 56) will be found serviceable for use in towns and small cities. With towers and ladders, the very highest trees can successfully be sprayed,

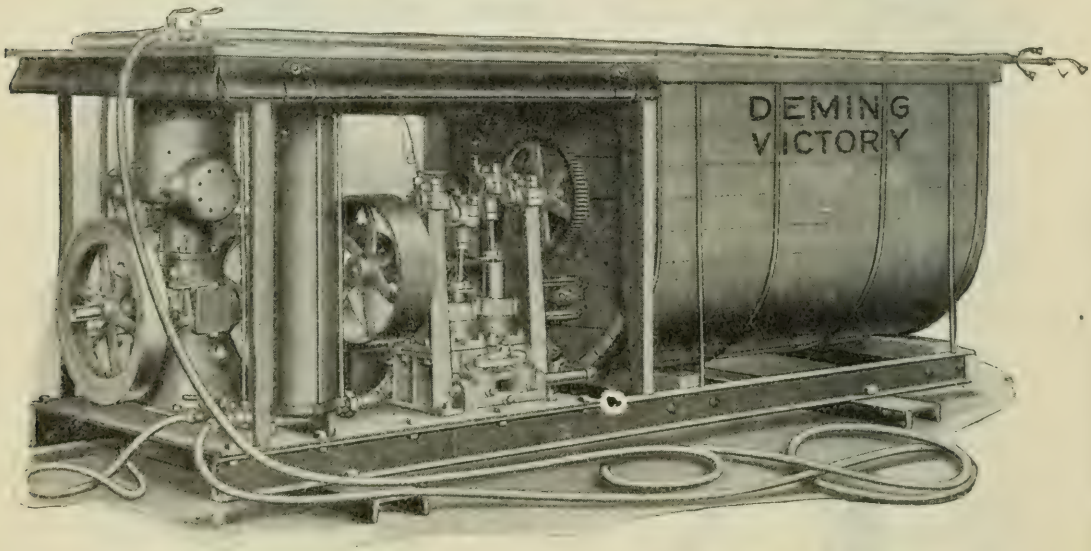

Fig. 56. Power outfit. A modern three-cylinder power pump designed for orchards, shade-trees and wood-lots. (The Deming Co.)

although the cost per tree may be greater than with the high power outfit.

(2) *High-powered type.*— This sprayer is unexcelled for the spraying of trees in municipalities, in large parks or in woodlands. Work can be done with expedition and economy. The machines are large, being mounted on heavy wagons or motor trucks. The engine is a 2 or 4 cylinder and develops a pressure of 200 to 250 pounds. They are extensively used in New England in the fight against the gypsy and brown tail moths. The cost is moderate for value received, $900

to $2,500, or even more, depending on the quality of the motor truck. For extensive spraying there is no machine to equal this type for cheapness, durability, effectiveness and reliability. However, when purchasing a power outfit of any design, the mechanical construction of the machine should be carefully studied, and if possible tested, as all machines on the market are not equally efficient.

Nozzles and Accessory Apparatus.— A good nozzle is just as essential as a good pump for successful spraying. The best nozzles now in common use are of four types.

(1) *Vermorel Nozzle.*— This nozzle consists of a small chamber into which the liquid spray is forced in at a tangent and leaves through a small hole in a removable cap, thus producing a fine cone-shaped spray. This makes a finer spray than any of the types which follow and is used therefore only in the application of oils and fungicides, since these are free from insoluble products. The nozzle clogs very readily which prevents it being used with arsenicals and lime-sulphur. As a rule, in shade tree work two or three are attached to a *T or Y*.

(2) *Disk Nozzle.*— Here the chamber is flatter and broader, thus as the spray enters, it is given a strong rotary motion and it is broken up, emerging as a fine spray through a large aperture. The nozzle is light, does not catch on twigs and rarely clogs. It allows the passage of a large amount of unstrained liquid, one of these spraying three or four times as much as a Vermorel.

(3) *Bordeaux Nozzle.*— In this type the spray is formed by a strong stream, hitting a metal lip and breaking it up, so that it comes out of the nozzle fan-like. The fineness of the spray varies with the width of the aperture. It is usually preferred for spraying shrubs and low plants, but it is sometimes used for trees.

(4) *Worthley Nozzle.*— This is a special nozzle designed for the gypsy and brown-tail moth work in New England, and it is used wholly for the spraying of shade trees where a large stream backed with high pressure is employed. The

spray material comes out in a straight solid stream as from a garden hose at full pressure. This stream at a certain distance from the nozzle breaks into fine particles forming a spray. The distance from the nozzle at which this occurs can be regulated by the operator and it is this quality which makes this type of nozzle so very valuable for trees of various sizes. The Gypsy Moth Commission in New England makes use of it in connection with their high-power outfits.

Extension rods.— In the spraying of shade trees an extension rod is often a necessity. The ordinary type of rod is a straight piece of ⅜ to ½ inch galvanized-iron pipe, threaded for the nozzle and stop-cock. This may be wrapped with burlap to make the grip of the operator secure. Many rods are of bamboo, enclosing a light brass tube, its tip having threads for the attachment of elbows and nozzles, and provided with a stop-cock at its lower end, so that the stream may be turned on or off when moving from tree to tree.

Towers.— A tower on a power outfit gives the operator the advantage of spraying more rapidly and more thoroughly. Most of the power outfits are built with a tower. In every case the tower should be as high as the weight of the truck and outfit will allow and should be surmounted by a railing which should come to the operator's waist.

C. SPRAYING

The application of insecticides to city trees is difficult under most conditions; especially is this true if various householders operate individually. As a rule there are but few trees on any one lot and usually these are tall, thus requiring an expensive spraying outfit. Therefore, only in large estates is it practicable and economical for individuals to own and operate sprayers adequate for use on large trees.

In the city the only sensible solution of this problem is the institution of a City Forestry Department, and the employment of a Municipal Forester. This is desirable and practicable for all cities, for then the sprayer will be operated by competent, experienced men, whose business it is to look after

public trees and who should be prepared to do private work for a reasonable charge.

Time and weather are important factors which must be carefully considered if the spraying of trees is to be successful. Insecticides should always be applied before the injury becomes acute, for after the damage is apparent it is usually too late for effective spraying. Therefore, to know just when to spray involves an understanding of the life history of the insect, revealing the point at which it is most vulnerable to the method adopted for control. Then, too, all sprays cannot be applied to foliage at the same strength in all kinds of weather. Thus, as was pointed out elsewhere, kerosene emulsion must be more dilute when applied on a damp, rainy, muggy day than on a bright warm one. The kerosene in the absence of sunlight injures the leaves. The weather, time, the development of buds and blossoms should always be carefully noted preliminary to spraying. Having decided on the time to spray, apply the material with thoroughness yet with economy, and there will be a large measure of success as a reward for the effort.

State University College of Forestry at Syracuse. Bulletin