S Insects

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 58.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

I. THE LOCUST BORER.

By A. D. HOPKINS, *In Charge of Forest Insect Investigations.*

II. THE WESTERN PINE-DESTROYING BARKBEETLE.

By J. L. WEBB, *Special Field Agent, Forest Insect Investigations.*

III. ADDITIONAL DATA ON THE LOCUST BORER.

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IV. THE SOUTHERN PINE SAWYER.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., August 5, 1910.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 58, five papers dealing with insects injurious to forests and forest products. These papers were issued separately during the years 1906 to 1909.

Part I, "The Locust Borer," by A. D. Hopkins, comprises a summary of information from published accounts, supplemented by data secured by recent investigations, and deals more particularly with practical methods for controlling this, our most important enemy of the black locust. It is designed to be of service to owners of plantations and forests, as well as to investigators, in the prevention of injuries to this useful tree.

Part II, "The Western Pine-destroying Barkbeetle," by J. L. Webb, has special reference to the results of investigations by Mr. Webb in central Idaho in 1905, but relates also to the results of other investigations and to available information on the insect and methods of controlling it.

Part III, "Additional Data on the Locust Borer," by A. D. Hopkins, comprises a partial revision of Part I and gives additional information based on the results of investigations carried on since that part was issued.

Part IV, "The Southern Pine Sawyer," by J. L. Webb, gives the results of special investigations by Mr. Webb and relates to a subject of much economic importance to the timber interests of the Southern States, and especially of sections in which the pine timber is damaged by storms. The results of these investigations and the information contained in this paper make it possible to avoid a large percentage of the losses from damage by the sawyer, which have heretofore seemed inevitable.

Part V, "Insect Depredations in North American Forests and Practical Methods of Prevention and Control," by A. D. Hopkins, gives a summary of facts, conclusions, and estimates relating to the forest-insect problem as applied to North American conditions and calls attention to its importance in the future management of private, state, and national forests. The matter is presented in as brief and concise a form as possible, in order that the information may be readily available to the general reader, as well as to the forester and student, and references are made to publications in which more detailed accounts may be found. The statements and conclusions relating to the insects and their work and to methods for their control are based almost entirely on investigations and observations by Doctor Hopkins and by assistants in the Bureau of Entomology working under his direction, carried on in all of the principal forest areas of the United States.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. W. M. Hays,
Acting Secretary of Agriculture.

CONTENTS[a]

[a] The five papers constituting this bulletin were issued in separate form on June 13 and August 18, 1906; March 5, 1907; and November 10 and December 4, 1909, respectively.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

SOME INSECTS INJURIOUS TO FORESTS.

THE LOCUST BORER.

(*Cyllene robiniæ* Forst.)[a]

By A. D. Hopkins,

In Charge of Forest Insect Investigations.

OBJECT OF PAPER.

The object of this paper is to give a summary of the more important published information, supplemented by recently determined new facts relating to the locust borer and methods of controlling it, which will be of service to the investigator in the determination of additional facts, and to the owners of plantations and forests in suggesting methods of preventing losses.

ECONOMIC IMPORTANCE OF THE INSECT.

The economic importance of the well-known locust borer as affecting the growth of the black locust or yellow locust (*Robinia pseudacacia*) is fully realized by everyone who is interested in this valuble forest and shade tree, and the urgent need of additional information on the subject is indicated by the frequent inquiries of correspondents and by the recent articles in newspapers, journals, and special publications which have been called forth by the proposed extensive commercial planting of the locust by railroad and other companies and by individuals.

INVESTIGATIONS.

In connection with the general study of insects injurious to forest trees, the locust borer has received considerable attention by the writer since 1890.[b] In March, 1905, a plan of cooperation between the

[a] Order Coleoptera, Family Cerambycidæ.

[b] From 1890 to 1892 for the West Virginia Experiment Station, and since 1902 for the U. S. Department of Agriculture.

Bureau of Entomology and the Forest Service in the investigation of insect enemies of the black locust was proposed and adopted, by which the subject is receiving special attention from the viewpoint of both the forester and the entomologist, with the primary object of practical results.

CHARACTER OF THE INSECT AND ITS WORK.

The locust borer is a whitish, elongate, so-called "round-headed" grub or larva (fig. 1), which hatches from an egg (fig. 2) deposited by a black or brown and yellow striped long-horned winged beetle (fig. 3) found on the trees and on the flowers of golden-rod from August to October. The eggs are deposited in the crevices of the bark of living, growing trees from August to October, and the young borers (fig. 2, *b*, *c*) hatching therefrom mine into the outer portion of the living inner bark (fig. 5), where they pass the winter, and in the spring bore through the bark into the sapwood and heartwood. Here they transform in July and August to pupæ (fig. 4) and in August and September to adult beetles, which soon emerge from the trees and deposit eggs for the next annual generation of borers and beetles.

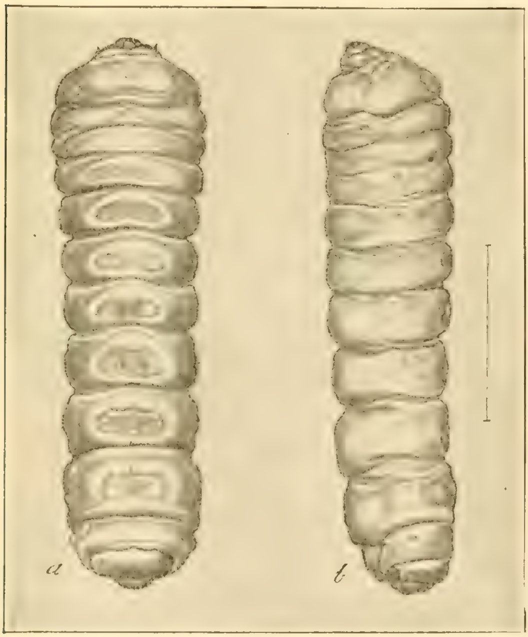

FIG. 1.—The locust borer (*Cyllene robiniæ*): *a*, larva, dorsal view; *b*, same, lateral view. Line at right represents natural length (original). The larva in profile should show minute prothoracic feet.

The injury to the trees (Pl. I) consists of wounds in the bark and sapwood which, if sufficiently severe or repeated year after year, result in either a stunted worthless growth or the death of young and old trees, while the numerous worm holes in the wood reduce its commercial value or render it worthless.

The presence of the insect in injurious numbers is indicated (1) by the frequency of the adults on the golden-rod flowers and on the trees, from August to October; (2) by the slight flow of sap and by the brownish borings where the young larvæ are at work in the bark, during April and May; (3) by the whitish sawdust borings lodged in

WORK OF THE LOCUST BORER.

a, Section of young tree 3 inches in diameter; b, section of young tree 2 inches in diameter which was broken off near surface of ground; c, d, section of branch from badly damaged tree, showing healing wounds in surface of wood; e, transverse section of same; f, g, sections of branches one-half inch in diameter or less, showing in each the total length of burrow in which a larva developed and transformed to the adult beetle. (Original.)

the rough bark, in the forks of the tree, and on the ground around the base of the trunk, during May, June, and July; (4) by the breaking down of the branches and young trees, and by the sickly appearance of the young twigs and leaves in July and August.

This insect appears to be present and more or less injurious in all of that part of the United States which is east of the Great Plains and north of the Gulf States. Published information and reports of forest officials and others indicate that in Oklahoma and Indian Territory and west of the Great Plains the locust is now quite free from injury by the borer; but that these regions will remain exempt is by no means certain.

EXTENT OF DAMAGE OR LOSS.

So extensive is the damage to natural growth, artificial plantations, and shade trees that in some sections within the natural range of the tree in the Eastern States, but particularly in the Middle West, where both the tree and the insect have been introduced, it is considered unprofitable to grow the tree for shade or timber, and in such sections the natural sprout growth is often considered a pest rather than otherwise.

FIG. 2.—The locust borer (*Cyllene robiniæ*): *a*, eggs; *b*, *c*, larvæ from hibernation cells. Much enlarged (original).

The loss resulting from defective timber, stunted growth, and the death of trees is represented by the difference in value between the damaged growth or product and the same if uninjured and healthy. This, if expressed in dollars, would represent a large sum.

POSSIBILITIES OF PREVENTING LOSSES.

There are sections, especially in the natural home of the tree, where, as has been frequently observed by the writer and others, the damage is not sufficiently severe to seriously affect the vitality of the trees or the commercial value of the product; and our present knowledge of the insect and of methods of preventing losses from its ravages indicates that in properly selected localities, and under proper forestry methods of management, the tree, so far as this insect is concerned, can be grown successfully on an extensive scale, and can be made to yield most satisfactory returns.

HISTORICAL REFERENCES.

The first reference to this insect, according to Fitch, is a figure and description by Pitiver in his Gozophylacium, published in London in 1702. Drury figured it in 1770, and the following year, 1771, Forster gave it the specific name of *robiniæ*, under which it is at present recognized. It has been referred to many different genera, but is now recognized as belonging to the genus Cyllene. Both Drury and Forster received it from the "Province of New York," and referred to it as inhabiting the locust tree (*Robinia pseudacacia*). It is therefore evidently an American species.

Some of the principal writers who have contributed important facts on the life history, habits, distribution, and remedies are: Dearborn, 1821; Harris, 1826–1841; Fitch, 1858–1863; Walsh, 1865–1867; Riley, 1867; Lintner, 1890; Schwarz, 1890; the writer, 1891–1898; Felt, 1901–1905; Cotton, 1905; White, 1906, and others. (See list of publications, p. 15.)

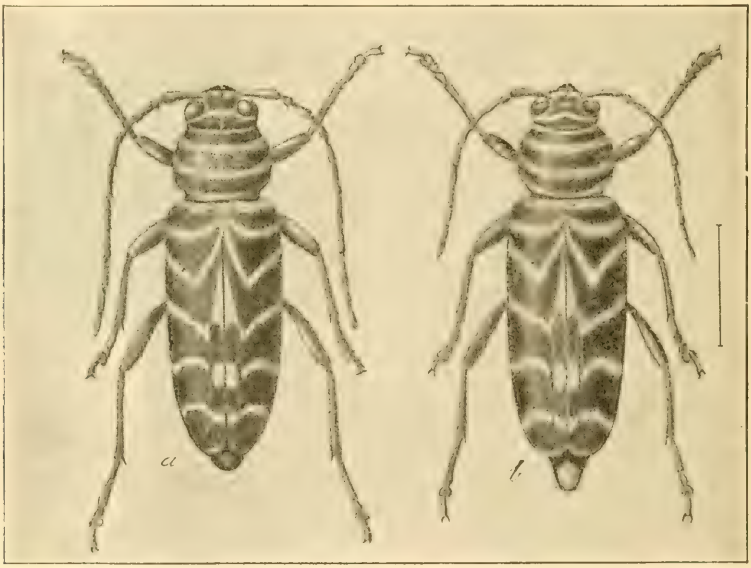

FIG. 3.—The locust borer (*Cyllene robiniæ*): *a*, male beetle; *b*, female beetle. Much enlarged (original).

REVIEW OF PUBLISHED DATA.

Gen. H. A. S. Dearborn was the first to record the more important facts in the life history and habits of the insect. Indeed, so complete and accurate were his observations that comparatively little has been added by subsequent writers, who have extensively quoted and repeated them. He found the beetles on the trunks of trees from the 1st to the 25th of September, the females depositing their "snow white" eggs in the crevices of the bark, four to nine in each place. These eggs hatched before cold weather, and "the young larvæ just buried themselves in the tender inner bark," where they remained until about the 1st of April, when they commenced boring, and soon passed into the solid wood. He stated that it could always be ascertained when and where the borers were at work by the oozing of sap from the wounds made by them. By the 20th of July the larvæ attained their full size, by the 28th some of them changed to pupæ, and the perfect insects were on the trees September 3. These observations were made on his grounds near Roxbury, Mass., during several years previous to 1821, when they were reported in a letter to John Lowell, and published, together with an account of his unsuccessful experiments with whitewash, mortar, and plaster, in the Massachusetts Agricultural Journal, Volume VI, 1821, pages 270–275.

Col. T. Pickering, in a letter to Mr. Lowell the same year and published in the same volume, stated that there were trees in New Hampshire uninjured by the borer, as well as in some of the Southern States; that he had observed the stems of young trees in Washington, D. C., infested, while in Georgetown (D.C.) he saw large thrifty trees uninjured; and he concluded that natural growth in groves was much less liable to injury than transplanted growth.

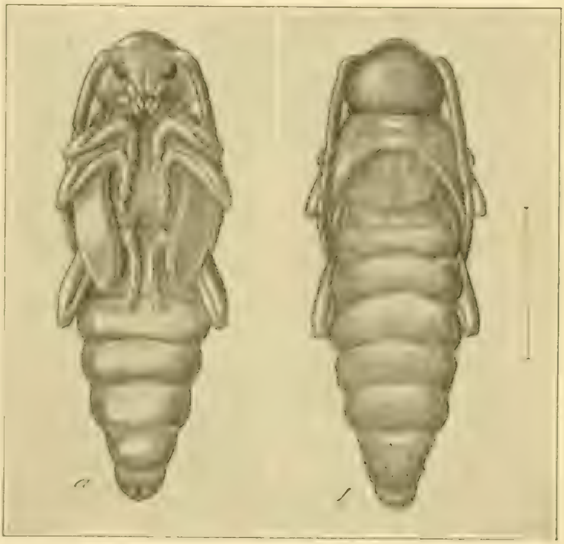

FIG. 4.—The locust borer (*Cyllene robiniæ*): *a*, pupa, ventral view; *b*, same, dorsal view. Much enlarged (original).

Fitch, writing in 1858, stated that numbers of specimens were sent to him year after year from Indian Territory.

Schwarz (1890) observed that in and around the District of Columbia the insect lives in large colonies, affecting all trees of small groves, while long hillsides full of locust are not infested.

R. S. Kellogg, in his discussion of forest planting in western Kansas, says:[a]

By locating plantation on good ground and giving it first-class care, the trees will reach fence-post size before the borers do much damage. They should then be cut and utilized. The rapid sprout growth will soon make a new crop. A stump sprout sometimes attains a height of 10 feet the first season. Handled in this manner, black locust can be profitably raised in many places where it is altogether unsuited for a permanent tree.

At present borers are a menace to black locust trees throughout western Kansas and Nebraska, though there are occasional local areas that are not affected. They

[a] Bul. 52, Bur. Forestry, U. S. Dept. Agric., 1904.

have so far done little damage in southwestern Kansas, but they are moving both southward and westward. They are abundant at Pratt, Kinsley, Dodge, and Scott, and are appearing at Medicine Lodge, Coldwater, Meade, and Garden City. Yet of the numberless trees that have been killed or seriously injured nearly all reached a size that could well be used for posts or stakes before succumbing. This shows that black locust may be successfully grown in commercial plantations if cut as soon as large enough for posts. * * *

Just south of the Kansas line, in Woods County, Okla., black locust grows remarkably well, and has not yet been molested by borers.

Cotton (1905) observed that in Ohio injury was greater in single trees and plantations of considerable size than in natural forests.

Dearborn found that whitewashing the trees in April and filling the holes with mortar in July was not entirely successful as a remedial measure, but he suggested cutting out and burning infested trees in April and protecting the young, thrifty trees. Harris suggested the collection of the beetles by children, and Fitch, the planting of goldenrod to attract the beetles, so that these could be collected and destroyed. Lintner suggested the application of soap solution and carbolic acid to prevent the beetles from depositing eggs, and the cutting out of young larvæ when their presence is indicated by sap and borings. Riley suggested destroying the young borers as soon as hatched. The writer recommended severe pruning in March, and clean culture was recommended by Felt.

The insect has been recorded from Canada southward to Pontchartrain, La., Texas, and Indian Territory, and westward into Nebraska.

Some of the records of destructive ravages are the following: Peck (1818), Harris (1826), in New England; Fitch (1858), in New York; Rogers, Reed, and Bethune (1855 to 1867), in Canada; Walsh (1866), in Illinois and Kansas; Laurent (1893), around Philadelphia; the writer (1891 to 1898), in West Virginia; Smith (1898), in New Jersey; Cotton (1905), in Ohio; White (1906), in the Mississippi Valley, about twenty years after extensive planting was begun by settlers.

REVISION OF PUBLISHED DATA.

Some of the published records relating to the insect which have been frequently quoted or repeated require, according to the writer's observations, some amendments and corrections.

It would appear that normally but a single egg is deposited in a place, rather than clusters of four to nine. The female does not pierce the bark or place her eggs in the cambium layer. The larvæ do not enter the sapwood before winter, but, as observed by Dearborn and verified by the writer, remain in the outer portion of the inner bark. Records of the insect infesting honey locust are probably due to the fact that the black locust is sometimes referred to under this name, which is the correct one for an entirely different tree. It appears now that its attack is confined entirely to Robinia. It is not necessary that a tree or branch should be some inches in diameter before it is damaged, for the writer has found full-grown larvæ in sprouts and branches less than one-half inch in diameter.

In the writer's opinion, all attempts to cultivate locust in the eastern United States *should not be abandoned* on account of the borer, although this has been recommended by some recent writers. It has been stated that the locust would probably not be injured by the borer in the southern limit of its range and in the country west of the Great Plains. While this may be true, precaution should be taken to prevent its introduction into such localities, since it is not improbable that if the insect be introduced and become established it may prove even more destructive there than in its natural home, as was demonstrated in the Mississippi Valley.

Nearly all methods heretofore recommended are subject to practical application to shade trees and small plantations only; therefore there is special need for suggestions of practical methods of combating the insect and preventing losses in large commercial plantations and in natural forest growth, and it is hoped that this paper will contribute something of value along this line.

OBSERVATIONS BY THE WRITER, 1890–1905.

Adults were collected on golden-rod flowers at Piedmont, Md., and Mineral County, W. Va., on August 25, 1890, and on golden-rod and locust leaves at Morgantown, W. Va., September 16 and 17, 1891. Young larvæ were found mining in living bark of trees at Kanawha Station, W. Va., May 1, 1891, and on May 20 the same larvæ had entered the wood, but a great many had died.

It was frequently noted that the locust in the forests of Chestnut Ridge in Monongalia and Pendleton counties, Laurel Hill in Preston County, and especially on Rich Mountain in Randolph County, W. Va., showed but slight damage by the borers. Similar observations were made in many other sections of the State, while in near-by and widely separated sections the damage was found to have been severe and continuous during the life of some of the older trees. In 1898 it was observed that badly damaged shade trees near Morgantown, W. Va., which had been severely pruned in March and April, had recovered, and the crowns were renewed by dense, vigorous, healthy growth, which suggested this method of treating badly damaged shade trees.

On October 9, 1904, it was found that the locust in the vicinity of Chevy Chase, Md., was but slightly damaged by the borer, although beetles were found in numbers on golden-rod and feeding on sap from wounds in bark of living sumac. This habit of feeding on sap is of special interest from the fact that it suggests the possibility of killing the beetles by means of a bait of some poisoned substance which would be attractive to them.

On May 23, 1905, it was found that the locust trees of all sizes in the open and in dense thickets along the old canal on Arlington Farm, Virginia, were thickly infested with the borers, which were all in the wood and ranged in size from quite small to nearly full grown. The ground around some of the trees in the open and on the borders of the groves was found to be covered with the sawdust borings to the depth, in some cases, of an inch or more, and the larvæ could be distinctly heard at work in the wood. Some of the young trees had been literally honeycombed and were broken off at the ground, others had many branches broken and hanging by the bark or fallen from the tree, and some other trees had the leaves turning yellow and dying, while one isolated tree in a field had failed to put forth leaves on some of the branches. Some infested branches cut on this date and placed in a box in the laboratory were found on July 12 to contain fully matured adults, and on July 20 they began to emerge, thus showing that the larvæ will complete their development in the wood after it is cut from the tree and becomes perfectly dry. Indeed, this record shows that the dry condition contributes to the rapid development of the insect, for on the same day (July 20) on which the beetles were found in the box, the trees from which the branches had been cut were examined and found to contain nothing but larvæ. Some more branches were cut on this date and placed in a tin can, where they were kept moist. The first beetles emerged from these on August 24, or more than thirty days after adults had emerged from the dry branch. On August 30 many adults had emerged. September 20 ten living adults and many dead ones were taken from the can, and on October 2 several more dead ones were removed.

When the trees were examined on July 20, a larva was found mining in a two-year-old branch less than one-half inch in diameter, and the cocoon of a parasite of the borer was found in one of the mines, but the adult parasite was not reared. Many dead borers were found in their mines in the trunks and branches surrounded by a white powdery fungus.

The trees were again examined on September 14, when adults were found abundant on the foliage, branches, and stems, and also on flowers of golden-rod. Adults and pupæ were also found in considerable numbers in the dead wood of broken branches, as well as in the living wood, and dead larvæ were frequent. Larvæ of an elaterid (click beetle) were quite frequent in the wood, where they had evidently been feeding on the locust borer.

Examination during August, 1905, of the locust on a hill near Kanawha Station, W. Va., where this tree forms the principal growth over old abandoned fields and in the adjacent forests, showed that the damage by the borer was very slight in trees of all sizes. On August 26 many adults and a very few pupæ, but no larvæ, were found in small trees in the valley, while the large trees in the same locality were but slightly damaged.

OBSERVATIONS BY MEMBERS OF THE FOREST SERVICE.

The following notes by Mr. S. N. Spring, forest assistant in the Forest Service, were submitted October, 1905, as a contribution to the results of cooperative studies. Early in July the work of the borer was noticed in the central portion of Westmoreland County, Pa. The first adult insect was seen on August 29. Evidence of the work of this insect was found in the localities investigated, but, for the most part, it was not serious enough to prevent the planting of locust for fence posts. To the north and west of Greensburg, in Westmoreland County, and in Allegheny County many roadside trees were badly bored. The work of the borer is slight on Chestnut Ridge and Laurel Hill, where locust thrives. Posts and pit props cut in these mountains show slight injury only. In the few places where injury was found to be great, within the area studied, the trees were dying, and many branches were broken off where the trees had been extensively bored by this insect. Owing to the fact that places of serious injury were so few, it was impossible to carry out any observations that would be of value in a study of immunity. In general the locust on the two high ridges thrived better than those on the lower elevation of Westmoreland and Fayette counties, and less injury due to this insect was found among the trees on the ridges.

Mr. J. W. Fetherolf, of the Forest Service, informed the writer, on January 26, 1905, that a grove of black locust planted in Salt Lake City, Utah, prior to 1850, is still in a thrifty condition and apparently free from all insect injury. The same can be said about this species seen elsewhere in the Salt Lake Valley.

Mr. Wesley Bradfield, of the Forest Service, informed the writer that he found the adult beetles common on badly damaged trees, 5 to 8 years old, near Marshall, Mich., in August, 1905; also, that according to his observation the locust in the southern quarter of Michigan was seriously damaged, while in the northern three-quarters, especially toward Lake Michigan, it was not.

RECENT OBSERVATIONS BY THE WRITER.

On March 11, 1906, it was found at Arlington Farm, Virginia, that the young larvæ had passed the winter in minute cells which they had excavated in the outer layers of the living bark and just beneath the outer corky bark (fig. 5), as recorded by Dearborn. So common were these hibernating larvæ in the trees that in the bark of some of them there were fifteen or twenty within an area of a few square inches;

but of the several hundred examined there was only one larva in a place, which would indicate that the eggs are not deposited in clusters, but that they are scattered about in the crevices, so that each larva occupies a separate hibernating cell. The slight wound thus produced in the outer layer of the living bark results in a small dead area surrounding the cell. This dead and brown condition was found, on the date mentioned, to have penetrated the thick inner bark to the wood. This condition evidently facilitates the operation of the young larva in boring through the inner bark to the wood, which a healthy condition of the immediately surrounding bark might prevent. It is not improbable that this small area of dead bark may be caused by a plant disease, which finds its way to the living plant tissue through the slight wound made by the larvæ and which, if this be so, may contribute greatly to the death of badly infested trees.

FIG. 5.—The locust borer (*Cyllene robiniæ*): Hibernation or larval cells in outer portion of living inner bark. About natural size (original).

The young larvæ were found in nearly every case in the part of the bark which had not been injured previously, thus indicating that the female deposits her eggs where the bark is perfectly healthy and not in or around the old scars. Indeed, the habit of the larvæ appears to render this quite necessary for their more or less isolated work. It was particularly noted that the remaining unaffected bark of the trees which had suffered most from previous generations of the insect was thickly infested with hibernating larvæ, while that of near-by large trees which had escaped previous injury contained very few, thus indicating that from some cause there are individual trees which are more or less immune. This fact, which has been so often observed, suggests the importance of experiments in the propagation of immune stock by means of seed or root cuttings from immune trees growing among badly infested ones.

The hibernating habits of the larvæ also suggest a simple method of destroying them, namely, the cutting and barking of the trees during the period between the first of November and the first of May. The simple removal of the bark, without burning, is sufficient to kill the larvæ.

It should be remembered that all the holes found in a tree and all other damage by the borer are not the work of one generation, but usually that of repeated annual attack during the life of the tree; also, that a burrow in the sapwood of a young tree remains the same burrow in the heartwood of the old tree, without change, except in the healing of the original entrance; therefore the number of borers and the amount of damage each year is not so great as it might appear, and, while each female is doubtless capable of depositing more than a hundred eggs,[a] it would appear from the writer's observations that only a small percentage of the larvæ hatching from them survive the bark-infesting stage or complete their development to the adult stage. This suggests that any method of management which will insure the destruction of a large number of larvæ and beetles each year will reduce the damage to a point where there will be practically no loss.

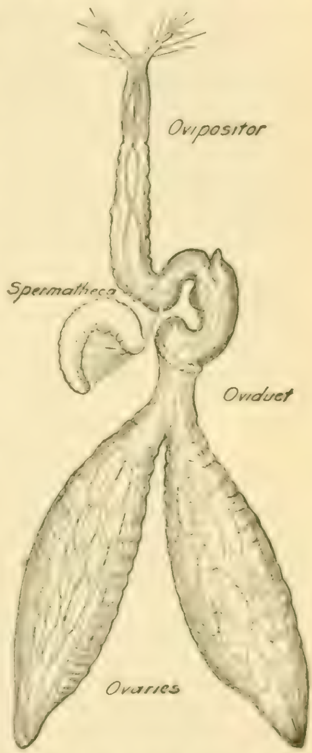

FIG. 6.—The locust borer ([illegible]): Reproductive organs of female beetle. Highly magnified (original).

SUGGESTIONS FOR CONTROLLING THE INSECT AND PREVENTING LOSSES.

With our present knowledge of the life history and habits of the locust borer, it would appear that the following suggestions might be of practical value in the control of insects in large plantations and forests.

The fact that the young larvæ from eggs deposited during the summer remain in the outer bark during the winter and do not enter the wood until the following May suggests that if locust for all purposes were cut between November and May, the bark removed from that portion which is of value, and the remainder burned, it would destroy vast numbers of the insects and contribute greatly toward the protection of the remaining growth.

The fact that badly infested trees may be detected during May, June, and July by the ejected sap and borings, suggests this simple method of locating such trees, which should be cut close to the ground and burned, before the first of August, to destroy the borers before

[a] An examination of the ovaries (fig. 6) of beetles collected in August shows that they may contain as many as fifty mature eggs at one time, in addition to a large number of immature ones.

they transform to the adult beetles and emerge. If preferable, the same end may be accomplished by burning the tops and worthless parts and by submerging the valuable parts in ponds or streams until the borers are killed.

DAMAGE TO CUT WOOD AND DANGER OF INTRODUCTION INTO NEW LOCALITIES.

As we have shown that after the borers have once entered the wood they may complete their development in the cut and dry branches, they will evidently do so in posts or other material manufactured from trees cut between the first of May and the middle of September; therefore, it is plain that locust should not be cut during this period for any purpose except to destroy the borers, or, if it should be necessary to cut it, the tops should be burned and the logs submerged in ponds or streams for a few days before they are shipped or manufactured. This is very important both to prevent damage to the manufactured material and the introduction of the insect into the far West and other sections of the country which are at present free from it.

PROPER LOCATIONS FOR EXTENSIVE PLANTATIONS.

The fact that there are many sections and localities of greater or less extent within the natural home of the locust and its insect enemies where, from some unknown cause, the tree grows to large size and old age without perceptible injury from borers and other insects, suggests the importance of selecting such localities for any proposed extensive operations in the line of artificial plantation, or utilization of natural growth. It will be found, however, that no area of considerable extent, even in such localities, is entirely free from this and other destructive insect enemies, and that certain precautions and well-planned methods of management with reference to their control will be necessary.

PRELIMINARY REQUISITES.

In the first place it is necessary, in order to provide against future losses from the borer, that a thorough survey be made in May and June, not only of the area to be utilized but of the entire neighborhood for a radius of a mile or more from its borders, for the purpose of locating and destroying scattering trees and groves which are more or less seriously infested or damaged by the borer. It would seem that the control of such large areas, by purchase or under a plan of cooperation between the owners of the land or trees, is one of the most important requisites for success in preventing future losses from the ravages of this and other insects in small as well as large plantations.

In fact, it is the writer's opinion that, with this precaution properly and continuously carried out, locust may be successfully protected from the borer in any locality.

SUBSEQUENT MANAGEMENT.

In the subsequent management of plantations and of natural forest and sprout growth it is important each year to locate and destroy the worst infested trees for the purpose of killing the borers in the wood, and to conduct the thinning and commercial cutting operations during the period between November of one year and May of the next in order to destroy the eggs and young before they enter the wood.

Worthless, scrubby, borer-infested trees should be killed outright by stripping the bark from 4 or 5 feet of the lower stem during August to prevent sprouts and seed production from them and at the same time to destroy the eggs and young borers. Trees deadened in this manner, as was demonstrated near Morgantown, W. Va., some years ago, may be so completely killed that not a single root sprout will appear. Therefore this method is of special value in preventing sprout reproduction from inferior individual trees.

COLLECTING THE BEETLES FROM GOLDEN-ROD FLOWERS.

Collecting the beetles from golden-rod flowers, by means of insect sweep nets, before they deposit their eggs, would be advisable, even for the protection of large plantations, and, as has been suggested, the planting of patches of the plant, or the cutting of all but certain strips and patches of natural growth for this purpose, would serve to concentrate the beetles where they could be caught in the nets and destroyed by emptying them into a pail containing water covered with a film of kerosene.

POISONED BAIT.

Experiments should also be made with poisoned baits, as suggested on pages 7–8.

SUGGESTIONS FOR PROPAGATING BORER-RESISTANT TREES.

FROM SEED (SEXUAL METHOD).

The fact that some trees are, to a greater or less extent, immune from attack or injury by the borer, while adjacent ones in the same grove are attacked year after year and seriously damaged, suggested the idea of breeding races and varieties of the species which would be permanently immune. This suggestion was included in the plan for cooperative investigation mentioned on pages 1–2. It was then thought that if the seed for general planting were collected from immune trees found growing among badly damaged ones, a much larger percentage of the product would resist attack and, by continuing this method of selection and breeding, immune varieties could in time be established. There are, however, some serious difficulties to be overcome by this sexual method, especially that of cross-fertilization and variation and the very long time required to get definite verified results.

FROM ROOT CUTTINGS (ASEXUAL METHOD).

It has since occurred to the writer that insect-resistant varieties might be secured by a much shorter method, namely, that of propagating from root cuttings and possibly from twig cuttings. By this simple method of asexual propagation a large number of offspring, in every respect like the parent stock, may be secured at once for the starting of experiments to determine whether or not the asexual product of trees which have not been injured by the borer will produce plantations equally as immune. The writer's experience in the establishment of improved varieties of timothy by this method leads him to believe that insect-resistant varieties of locust can be established. If so, the principal difficulties in the problem of preventing losses from the ravages of the borer will be solved.

It should be mentioned in this connection, however, that it is possible that the borer, if deprived of the trees which are most attractive to it, may gradually adapt itself to the more resistant ones and become more or less injurious to these, and that other insect enemies may be troublesome. There will be so many advantages, however, in propagating from healthy vigorous stock that, in the writer's opinion, the matter should receive immediate attention, and selection and propagating experiments should be started at once. The success of the effort will depend largely on the proper selection of immune trees from the worst infested groves or sections rather than from those growing in partially immune localities.

Domestic animals and cultivated plants have been improved by selection and breeding to meet almost every need and requirement of man, and it is well known that some races and varieties are much less susceptible to injury by disease and enemies than are others. It is reasonably certain, therefore, that the locust will not be an exception, but that it will yield to the breeders' manipulations and may be made to produce insect-resistant varieties and forms specially fitted to supply the different needs of commercial planting, shade, and ornament.

In the meantime, much of immediate practical value and importance may be accomplished by following the suggestions herein contained for the direct control of the insect in extensive plantations and in natural forest growth.

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SOME INSECTS INJURIOUS TO FORESTS.

THE WESTERN PINE-DESTROYING BARKBEETLE.

(*Dendroctonus brevicomis* Lec.)[a]

By J. L. Webb,
Special Field Agent, Forest Insect Investigations.

INTRODUCTION.

The object of this paper is to give available information on this insect and methods of combating it, with special reference to the results of investigations by the writer during the summer of 1905 in central Idaho.

The need of the investigations was suggested in a letter dated August 10, 1904, from Mr. Gifford Pinchot, forester of the U. S. Department of Agriculture, to Dr. L. O. Howard, chief of the Bureau of Entomology, as follows:

I learn from the Payette Lumber and Manufacturing Company, one of the Weyerhaeusers, whose land lies on the Payette River north of Boise, that the pine in their holdings is said to be dying from the attacks of insects. If it were possible for you to assign Doctor Hopkins, or one of his assistants, to make examination of this region, unless it has already been done, I should greatly appreciate it, and I should likewise appreciate your sending to Mr. Edgar M. Hoover, general manager of that company at Boise, any information you may have bearing on this subject.

In response to this request the matter was referred by Doctor Howard to Dr. A. D. Hopkins, in charge of forest insect investigations, for attention, and Mr. H. E. Burke, an assistant, was instructed to make preliminary investigations in October of the same year. In May, 1905, the writer was assigned to this work, with instructions from Doctor Hopkins to make a detailed study of the forest insects of the region, with special reference to determining the following points: (1) The relation of the several species of insects to the dying of the trees; (2) the number of species involved, the relation of each to primary and secondary attack, and the life histories of the primary and secondary enemies; (3) the extent of the infested area, the percentage of timber killed each year during the past two or three years within given areas, the approximate losses, etc.; (4) the relation of logging operations to

[a] Order Coleoptera, family Scolytidæ.

depredations by insects in adjoining forests, and the relation of time of felling timber in regular logging operations to attack by Dendroctonus and other bark and wood boring insects.

Accordingly, investigations were begun by the writer on May 17, 1905, with headquarters at Centerville, Idaho, and continued until October 10, 1905.

DEATH OF THE PINE CAUSED BY THE WESTERN PINE-DESTROYING BARKBEETLE.

Observations by the writer served to confirm the conclusion of Mr. Burke that the primary enemy was a barkbeetle identified by Doctor Hopkins as the western pine-destroying barkbeetle (*Dendroctonus brevicomis* Lec.).

CHARACTER OF THE INSECT AND ITS WORK.

The adult insect is a stout, brownish-winged beetle (fig. 7) from one-eighth to three-sixteenths inch in length, which attacks the living trees in swarms, and burrows into the living bark, through the inner layer of which each female excavates winding galleries (fig. 8 and Pls. II, III) in which to deposit eggs. These galleries serve to cut off the natural movement of the sap and completely girdle and kill the tree. In the vicinity of Centerville, Idaho, the eggs, deposited during June, July, or August, in little niches in the sides of the galleries, hatch within 4 or 5 days into small whitish larvæ (fig. 9), which mine at right angles from the primary gallery through the outer layers of the inner bark until they have completed their growth, which requires from about 20 to 30 days. They then bore into the outer corky bark (fig. 12, *a*) where they excavate little cells in which to transform, first to the pupa (fig. 10) and later to the adult. When the broods of the first generation have thus developed—in about 60 or 70 days—they bore out through the bark and fly to other trees to repeat the process and continue their depredations.

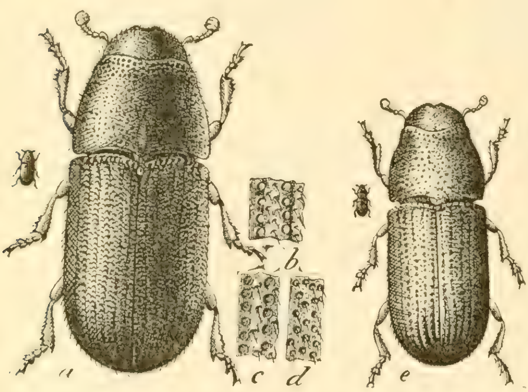

FIG. 7.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): *a*, adult female; *b*, *c*, *d*, details of punctuation; *e*, adult male. Natural size at left (original).

The presence of this destructive insect in a forest is indicated (1) by dead and dying trees scattered about or in clumps or large patches. (The dying ones, with fading yellowish and reddish foliage, are called

WORK OF THE WESTERN PINE-DESTROYING BARKBEETLE IN BARK, REMOVED FROM KILLED TREE; ALSO FAINT MARKS ON SURFACE OF WOOD. (ORIGINAL.)

WORK OF THE WESTERN PINE-DESTROYING BARKBEETLE, REMOVED FROM KILLED TREE. (ORIGINAL.)

"sorrel tops," and the dead ones, with reddish-brown foliage, are called "red tops," or, if with bare branches or broken tops, are known as "black tops" or "broken tops;"[a] (2) by small masses of resin (pitch tubes, figs. 11 and 12, *c*) in the crevices of the bark of recently attacked living trees, as well as in those of the dying and dead ones; and (3) the presence of the species is determined by removing the bark from the dying and dead trees and finding the characteristic galleries (fig. 8 and Pls. II, III).

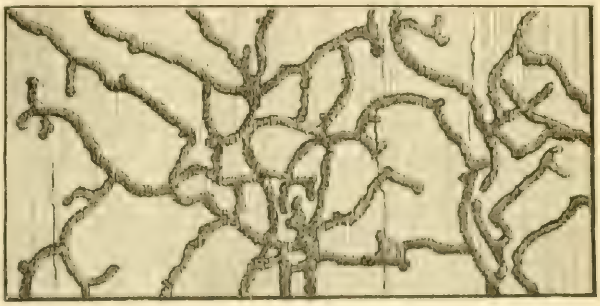

FIG. 8.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): Galleries in the inner bark. (Original.)

It must be remembered, however, that there are many different kinds of insects, some of them closely resembling the destructive species, always found in dying pine trees. Therefore, for the general observer to be positive in the matter, specimens of insects and work should be sent to the Bureau of Entomology for authentic identification.

DISTRIBUTION.

The insect is found in southern Idaho throughout, and its range extends to the northern part of the State. It is recorded from California, Oregon, and eastern and western Washington, and, according to Doctor Hopkins, a variety occurs in Arizona and New Mexico and attacks the western yellow pine (*Pinus ponderosa*) and the sugar pine (*Pinus lambertiana*).

EXTENT OF DAMAGE AND LOSSES.

With our present knowledge of the destructive work of this insect, it is evident that a vast amount of timber has been killed by it during the past ten years within the range of its distribution. It is estimated that each year for the past two or three years, from 2 to 5 per cent of the matured standing bull pine timber within the section investigated in the summer of 1905 has died as the result of its ravages.

POSSIBILITIES OF PREVENTING LOSSES.

With our additional knowledge of the life history and habits of the beetle, we are able to suggest practical methods of controlling it and of preventing a large percentage of the losses heretofore caused by its depredations.

[a] See Bul. 56, Bur. Ent., U. S. Dept. Agric. The Black Hills Beetle.

EARLY HISTORY OF THE SPECIES.

LeConte, in 1876, described the species under the name *Dendroctonus brevicomis* from a single specimen collected in middle California. Dietz, 1890, considered *D. brevicomis* the same as the southeastern species, *D. frontalis* Zimm. Hopkins, 1899, concluded that it was distinct from *D. frontalis*, and therefore that the old name should be retained.

It appears that previous to 1899 nothing had been recorded in regard to the habits and life history of this insect, and that, therefore, the earliest records were made in 1899 by Hopkins, who found it associated with dying sugar pine and western yellow pine at McCloud, Cal., on April 21, 1899, and the next day at Grants Pass, Oregon, with several hundred pine trees which had evidently died from its attack. On May 20, also, at Buckeye (near Spokane), Wash., many trees were found which were dying, or had died, as evidenced by the abundance of the insects and the extent of their work, and on June 6, at Cedar Mountain, Idaho, Doctor Hopkins found it in the bark of pine trees which had been defoliated the previous year by the caterpillars of the pine butterfly (*Neophasia menapia* Feld.). He found also that this beetle was quite intimately associated with the destruction of a large amount of timber only partly defoliated by the caterpillars.

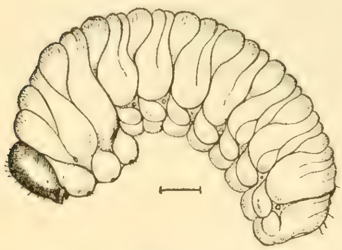

FIG. 9.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): Larva. Line below represents natural length (original).

Under his discussion of the principal scolytid enemies of the forests in the Northwest, Doctor Hopkins refers to this species as follows:[a]

> *Dendroctonus brevicomis* Lec. was found to be a most destructive enemy of the yellow pine (*Pinus ponderosa*) in northern California, southern and eastern Oregon, northeastern Washington, and western Idaho. A large amount of some of the finest timber in all of these localities had died within the past seven or eight years, evidently as a direct result of attacks by this bark beetle. It was also found to attack and prevent the recovery of trees injured by defoliating insects and other causes. Its habits and the character of its galleries appear to be identical with those of *Dendroctonus frontalis*, which is noted for its destruction of vast quantities of pine and spruce timber in West Virginia and adjoining States between 1890 and 1893. It is killing the western yellow pine just as *D. frontalis* commenced to kill the eastern yellow pine (*Pinus echinata*) before it spread to all the other pines and spruce. Therefore, just as *D. frontalis* has proven to be the most destructive enemy of eastern conifers, the western representative of this species will doubtless prove to be, under similarly favorable conditions, equally as destructive to the western forests in which the conifers predominate.
>
> Among the most important features observed regarding the habits of this beetle was the fact that it is attracted to trees girdled by settlers and farmers in the process of clearing land, and that in the bark of such trees it breeds and multiplies in sufficient numbers to enable it

[a] Bul. 21, n. s., Div. Ent., U. S. Dept. Agric., 1899.

to attack and kill the timber in adjoining healthy forests. Indeed, my observation leads me to conclude that a considerable number of girdled pine trees may easily form a nucleus for a destructive invasion by it.

In the same bulletin, under the head of "The western yellow pine," he says:

It has in *Dendroctonus brevicomis* a most pernicious enemy, which penetrates and excavates winding galleries through the living bark of the finest trees, thus speedily causing their death. Very many trees have died and are dying from this cause, and the dead ones are contributing to the spread of forest fires.

Specimens of the insect and its work occupied a prominent place in the exhaustive exhibit of insect enemies of forests and forest products at the Louisiana Purchase Exposition at St. Louis, in 1904, and the Lewis and Clark Centennial Exposition at Portland, Oregon, in 1905, and were referred to in the catalogues of the exhibits by the Bureau of Entomology.[a]

OBSERVATIONS BY HOPKINS, 1899-1904.

The following summary relating to this species, prepared by Doctor Hopkins from his field notes, includes many facts which have not been published and which have a direct bearing on the life history and habits of the species in different sections of the country where it is found:

McCloud, Cal., April 21, 1899.—Work and dead adults were discovered in a sugar pine log, evidently from a tree which was dying when felled; also dead parent adults in primary galleries, and larvæ and pupæ abundant in outer bark of large dying western yellow pine with the characteristic appearance of eastern pines when dying from the attack of the destructive pine barkbeetle, *D. frontalis*. A few immature adults were found in the outer bark, and evidence that some had emerged. This evidence was in the form of apparent exit holes in the bark, which may have been ventilating holes from main galleries, for with our present knowledge it is not likely that any adults could have emerged so early.

Grants Pass, Oregon, 1899.—On April 24 numerous dying western yellow pine trees were found here scattered through the forest where a severe windstorm had blown down much large timber on September 24, 1895. Young adults, larvæ, and pupæ were found in the outer bark of the standing trees which had evidently been attacked and had commenced to die the previous fall. April 25, numerous trees were observed which died the fall before and others which were not yet dead. One group of 30 young trees about 2 miles north of town were dying at the top, the leaves turning yellow and brown. All trees, without exception, were either infested or had been infested with *D. brevicomis*, and every indication pointed to this species as primarily to

[a] Buls. 48 and 53, Bur. Ent., U. S. Dept. Agric.

blame for the trouble. There were many trees which had been dead for from 3 to 10 years, and in the bark of those dying within the past 4 years traces of the characteristic galleries of *D. brevicomis* were found. No large bodies of timber had died, but the dead and dying trees were scattered all through the forest. A few examples of adults were found mining in living bark of a dying tree, where they had evidently passed the winter, since none of the broods had sufficiently matured to emerge. April 26, eight large trees—five western yellow pine and three sugar pine—which had evidently died in 1897, were observed in the Slate Creek Valley. The western yellow pine exhibited abundant work of *Dendroctonus brevicomis*, and the sugar pine the work of both this and a larger species of the same genus (*D. monticolæ*).

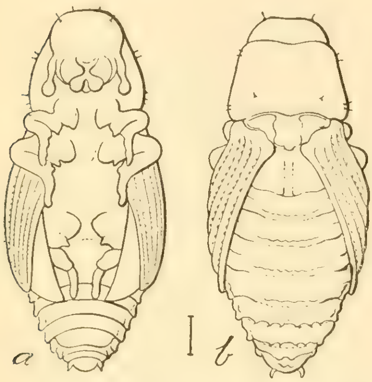

FIG. 10.—The western pine-destroying bark-beetle (*Dendroctonus brevicomis*): *a*, pupa, ventral view; *b*, same, dorsal view. Vertical line in center represents natural length (original).

Buckeye, Wash. (*near Spokane*), *May 22.*—A small western yellow pine tree, evidently killed by the insects, was found. None of the brood had emerged, having died in the bark, possibly from the effects of unfavorable climatic conditions. In another tree killed by this species at this place, young living adults were found.

Cedar Mountain, Idaho (*near Moscow*), *June 4.*—The bark of western yellow pine trees defoliated by pine butterfly larvæ was found to be infested by larvæ and pupæ of *D. brevicomis*. Dead parent adults, also, were found in the primary galleries.

Mariposa County, Cal., June 9, 1904.—Fragments of dead adults were found in primary galleries in bark of a large western yellow pine tree, evidently killed by this species.

Yosemite Valley, California, June 13, 1904.—Western yellow pine trees cut between September 20 and 24, 1903, were found to be thickly infested with larvæ of this species from eggs evidently deposited in September or October.

OBSERVATIONS BY H. E. BURKE, 1904.

From October 20 to 26, 1904, Mr. Burke found the work of this species on western yellow pine quite abundant in the region of Smiths Ferry, Idaho. Under date of October 26 he records observations regarding this barkbeetle in a western yellow pine tree 3 feet in diameter felled some time during that summer; the foliage and bark were living, but red borings on the bark showed where insects had entered. Adults of the Dendroctonus were present in short winding galleries in the living inner bark, two adults to a gallery. Eggs occurred singly in niches on the sides.

He estimated that as a result of the work by this insect near Smiths Ferry 30 per cent of standing timber was dead and 5 per cent was dying. This was at the worst point of infestation, but scattered dying timber was found all over Boise and Payette basins. The same condition extended into the Bitter Root Forest Reserve.

OBSERVATIONS BY THE WRITER, 1905.

The investigations by the writer during the summer of 1905, so far as they related to this species, were mainly for the purpose of determining the principal facts in its life history and habits in the vicinity of Centerville and Smiths Ferry, Idaho. The results may be summarized as follows:

LIFE HISTORY AND HABITS OF THE INSECT.

HIBERNATION.

While it is probable, as observed by Hopkins at Grants Pass, Oregon, that a few parent adults which enter the bark in the fall may pass the winter in that stage, it appears that it is in the young to matured larval stages that the insect normally passes the winter, each individual in a separate mine or cell in the outer corky bark of the tree in which it developed the previous summer and fall. The earliest observations at Centerville were made on May 18, when larvæ, pupæ, and young adults were found. Some of the larvæ were small, but the majority of them were mature and ready to change to pupæ. The pupæ and adults had evidently transformed from larvæ since the beginning of activity in the spring.

The latest date on which larvæ of the hibernating broods were found was June 13. Pupæ were found as late as July 3, and adults July 7. It is therefore evident that the majority of the over-wintering broods develop to the adult stage by about the middle of June, but broods from eggs deposited late in the fall may not develop until nearly the middle of August. Adults begin to emerge in the latter part of May and continue to do so through June and July and into August. Thus the period of activity of the hibernating broods at Centerville is probably from the first warm days in April and May until about the last of July—approximately 90 days—the majority, however, coming out in June and in early July.

FIRST GENERATION.

The first generation at Centerville begins with the first eggs deposited, apparently about the last of June, by the adults developed from hibernating larvæ and pupæ. These eggs hatch in about 4 days after deposition. The principal egg-laying period for this generation is evidently between the latter part of June and the first part of August.

It would appear that the length of time spent in the larval state is from 31 to 35 days. Sometimes, however, a few individuals of this first generation, either from retarded development or other causes, do not go through their transformations with the rest of the broods, but remain as larvæ all through the fall and winter, evidently changing to pupæ in the following spring.

The length of time spent in the pupal stage is approximately 15 days. Pupæ of this generation were observed in different broods from August 14 to September 6.

The first adults, evidently of this generation, were observed in the bark August 14. The length of time spent in the bark after reaching this stage appears to be from 7 to 14 days. It is difficult to tell just when the emergences cease, as the last individuals of the brood come out scatteringly. Thus, on October 10 a few adults were still found in the bark. As this was the last observation, it is not known whether adults emerged later in the fall or whether they passed the winter in the bark before emerging; but the latter was probably the case. In one tree under observation eggs were deposited July 6 and the broods developed and emerged by August 28, a period of 53 days. Thus it appears (1) that the first generation begins with eggs deposited probably in the latter part of June; (2) that the majority of the broods develop and emerge by the first part of September (a period of about 60 days), but that some may continue to develop and emerge until in October; and (3) that possibly some pupæ and young and matured adults may hibernate along with the larvæ. Thus it may require 300 to 390 days or more for the complete development and emergence of some individuals of the first generation.

SECOND GENERATION.

Eggs deposited by adults of what appears to have been the first generation were found August 26 and as late as September 13. It will therefore be seen that there is a partial overlapping of the periods of the two generations.

Larvæ were found as early as September 4, and on October 10, when the last observation was made, some larvæ were apparently full grown.

No pupæ or adults of this generation were found up to the time of the writer's last observations—on October 10, 1905. Mr. Burke found adults, but probably of the first generation, excavating galleries and depositing eggs as late as October 26, 1904. Thus it appears that the second generation, beginning with the first eggs deposited by adults of the first generation, passes the winter in the larval stage and develops and emerges by the middle of the following June to the first part of July. It therefore occupies a period of about 315 to 330 days, including about 60 days of activity in the fall, 165 days of hibernation, and 90 to 105 days of activity in the spring and early summer.

It is probable that at higher elevations and farther north the majority of the broods would not develop in much less than a year's time and that at more southern and warmer localities in the Pacific Coast region there would be two complete generations and possibly a partial third.

HABITS.

When first transformed, in May and June, the young beetles have very soft, delicate tissues. They therefore remain in their pupa cases until their bodies are fully hardened or chitinized. When nearly ready to emerge, the adults bore their way almost to the surface of the bark (fig. 12, *a*), but pause before emerging, appearing to rest in the burrows they have just made. They do not, however, hollow out the space immediately adjoining the pupa case, as is the habit of another species of this genus. When quite ready to emerge, the beetles continue their burrows out through the remaining portion of the bark. The individuals of a brood do not appear to emerge simultaneously, but they come forth at irregular intervals until all are out, leaving the bark thickly punctured with small, round, clean-cut holes, as shown in figure 12.

FIG. 11.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): Pitch tubes on bark of tree. (Original.)

After leaving the tree or trees in which they went through their transformations the beetles fly away to find trees in which to deposit eggs. They may select trees close at hand or may fly quite a long distance before making a selection. They will also enter the living bark of recently felled trees. Large numbers of the beetles usually settle upon a few trees close together and crawl about upon the bark from near the base to about two-thirds of the distance to the tree's top, seeking suitable places for entrance. Crevices in the bark are favorite places with them for this purpose. The female appears to bore the entrance hole in the bark, and may or may not be closely followed by her mate. In some cases where galleries had just been started, females were found alone, that is, one female to a single gallery. In others, the female was followed by the male. As the first incision is made into the living inner bark, the tree begins exuding pitch to cover the wound made by the intruding beetle. This pitch or resin collects at the mouth of the entrance hole in the form usually known as a pitch tube (figs. 11 and 12, *c*). Where the attacking force of beetles is small, the efforts of the tree to heal these wounds not infrequently succeed, the flow of pitch being so great as to overcome and suffocate the beetles. In such cases the dead beetles may be found in the pitch masses after the tree has recovered. Where the attacking force is large, however, the flow of pitch does not seriously hinder the beetles. After completing the egg laying, the parent adults remain for some time in the galleries and excavate irregular branching burrows toward the end farthest from the entrance, where they remain until they die.

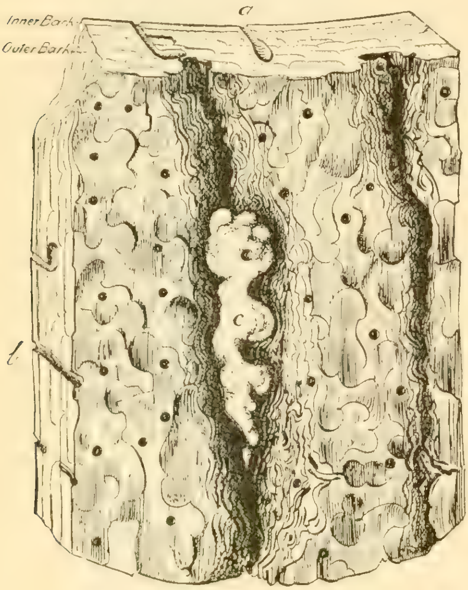

FIG. 12.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): *a*, hibernating or transformation cell; *b*, exit burrow; *c*, pitch tubes and exit holes. (Original.)

After successfully effecting their entrance into the bark, the females excavate, through the inner layer of bark, winding, irregular galleries, which run into and cross each other many times (fig. 8). The eggs are laid at the sides of the gallery, each in a little niche hollowed out to receive it and packed in with the borings made in excavating the gallery.

Almost immediately after hatching the larva begins feeding upon the cambium surrounding the niche in which it hatched. For a few days it remains in the cambium, then bores out toward the outer bark. As it progresses, it is at the same time growing, and this growth is indicated by its constantly widening mine or burrow, which is made larger to accommodate the size of the body. Having reached the outer bark, it hollows out an oval space or pupa case, in which to go through its transformations.

NATURAL ENEMIES.

INSECTS.

Larvæ of the predaceous beetles of the genus Clerus, which are known to prey upon Dendroctonus larvæ, were quite common in and under the bark of the infested trees, and they doubtless help to some extent in keeping down the numbers of the barkbeetles.

BIRDS.

Birds contribute their part also in destroying larvæ and pupæ. The work of woodpeckers was found upon most of the trees which had been killed by *D. brevicomis*, and these birds had evidently destroyed a large percentage of the insects in some of the trees.

METHODS OF COMBATING THE INSECT.

FIRST RECOMMENDATIONS.

The following information and recommendations relating to this insect and methods of preventing losses from its ravages were conveyed by Doctor Hopkins to Mr. E. M. Hoover, of Boise, Idaho, manager of the Payette Lumber and Manufacturing Company, in a letter dated January 23, 1906, and afterwards published, with Mr. Hoover's reply, in a local newspaper.

Our special field agent, Mr. J. L. Webb, has submitted his report on forest insect investigations in the vicinity of Centerville and Smiths Ferry, Idaho, during the past summer, and it will interest you no doubt to know that the insect which is primarily to blame for the death of pine trees was located and thoroughly studied by him.

He found that the broods of the destructive species pass the winter in the grub state in the bark of trees which died during the late summer and fall and that they do not transform to the winged form and emerge until after the 1st of May. Therefore the method of combating the pest is simply to cut the infested trees any time between the 1st of October and the 1st of May and to remove the bark from the main trunk and burn it.

It is necessary to burn the bark in order to kill the broods of this insect, because they occupy the intermediate portion between the inner surface and the outer scale portion; hence the drying of the removed bark will not kill them as it would if they occupied the inner moist portion.

The infested trees can be located (1) by the yellowish and light reddish brown color of the foliage; (2) by cutting into the bark as high up on the trunk as a man can reach with an ax to determine whether the middle portion of the bark is infested with the small white grubs, which are about three-sixteenths of an inch long. If these are found, it will be conclusive evidence that the tree has been killed by the beetle and is infested with its broods. It must be remembered that there are hundreds of other kinds of insects which occupy the *inner* portion of the bark and wood of such trees, but none of the smaller ones pass the winter in the *outer* bark. * * *

Perhaps the most important thing for you to do as a preliminary to any definite action you may take in the matter is to have a number of intelligent cruisers make a survey of your holdings for the purpose of locating the principal sections in which trees have died during the past summer and the location of the larger clumps and patches of infested trees within such sections; then, if the locations of the infested areas and clumps are indicated on a map, it will aid materially in planning effectual operations. If you could conduct your logging operations in these sections and utilize the infested trees the desired results would be accomplished without much expense. It is not necessary that all scattering infested trees should be felled and barked, but it is of the greatest importance that all of the larger clumps and patches within the worst infested areas should be thus treated within the period mentioned. If this can not be done this year, the work of locating infested areas should be conducted next summer (1906), in order that the more important sections may receive attention next fall and winter.

We shall hold ourselves in readiness to give you further information and suggestions on subjects which may not be clear to you, and whenever there is doubt about the insect or its work specimens should be sent to us for authentic identification.

In response to this letter, Mr. Hoover wrote:

We are most gratified with the information given us and feel that it will be of much value to us in our woods operations. * * *

The ferreting out of the insect pest and advising a way to combat it is a work of great value to the country and of especial interest to all persons interested in forests, and we wish to add our word of appreciation of the service of your Bureau.

Your letter is clear and explicit, and we will be glad to take advantage of your suggestions in our logging operations and have conveyed the information to other lumber companies operating in this vicinity.

Doctor Hopkins has, since then, prepared the following additional recommendations and summary:

TRAP TREES.

With our present knowledge of the life history of the western pine-destroyer and its habits of attacking girdled and felled trees, it is evident that trap trees[a] may prove effective in keeping the insect under control, especially in localities where only a few trees are being killed each year or after a large number of the infested trees have been felled and barked in a badly infested locality.

The time to girdle and fell trees to catch the first generations would be about the middle of June, the bark to be removed and burned in about 20 to 25 days, or before the broods emerge. Girdled or deadened trees are prepared by the "girdle to heartwood" method—that is, cutting through the sapwood all around the trunk 3 or 4 feet above the base or as high above the base as convenient to chop; for this purpose large, inferior trees should be selected.

Felled trees should be lodged or allowed to fall on logs, rocks, etc., so that the prostrate trunks will be as far as possible from the ground. Trees prepared in this manner will usually be attacked by swarms of the beetles, which will excavate galleries in the bark and deposit their eggs. After the eggs have hatched and the larvæ are about full grown, the removal and burning of the bark will effectually destroy the broods and thus contribute greatly to reducing the numbers of the beetles—

[a] Living trees girdled or felled at the proper time to attract the flying beetles to them and away from healthy trees.

which must occur in large numbers before they can attack and kill a tree. Some of the living trees in the immediate neighborhood of the trap trees may be attacked by beetles attracted to the vicinity by the felled or girdled trees. These should be felled and treated the same as trap trees.

If the conditions appear to warrant it, additional trees should be girdled or felled about the first part of August to catch the second brood. These may be barked, to kill the broods, any time between the first part of October and the first part of the following May.

SUMMARY.

HABITS AND LIFE HISTORY.

The western pine-destroying barkbeetle usually attacks and kills the best examples of western yellow pine and sugar pine.

If neglected and under certain conditions favorable to the species, it is capable of devastating the pine forests over large areas. The broods of the beetle pass the winter in the outer bark of trees killed by it the previous summer. The adults of the overwintering broods emerge and fly in May, June, and July, the beginning and ending of the period varying with the seasons, latitude, and altitude.

The first eggs from the first generation are deposited in June or July, and in some of the warm localities possibly as early as the middle of May. In localities intermediate between the colder and warmer regions the majority of the adults of the first generation evidently develop and emerge in August, but some individuals may remain in the trees until June of the next year.

The first eggs of the second generation are evidently deposited in August and September, depending on locality, and it would appear that in intermediate localities all of the broods of this generation pass the winter (hibernate) in the larval stage in the outer bark. In the warmer localities some of them may develop and emerge in the fall, while in the colder localities there may be but one generation.

The first evidence of attack on living trees is the presence of pitch tubes (figs. 11 and 12, *c*) on the bark or of reddish borings lodged in the crevices and around the base of the tree.

During the fall, winter, and following spring, after a successful attack, the infested trees will be indicated by the fading yellowish and reddish leaves.

The work of the insect will be indicated by the winding galleries through the inner bark (fig. 8). Trees from which the broods have emerged will be indicated by large numbers of small holes through the outer bark (fig. 12).

REMEDIES.

The principal areas of infestation and the principal patches of infested trees should be located in September and October.

Beginning with the first part of October, the infested trees should be felled and the bark removed from the main trunk and burned, these operations to be completed by the first part of the following May.

If all of the trees within a given area can not be thus felled and treated, the work should be concentrated on the larger clumps and patches of infested trees.

The cost per tree for cutting, barking, and burning the bark will range from about 30 cents to $1, depending on locality and accessibility.

Summer cutting, except in regular logging operations, is undesirable, since the cutting of a few trees in the midst of a large forest may attract the insects from a long distance, and thus result in extensive depredations in bodies of timber which it is most desirable to protect.

TRAP TREES.

In sections where it is known that the beetle is killing some of the timber, trap trees should be provided in June and August. Ordinarily, 4 or 5 inferior living trees within each section, on which there is evidence of the work of the beetle, should suffice.

Trap trees should not be prepared unless it is reasonably certain that the bark will be removed and burned before the broods of the beetles develop and emerge, otherwise such trees may contribute to the destruction of a larger amount of timber.

STORM-FELLED OR LIGHTNING-STRUCK TREES.

Storm-felled and lightning-struck trees are a menace to a healthy forest within the distribution of this insect, since they serve as breeding places and centers of infestation. Therefore, whenever practicable, such trees should be watched, and if found infested with broods of this beetle, they should be treated as recommended for infested and trap trees.

PUBLICATIONS RELATING TO THE WESTERN PINE-DESTROYING BARKBEETLE.

1876. LeConte, J. L.—The Rhynchophora of America North of Mexico. Proc. Am. Philos. Soc., Vol. XV, Dec., p. 386. Species described.

1890. Dietz, W. G.—Notes on the species of Dendroctonus of Boreal America. Trans. Am. Ent. Soc., Vol. XVII, p. 32. Revision notes.

1899. Hopkins, A. D.—Preliminary Report on the Insect Enemies of Forests in the Northwest. Bul. No. 21, n. s., Div. Ent., U. S. Dept. Agric., pp. 13–15. First notes on habits.

1904. Hopkins, A. D.—Catalogue of Exhibits of Insect Enemies of Forests and Forest Products at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. Bul. No. 48, Div. Ent., U. S. Dept. Agric., p. 18. Character of work described.

1905. Currie, R. P.—Catalogue of the Exhibit of Economic Entomology at the Lewis and Clark Centennial Exposition, Portland, Oregon, 1905. Bul. No. 53, Bur. Ent., U. S. Dept. Agric., pp. 74 et seq. Reprinted from Bul. 48.

SOME INSECTS INJURIOUS TO FORESTS.

ADDITIONAL DATA ON THE LOCUST BORER.

(*Cyllene robiniæ* Forst.)[a]

By A. D. Hopkins,
In Charge of Forest Insect Investigations.

This part of Bulletin 58 contains a partial revision of Part I, with additional information based on the results of subsequent investigations by the writer and one of his assistants, Mr. W. F. Fiske.

SEASONAL HISTORY.

The data under this head refer to the District of Columbia and vicinity, latitude 39°, altitude 10 to 90 feet above tide.

HIBERNATION.

Hibernation begins soon after the larvæ hatch from eggs deposited at various times from August to October, and the period is passed as minute larvæ, scarcely longer than the eggs from which they hatch, in small individual hibernating cells excavated by them just beneath the corky bark and in the outer layers of the living bark on the main trunk of the larger to small trees or small saplings, and larger to small branches.

ACTIVITY OF THE OVERWINTERED LARVÆ.

Activity of the overwintered larvæ begins in April, or with the beginning of the movement of the sap in the bark and just before the leaf buds open. In 1906 activity began April 11; on April 13 the more advanced individuals had entered to the wood, on the 16th were grooving the surface, and on the 25th some of them had entered the wood. By May 11 nearly all of them had entered the sapwood and some of them had extended their burrows into the heartwood and were rapidly

[a] Order Coleoptera, Family Cerambycidæ.

increasing in size and very active, so that by May 20 some of them were more than half grown. They continued actively feeding and growing until after the middle of July, when they began to transform to pupæ and continued transforming during August until all had transformed, probably by the 1st of September. The pupæ begin transforming to adults about the 1st of August and continue transforming probably into September, although the principal transformation is in August.

ACTIVITY OF THE ADULTS.

The adults begin to emerge as early as the 7th of August, and continue emerging until the last of September, the greater number coming out during the last part of August and the first half of September. Evidently all beetles are out by the first week in October.

The females begin to deposit eggs within a few hours after they emerge. The principal period of oviposition appears to be between the middle of August and middle of September, but oviposition continues until in October. The eggs hatch within eight or ten days after they are deposited, and the young larvæ excavate their hibernating cells and remain dormant until the following spring.

VARIATION IN SEASONAL HISTORY BETWEEN DIFFERENT LATITUDES AND ALTITUDES.

Phenological investigations of plants and insects by the writer[a] during the past ten years indicate that the average difference in the dates of occurrence of the different stages of *Cyllene robiniæ* at different latitudes and altitudes in the eastern United States will not be far from four days later for each degree north of latitude 39° and for each 400 feet of altitude above Washington at the same latitude, or four days earlier for each degree south of latitude 39° at the same altitude.

Thus, at latitude 43° in central New York, or central Michigan, with altitude the same as at Washington, the dates would be about sixteen days later, and at altitudes of 1,000 feet at latitude 43° they would be about twenty-six days later; at the same altitude as that of Washington at latitude 35° in southern North Carolina and Tennessee they would be about sixteen days earlier or at 1,600 feet elevation about the same. Thus we would have about thirty-two days' difference between localities at the same altitude in central New York and southern North Carolina. We would also have thirty-two days' difference between Washington and localities at latitude 39° and altitudes of 3,200 feet in the mountains of Virginia and West Virginia.

[a] Bull. 50, W. Va. Agric. Exp. Sta., 1898, pp. 17, 18, and Bul. 67, 1900, pp. 241–248, with map.

HABITS OF LARVÆ AND ADULTS.

When a larva begins activity in the spring it molts and proceeds to excavate an independent food and entrance burrow through the dead area of bark surrounding the hibernating cell or through the living bark immediately surrounding the dead area, until it reaches the cambium. It then excavates an irregular groove or cavity in the outer sapwood, returning frequently to the outer cell or opening to push out the borings and apparently to get relief from the exuding sap. A large per cent of the larvæ die before any further progress is made, but survivors grow rapidly and soon succeed in overcoming the many obstacles, including natural enemies, resistance of the tree, etc., and enter the sapwood. From this stage on until the larvæ have attained their full growth they are very active and destructive. Their food consists principally of the nutritious substances of the bark and wood, and probably of the liquids flowing into the burrow, but they do not hesitate to kill and feed upon each other when two or more come in contact within the same burrow. The fact that the entire development often takes place in a burrow scarcely more than twice the length of a matured larva indicates that food must be obtained from some source other than the wood and bark. Throughout its active life the larva frequently returns to the inner and outer bark to enlarge the burrow, and push out its borings, so that the burrow when completed is of a diameter throughout sufficient to allow the passage back and forth of the full-grown larva. When full grown the larva enlarges the inner end of the burrow, plugs the outer portion with boring chips, and in due time transforms in succession to the pupa and adult. When the adult is fully matured it escapes through the exit prepared by the larva. Immediately after a female emerges she is joined by one or more males, and within a few hours, or within twenty-four hours, she proceeds to deposit eggs. She runs about over the bark investigating the crevices, by means of her ovipositor, to locate those most suitable for an egg. Sometimes as many as twenty places are critically examined before one is selected, and it appears that but one egg is deposited in a place by the same female, but other females may find the same place and each deposit an egg, so that sometimes several eggs are found in one crevice. As a rule, however, there is but one. The faculty of the female in locating the most suitable place for an egg by means of the sensitive palpi on the tip of the ovipositor is remarkable.

The beetles feed principally on pollen from the flowers of golden rod, but are very fond of any sweet liquid, such as sugar sirup placed on the trunks of the trees. They are found during the day on the trunks, branches, and foliage of the locust, and during their principal period of activity, from toward the last of August to the middle of September, they are especially common on the golden-rod flowers. Mr. Fiske determined that they were also actively copulating and depositing eggs as late as 10 o'clock at night.

The attack of this insect is apparently confined to the black or yellow locust (*Robinia pseudacacia*).

ECONOMIC FEATURES.

DESTRUCTIVE CHARACTER OF THE WORK.

The destructive character of the work of the locust borer is a matter of great economic importance. This insect attacks the otherwise perfectly healthy trees, and in addition to causing the detrimental wormhole defects in the wood it often kills the trees or renders an otherwise valuable product worthless except for fuel. It is much more destructive in some localities and sections than in others, and also much more destructive to some trees in the same grove than it is to others. It is more destructive also to young saplings and the branches of medium-sized trees than to the larger trees.

The death of a tree is caused principally by injuries to the inner bark and cambium, resulting from repeated attacks. Injuries to the wood alone do not result in the death of trees except when all of the wood is practically destroyed or sufficiently injured to cause the tree to fall or be broken down by the wind.

The commercial value of the wood product is diminished or destroyed by the wormhole defects, but for certain purposes, as, for instance, fence posts, a limited number of such defects are not detrimental, except so far as they may contribute to decay.

EVIDENCES OF ATTACK.

The first evidence of attack is fine brownish boring dust and wet spots on the bark, first observed in April, when the overwintered larvæ begin to enter the inner bark. As soon as the larvæ begin to groove the surface of the wood and enter the sapwood, their presence, in addition to the wet spots, is indicated by yellowish boring dust mixed with liquids and the gum-like exudations. After all of the larvæ have entered the wood their presence is plainly shown by the quantities of yellowish boring dust lodged in the loose bark on the trunk, in the forks of the tree or branches, and around the base. At this stage, usually about the middle of May, the badly infested trees which will die are plainly indicated by the failure of the leaf buds to open, or by the dwarfed or faded and sickly appearance of the foliage, and toward the last of the month and until the larvæ have completed their work in July, by the breaking down of the branches and small trees.

FAVORABLE AND UNFAVORABLE CONDITIONS FOR DESTRUCTIVE WORK.

Favorable conditions for the destructive work of the borer appear to be found in the presence of isolated trees and groves in the open in localities where golden-rod is present or abundant; also, where less resistant varieties of the tree prevail.

Unfavorable conditions are found in forest growth or large areas of pure stands, or mixed stands where the locust predominates; also, in plantations and groves where resistant varieties prevail, and where there is no golden-rod or other favorite food for the beetles. It is also found that coarse, thick bark is less favorable than the thinner bark on old and young trees and saplings.

NATURAL ENEMIES.

INSECTS.

Several predaceous insect enemies of the larvæ have been observed, but so far no true parasites have been discovered. A large elaterid larva (*Hemirhipus fascicularis* Fab.) appears to be the principal enemy of the borer after the latter has entered the wood. It resembles the borer somewhat, but is easily distinguished by the more flattened and shiny body, long prothoracic legs and two curved spines on the last abdominal segment. This predaceous larva is frequently found in the empty mines of the Cyllene larvæ, therefore it is evidently an enemy of considerable importance.

A slender, cylindrical, whitish, footless dipterous larva of an undetermined species is sometimes found in the mines in the wood, and, according to an observation made by Mr. Pergande, it may attack and kill the borers.

Whitish, flattened larvæ of the nitidulid genus Ips, with prominent branched hooks on the last abdominal segment, are common in the sap at the entrance of the mines and in the burrows made by the young borers in the inner bark and outer wood. They are supposed to be sap feeders, but the writer found they would attack and devour young Cyllene larvæ when confined together in a bottle. Therefore it is possible that they kill a great many of the young borers before these enter the wood, which may account, in part, for the disappearance of such a large number of the young borers while in the bark-boring stage.

It was also demonstrated that if several young Cyllene larvæ of various sizes were placed together in a small vial, the larger ones would kill and eat the smaller ones. It is probable, therefore, that when several larvæ hatch from a cluster of eggs and but one survives—which is usually the case—the larger or stronger one has killed the weaker ones.

DISEASE AND SAP FLOW.

Dead larvæ are frequently found in the mines, covered with white flour-like spores, and sometimes these spores are so common that a perceptible cloud rises from the wood when it is split open. Experiments in placing some of the spores with healthy uninjured larvæ in bottles, as well as with those in the normal position in the wood, resulted in the death of the larvæ and the development of apparently the same disease, while the duplicate larvæ kept under the same conditions, but without contact with the spores, remained normal and healthy. Therefore this is a fungus which will kill the borers and one which is evidently of considerable importance.

The profuse flow of sap together with a gummy substance in the wounds made in the living bark and cambium is evidently detrimental to the normal progress of the young larvæ and apparently many of the latter are thus destroyed.

METHODS OF CONTROL.

It should be remembered that all the holes found in a tree and all other damage by the borer are not the work of one generation, but usually that of repeated annual attack during the life of the tree; also, that a burrow in the sapwood of a young tree remains the same burrow in the heartwood of the old tree, without change, as long as the tree exists, except in the healing of the original entrance. The number of borers and the annual amount of damage is not so great, therefore, as might appear, and, while each female is capable of depositing a hundred eggs, only a small percentage of the larvæ hatching from them survive the bark-infesting stage or complete their development to adults. This suggests that any method of management which will insure the destruction of a large per cent of the surviving larvæ and beetles each year will reduce the damage to a point where there will be practically no loss.

With our knowledge of the life history and habits of the insect it is now possible to make definite recommendations and suggestions for its control. Some of those of immediate practical importance are as follows:

TIME TO CUT LOCUST TO DESTROY THE YOUNG LARVÆ.

The cutting of locust for all purposes, including thinning operations and for private or commercial use, should be done during the period between the 1st of October and the 1st of April, the bark removed from the crude product, such as posts, poles, and the like, and the tops and thinnings burned. The removal of the bark from all desirable portions of the trunks of the trees felled during this period is important and necessary in order to destroy the larvæ before they enter the wood. The work in all cases should be completed before the leaf buds begin to swell on the living trees in the spring.

DESTRUCTION OF INFESTED TREES AND WOOD.

When it is desirable to simply remove and destroy, by burning or otherwise, the badly infested and damaged trees to kill the broods of larvæ, the work should be done in May and June, when all such trees can be easily recognized by the boring dust, fading leaves, broken branches, etc., and must be completed before the beetles begin to emerge. Perhaps the best rule, applicable to all localities, latitudes, and elevations, is to complete the work by the time the flowers have all fallen from the trees, which will vary between different altitudes and latitudes from about the middle of May to the last of June. Another rule would be to complete the work before the earliest varieties of golden-rod begin to show evidences of flowering. This, however, would be the latest that the work should be done, because the beetles begin to emerge by the time the first golden-rod flowers appear.

SPRAYING THE TRUNKS AND BRANCHES TO KILL THE YOUNG LARVÆ.

Experiments have demonstrated that the hibernating larvæ may be killed by spraying the trunks and branches with a strong solution of kerosene emulsion. Therefore, when it is practicable or more desirable to adopt this method for the protection of small plantations, groves, or shade trees, the spraying should be done in the fall or winter, not earlier than November 1, and not later than April 1—in other words, during the dormant period of the tree. The following paragraphs, relative to the preparation of kerosene emulsion, are taken from Farmers' Bulletin No. 127, by C. L. Marlatt:

Kerosene emulsion (soap formula)—

Kerosene ....gallons..	2
Whale-oil soap (or 1 quart soft soap)........................pound..	½
Water ....gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added, boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed. * * *

For use on locust trees dilute 1 gallon of emulsion with 2 gallons of soft water.

Pure kerosene and pure petroleum will effectually kill the insects, but may do some damage to the bark of the trees.

Experiments with carbolic emulsion indicate that this preparation is of no value to kill the young larvæ.

POISON BAIT.

Experiments showed that the beetles would feed readily on poisoned bait, such as sugar, sirup, or molasses with some arsenical mixed in, when this was smeared on the trees. Such baits are fatal to the beetles, but the danger of killing honeybees is so great that their use is not recommended in localities where honeybees are kept.

DAMAGE TO CUT WOOD AND DANGER OF INTRODUCING THE INSECT INTO NEW LOCALITIES.

We have determined that after the borers have once entered the wood they may complete their development in the cut and dry branches; they will evidently do so, therefore, in posts or other material manufactured from trees cut between the 1st of May and the middle of September; from this it is plain that locust should not be cut during this period for any purpose except to destroy the borers, or, if it should be necessary to cut it, the tops should be burned and the logs submerged in ponds or streams for a few days before they are shipped or manufactured. This is very important, both to prevent damage to the manufactured material and the introduction of the insect into the far West and other sections of the country which are at present free from it.

SELECTION OF LOCATIONS FOR EXTENSIVE PLANTINGS.

The fact that there are many sections and localities of greater or less extent within the natural home of the locust and its insect enemies where, from some unknown cause, the tree grows to large size and old age without perceptible injury from borers and other insects, suggests the importance of selecting such localities for any proposed extensive operations in the line of artificial planting, or utilization of natural growth. It will be found, however, that no area of considerable extent, even in such localities, is entirely free from this and other destructive insect enemies, and that certain precautions and well-planned methods of management with reference to the control of the latter will be necessary.

MANAGEMENT OF PLANTATIONS TO PREVENT INJURY.

In the first place it is necessary, in order to provide against future losses from the borer, that a thorough survey be made in May and June, not only of the area to be utilized but of the entire neighborhood for a radius of a mile or more from its borders, for the purpose of locating and destroying scattering trees and groves which are more or less seriously infested or damaged by the borer. It would seem that the control of such large areas, by purchase or under a plan of cooperation between the owners of the land or trees, is one of the most important requisites for success in preventing future losses from the ravages of this and other insects in small as well as large plantations. In fact, it is the writer's opinion that, with this precaution properly and continuously carried out, locust may be successfully protected from the borer in any locality.

In the subsequent management of plantations and of natural forest and sprout growth it is important each year to locate and destroy the worst infested trees for the purpose of killing the borers in the wood, and to conduct the thinning and commercial cutting operations during the period between October of one year and April of the next, in order to destroy the young borers before they enter the wood.

Worthless, scrubby, borer-infested trees should be killed outright by stripping the bark from 4 or 5 feet of the lower stem during August to prevent sprouts and seed production from them, and at the same time to destroy the eggs and young borers. Trees deadened in this manner will usually be so completely killed that not a single root sprout will appear. Therefore this method is of special value in preventing sprout reproduction from inferior individual trees.

SELECTING AND BREEDING BORER-RESISTANT TREES.

The fact that some trees are more or less resistant to attack or injury by the borer, while adjacent ones in the same grove are attacked year after year and seriously damaged, suggests breeding races and varieties of the species which would be permanently resistant.

Breeding experiments have been begun in cooperation with the Bureau of Plant Industry and the Forest Service, but it will require several years to get definite results. In the meantime, however, it is important that seed and cuttings for commercial planting should be selected, as far as possible, from trees which show least damage from the borer and are otherwise vigorous and healthy. From a well-established principle in the heredity of plants and animals, this practice of propagating from the best examples must certainly yield better results than would follow a disregard of the character of the trees from which seed or root propagations are made.

For reference to literature, and other information not included in this paper, the reader is referred to Part I of this bulletin, pages 1 to 16.

SOME INSECTS INJURIOUS TO FORESTS.

THE SOUTHERN PINE SAWYER.

(*Monohammus titillator* Fab.)

By J. L. WEBB, M. S., *Agent and Expert.*

INTRODUCTION.

Monohammus titillator, or the southern pine sawyer, has been known to systematic entomology for over a century. It is somewhat surprising to note, therefore, that scarcely anything is to be found in literature upon the economic importance of this insect, which may truly be said to be one of the most destructive enemies of the crude product of pine forests, especially in the Southern States. Of late years the increasing number of severe storms, so destructive to pine forests in the Southern States, has provided such excellent breeding places for the sawyer in felled trunks and standing stubs that its work is now known to every lumberman in that section of the country as one of the worst injuries to his industry with which he has to contend. The increasing demand by these lumbermen for exact information in regard to the insect rendered necessary a personal investigation of the seasonal history, habits, and facilities for control. To that end the writer spent the months of July and August, 1908, in southern Mississippi, near the town of Baxterville, for the purpose of studying the insect and its habits and conducting a few experiments to determine the best remedy for combating it. Subsequently trips were made to this region in October, 1908, and March, 1909. Investigations were also made, in the latter part of July, 1908, in a district near Kentwood, La., that had been visited by a cyclone, and in a similar district near De Queen, Ark., in October, 1908. The results of these investigations are given in the following pages.

The writer desires to acknowledge, in this connection, the courtesy and kindness of Mr. E. McLennan, of Hattiesburg, Miss., general agent for a company controlling timber land in that vicinity, in furnishing trees on the company's property to be felled for use in seasonal history experiments.

HISTORY.

In 1775 Fabricius published a short description of the adult from a specimen in the British Museum, calling it *Lamia titillator*, and gave its habitat as "Carolina." He also published short descriptions under the same name in 1781 and 1787. Somewhere between 1788 and 1793, the exact date unknown, Linnæus, in the Systema Naturæ, edited by Gmelin, published a short description under the name *Lamia titillator* Fab. In 1792 Fabricius again published a short description of *titillator*, and also published a description of *Lamia dentator*, with "Carolina" as habitat. The latter name has since been placed in synonymy. Olivier, in 1795, published a short description and figure of the adult under the name *Cerambyx titillator* Fab. He gives it the common name "Capricorne chatouilleux" or the "long-horned tickler," and the habitat as "Carolina." At the same time he published a short description and figure of *Cerambyx carolinensis* (common name, the Carolina longhorn), which has since been made a synonym of *titillator*, and gave the habitat as South Carolina. Somewhere between 1795 and 1811, the exact date not being known, the same author published short descriptions of *Lamia titillator* and *Lamia carolinensis*, giving the habitat of the former as "Carolina," and of the latter as South Carolina. In 1805 Beauvois published a short description and figure under the name *Lamia dentator*. In 1835 Serville described the genus Monohammus, and placed *dentator* and *carolinensis* in it, without mentioning *titillator*. Le Conte, in 1854, published a short description and placed *dentator* and *carolinensis* in synonymy. In this connection he says: "Olivier's *carolinensis* very obviously is the female of his *titillator*. * * * It is common in the Southern States."

In 1862 Harris, in his Insects Injurious to Vegetation, published a short description, with a figure and a note on the habits of adults, but stated that the kind of tree the "grub" inhabited was unknown to him. In 1873 Le Conte published a description of *Monohammus minor*, which has since been made a synonym of *titillator*. At the same time he published a short description of *M. titillator*. Of the genus Monohammus, he says: "The species infests pine trees throughout the whole extent of the United States and contiguous northern regions." In the same year Bowditch, under the name *M. dentator*, published short descriptions of the larva, pupa, and adult, and a short note on seasonal history and habits. He found it infesting *Pinus mitis* (*echinata*) in Massachusetts. In 1885 Horn published a short description under the name *M. titillator* and placed the names *carolinensis*, *dentator*, and *minor* in synonymy. He gave the distribution as from Canada to Washington Territory and south to Florida. In 1899 Hopkins published a short note on the occurrence of this species resting upon pitch and scrub pine trees at Tibbs Run, near Dellslow, W. Va. In the same year Chittenden published a a short account of the destructive habits of the species of the genus Monohammus. J. B. Smith, in his Insects of New Jersey, published the same year, mentions this species as occurring throughout the State on pine in June and July. In 1906 Felt, in his Insects Affecting Park and Woodland Trees, under the name *M. titillator* (common name, tickler), published a very short description, saying further that it was met with in very small numbers [in New York] in 1901 on both white pine and hard pine.

DISTRIBUTION.

The records of the Bureau of Entomology indicate that this species is to be found over the whole eastern half of the United States, from Maine to Texas. As stated in the historical notes, Doctor Horn gave the distribution as from Canada to Washington Territory, and south to Florida, but I have not been able to verify his statement as to the northern and western limits of distribution.

HOST PLANTS.

So far as known, this species attacks only pine trees, not favoring any one species of pine, but apparently attacking all species of pine trees within its range of distribution.

CONDITION OF TREES ATTACKED.

Only felled or injured trees are attacked by this species. So far as known, healthy standing trees are never in any danger whatever from this source.

INJURY TO PINE FORESTS BY STORMS.

In September, 1906, a high wind accompanied by rain, blowing steadily for two or three days, uprooted a vast amount of pine timber in the southern part of Mississippi.

In May, 1907, near Tuscaloosa, Ala., a storm occurred which felled about 800,000 feet of pine timber.

On April 24, 1908, a cyclone of huge proportions passed through Mississippi and Louisiana, tearing down a swath of timber from 1 to 2 miles wide (fig. 13). The cyclone passed through some of the finest pine forests in these States, thus bringing down or breaking off many millions of feet of timber. It is quite probable that the same storm did damage in Arkansas. At any rate, two storms occurred in Arkansas, one in April and one in May, 1908, both of which were very destructive to pine timber. During the fall and winter of 1908 two or three more storms occurred in the same State which doubtless contributed to the destruction of the pine forests.

INJURY TO STORM-FELLED TIMBER BY THE SOUTHERN PINE SAWYER.

Practically all timber felled by the storm of September, 1906, became infested by the sawyer. When the writer reached Baxterville, Miss., July 6, 1908, the broods had all matured and emerged from these trees. In this vicinity, where most of his investigations were carried on, from 75 to 90 per cent of the trees felled by the storm of April 24, 1908, were infested by the sawyer. Adults were at that time actively engaged in laying eggs in the uninfested trunks

FIG. 13.—The effect of the storm of April 24, 1908. (From a photograph taken near Baxterville, Miss.)

and stubs. This continued for the balance of the summer, so that it is safe to say that a very small percentage of the pine timber injured by this storm escaped infestation. The damage to each log infested is the work of the larvæ or grubs which mine in and through the sapwood, and even penetrate the heartwood, making large unsightly holes which cause the lumber made from this portion of the log to be thrown into the very lowest grade, known to the lumbermen as "No. 2 common."

PECUNIARY LOSS.

Approximately 25 per cent of the lumber in each log infested by the sawyer is seriously damaged. The pecuniary loss may therefore be computed as follows: Lumber undamaged by insects was worth, in 1908, $19 a thousand feet b. m. at the mill in southern Mississippi. When infested by the sawyer the 25 per cent damaged was reduced in value to $7.50 a thousand.

It is estimated that in the storm of September, 1908, 2,000,000,000 feet of timber were blown down. In the 1907 storm, in Alabama, 800,000 feet were blown down, and in the storm of April 24, 1908, which passed through two or three States, 180,000,000 feet were blown down. This gives us 2,180,800,000 feet of timber blown down by these three storms. Practically all of this storm-felled timber was damaged by the sawyer.

As stated above, 25 per cent of each log damaged is reduced from $19 a thousand feet to $7.50 a thousand feet; therefore we may consider that 25 per cent of the whole, or 545,200,000 feet b. m. was reduced from $19 a thousand to $7.50 a thousand. At $19 a a thousand this amount of timber would be worth $10,358,800. At $7.50 it would be worth $4,089,000. The difference between these two sums is $6,269,800. Therefore, if this timber had been used, or could have been used before the sapwood decayed, the last figure given would represent the total loss chargeable to the sawyer.

CHARACTER OF THE INSECT.

Adult.—The adult (fig. 14) is an elongate beetle varying from 16^{mm} to 31.5^{mm} in length and from 5 to 10^{mm} in width. The color is a mottled gray and brown. In the male the horns, or antennæ, are very long, often being two or three times the length of the beetle. In the female they are much shorter than in the male, but are still somewhat longer than the body.

Egg.—The egg (fig. 15) is elongate-oval, approximately 4^{mm} long, by 1.5^{mm} in diameter at the middle. The color is opaque white. There are two distinct coverings, which correspond to the outer and inner shells of the egg of a fowl. The outer is known as the chorion (fig. 15, *a*, *d*), and the inner as the amnion (fig. 15, *b*). At one end is found a depression or little round hole, which is known as the micropyle (fig. 15, *c*). Under a high-power microscope the chorion is seen to be very prettily sculptured on its outer surface (fig. 15, *e*).

Larva.—The larva (fig. 16) is an elongate, footless, white grub with powerful jaws or mandibles for boring through the wood. The size varies considerably in different individuals and according to age. The largest at maturity have been found to measure slightly over 60^{mm} in length and 9^{mm} in breadth at the broadest point (the pro-

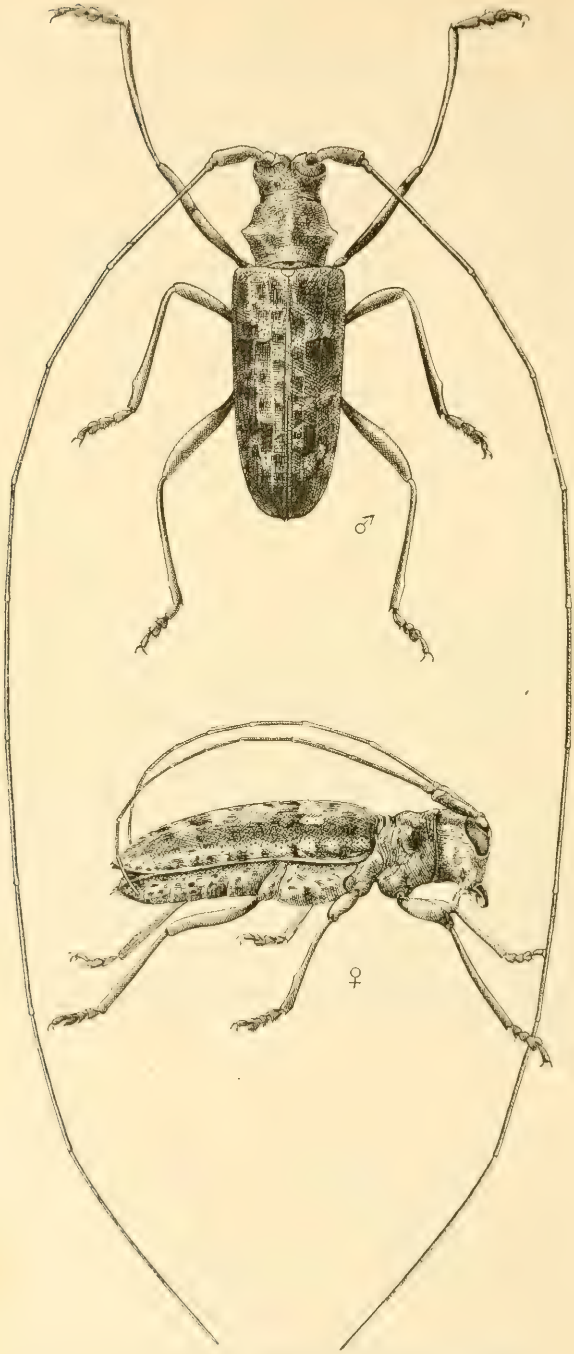

FIG. 14.—The pine sawyer (*Monohammus titillator*): ♂, Male; ♀, female. Enlarged about one-third. (Original.)

thorax). Larvæ which develop into the smaller sized adults are, of course, much smaller than this at maturity. The body is divided into 14 well-marked segments. The first is the head. The following three constitute the thorax, the first being the prothorax, the second the mesothorax, and the third the metathorax. The following 9 segments constitute the abdomen, and are designated as the 1st, 2d, 3d, etc., abdominal segments. The last segment is called the anal segment. The head (fig. 16, *a*) is considerably longer than broad, and is capable of being deeply retracted into the thorax. The prothorax, upon the anterior part of the upper or dorsal surface, is smooth and shining, but the posterior part has an opaque leathery appearance. This opaque surface is dotted over by small shining spots more or less longitudinally elongate in shape. The mesothorax is smooth upon the upper or dorsal surface, but on the lower or ventral surface is found a double transverse row of fine fleshy granules. On the extreme anterior portion of the side of this segment is found a transverse, oval, brown spot. This is the first spiracle or breathing pore. On the

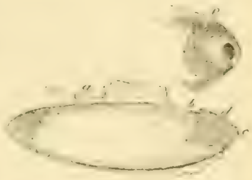

FIG. 17.—The pine sawyer. Egg, greatly enlarged: *a*, Chorion; *b*, amnion; *c*, micropyle; *c*, same, highly magnified; *d*, sculpture of chorion. (Original.)

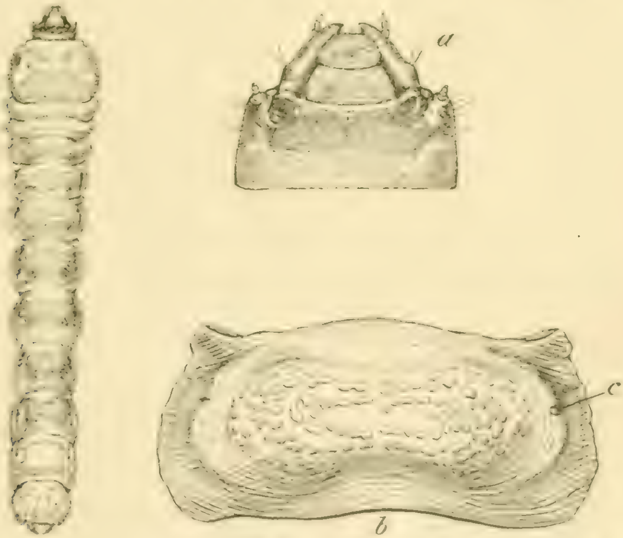

FIG. 16.—The pine sawyer. Larva, slightly enlarged: *a*, Fore part of head; *b*, second abdominal segment; *c*, abdominal spiracle. *a*, *b*, Greatly enlarged. (Original.)

metathorax a double transverse row of granules occurs, both on the dorsal and on the ventral surface, but there is no spiracle upon this segment. On the first 7 abdominal segments there are 4 rows of granules on the dorsal surface (fig. 16, *b*), and 2 on the ventral. The last 2 segments are free from granules. On the anterior half of the side of each abdominal segment except the last, a spiracle (fig. 16, *c*) similar to that on the mesothorax, except that it is much smaller, is to be found. In mature larvæ each abdominal segment bears a longitudinal fold on each side, known as the pleural fold. On immature larvæ the pleural folds on the first 2 abdominal segments are so obscure as to be scarcely noticeable. The anal fold is quite hairy and bears the anal opening. Numerous hairs occur upon each segment of the entire body.

Pupa.—The pupa (fig. 17) shows the form in some degree of both the larva and the adult. The number of segments is the same as in the larva; the first abdominal segment, however, is not visible upon the under side of the body. The head is of the same general shape as that of the adult, but is bent forward and under, so that the mouth-parts point directly back toward the posterior end of the body. Several bristles are found upon the anterior part of the head. The antennæ are well developed and are coiled on the under side of the elytra, or wing covers, which extend from the mesothorax in a posterior lateral direction, the tips being directly underneath the body and attaining the fourth abdominal segment. The elytra thus lie between the body and the first two pairs of legs. The third pair of legs is between the body and the elytra. The wings are flattened against the under side of the elytra, each one projecting slightly beyond the outer side margin of the elytron, under which it lies. The elytra are attached to the mesothorax and the wings to the metathorax.

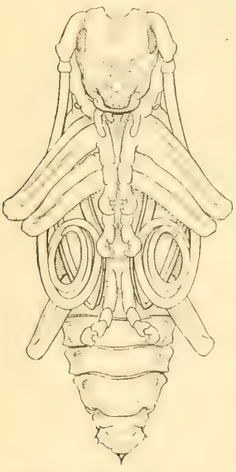

FIG. 17.—The pine sawyer: Pupa. About twice natural size. (Original.)

There is a large fleshy tubercle at each side of the prothorax. The legs are folded underneath the body. The first pair is borne by the prothorax, the second by the mesothorax, and the third by the metathorax. The mesothorax bears a spiracle in the same position as that of the larva, and the first 5 abdominal segments bear spiracles; the rest apparently do not. Upon the dorsal surface all segments of the thorax and abdomen bear bristles. The ventral surface of all abdominal segments, except the last, is smooth. The last abdominal segment, which occupies the extreme posterior end of the body, has a peculiar triangular shape. One of the points of the triangle is prolonged upward into a sharp, chitinized spine. The two lower points of the triangle are armed with several chitinized bristles. The anal segment occurs directly beneath the last abdominal segment, and is inclosed on three sides by the latter. A strongly marked sexual difference is to be found between the anal segment of the male and that of the female. In the male this segment shows merely the anal opening. In the female two globular tubercles are borne side by side on this segment.

SEASONAL HISTORY.

There are four stages in the life of the sawyer, first, the egg (fig. 15); second, the larva (fig. 16); third, the pupa (fig. 17); fourth, the adult (fig. 14).

In southern Mississippi the egg-laying period lasts from about the first of March to the middle of October. In some cases eggs may be laid earlier or later than the dates given, but the main activity in egg-laying will be found to be comprised within this period. The young larvæ hatch from the eggs in about five days after the eggs are deposited.[a]

The length of time from the hatching of the young larva to the time of maturity and change to the pupa appears to vary considerably in different individuals. The comparative periods of time spent in the larval and pupal stages are not known. However, it is probable that while the larval period may last for several months the pupal period is not longer than two or three weeks. The length of time occupied in passing from the egg to the adult stage varies greatly in different individuals. It appears that normally there is one generation a year, with a partial second generation. Thus, on August 12, 1908, the writer found larvæ, pupæ, and emergence holes in the trunk of a tree which had been felled by storm April 24, 1908. The fact that the tree was felled on this date makes it certain that the eggs of the sawyer were deposited subsequently. This gives us a period of less than four months for the development from the egg to the emerged adult, in some individuals. Returning to the same tree October 6, 1908, more emergence holes were found, but there were still plenty of larvæ in the trunk. Also, scattering emergence holes were common at this date in other trees felled by the storm of April 24, 1908, which were also abundantly infested with larvæ. On March 19, 1909, the writer again visited the tree just mentioned, and found a good many larvæ and one pupa still in the log. Thus it is seen what a great variation in the length of time taken for development there may be among different individuals in the same log. The case of the sawyer in the Southern States appears to be somewhat analogous to that of certain species of Lepidoptera, a few adults of which emerge in the fall, while the greater number of the pupæ go through the winter before changing

[a] This statement is based upon observations made during the hottest part of the summer. Possibly eggs laid in the spring or fall might not hatch so quickly, as there would be less heat at those periods.

to the adult. In the case of the sawyer, however, the winter is passed in the larval stage and not the pupal stage. In November, 1908, Mr. R. W. Van Horn found emergence holes of the sawyer in trees felled the previous spring near Virginia Beach, Va., thus showing that the same conditions prevail there.

Among the larvæ which pass the winter in the logs, those which are farthest advanced in development are, of course, the first to go through the changes to the adult, and to emerge in the spring. It is probable that this emergence begins about March 1. At the time the writer was in southern Mississippi, March 18–20, 1909, many adults had already emerged and others were ready to emerge. Females were actively engaged in laying eggs at this time.

Just how long it takes for all the overwintered larvæ, which have not already done so, to go through the changes to the adult stage and emerge is not known, but it is probable that this will be accomplished at least by June 1.

From the last of July, 1908, to the first of February, 1909, the writer had trap trees felled at stated intervals, for the purpose of getting seasonal history notes. The following tabulation shows the net results of these experiments:

Seasonal history records of the pine sawyer from pine trees felled from July, 1908, to February, 1909.

Hopk. U. S. No.	Date of felling.	First eggs noted.	Condition on March 18–19, 1909.
	1908.	1908.	
5873	July 29	Aug. 6	Larvæ and pupæ in wood. A good many adults have emerged.
5874	29	6	Larvæ, pupæ, and young adults in wood. A good many adults have emerged.
5879	Aug. 10	13	Larvæ and pupæ in wood. No emergence holes noted.
5880	10	13	Do.
5885	20	....	Larvæ and pupæ plentiful in wood. No emergence holes noted.
5886	20	....	Larvæ and pupæ common in wood. Three adults have emerged.
5893	31	....	Larvæ and pupæ in wood. Several adults have emerged.
5894	31	....	Larvæ and pupæ in wood very scarce. One young adult (quite small). Two adults have emerged.
5895	Sept. 11	....	Larvæ and pupæ in wood. No emergence holes.
5896	11	....	Larvæ and pupæ rather scarce in wood. A few adults have emerged. A few larvæ between bark and wood, scoring the wood.
5897	28	Oct. 7	Larvæ and pupæ in wood. One larva found between bark and wood, which crawled back into its hole in the wood. One adult has emerged.
5898	28	7	Larvæ, pupæ, and young adults in wood. Several adults have emerged.
5914	Oct. 15	....	Larvæ, some of which have not entered wood, others in wood with exit burrow excavated nearly to surface. No pupæ or emergence holes.
5915	15	....	Larvæ, some between bark and wood, scoring the wood, not having made entrance holes into wood. Others in wood with emergence gallery excavated nearly to surface. No pupæ or emergence holes noted.
5912	Nov. 3	....	A few inconspicuous egg pits evidently made last fall. Two half-grown larvæ, one of which had commenced to mine into the wood. The other had not commenced to do so.
5913	3	....	Two or three egg pits, evidently made last fall, but no larvæ or eggs found.
5910	Dec. 8	....	Many egg pits. Eggs and young larvæ in some cases, in others the conditions seem to have become unfit by reason of the excavations of other insects.
5911	8	....	Many egg pits. Eggs and young larvæ under bark.
	1909.	1909.	
5908	Jan. 7	....	A few egg pits of Monohammus with eggs. One small larva found.
5909	7	....	Scattering egg pits over the log. Eggs and larvæ apparently one or two weeks old.
5906	Feb. 6	Mar. 18	A few egg pits, both in trunk and stump. Eggs under bark, but none found that have hatched. March 20, female digging egg pit.
5907	6	18	A few egg pits with eggs under the bark. One larva found apparently just hatching. March 20, six beetles, three males and three females, observed on this log, the females excavating egg pits, two males fighting and the other male hanging on to a female.

HABITS.

Preparatory to laying the eggs, the female digs with her mandibles quite a conspicuous egg pit in the bark (figs. 18, *a*, and 21, *c*). This pit is more or less funnel shaped, though sometimes it is merely a transverse slit, and reaches as far as the outermost layer of soft, sappy bark. The female, while digging the egg pit, is generally accompanied by the male, who clasps the posterior end of her body with his fore-legs, and frequently fertilizes her while she is digging the pit. In one instance where the operation was noted, the female did not discontinue digging while copulation took place. Many combats take

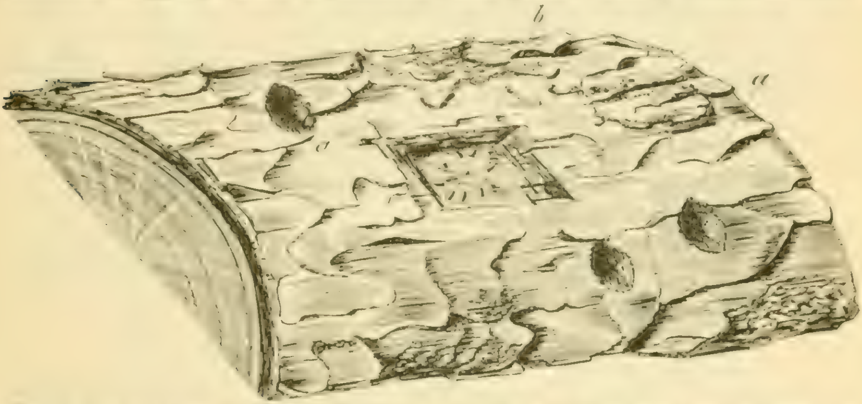

FIG. 18.—The pine sawyer: *a*, Egg pit; *b*, eggs in position in which they were placed by female, the outer bark being removed. About one-half natural size. (Original.)

place between males for the possession of a female during oviposition. The ovipositor is thrust into the egg pit and in between the soft, sappy bark and the first layer of outer hard bark, and the eggs are deposited in a circle around the bottom of the egg pit, the egg (or the end of the egg nearest the pit) being placed from one-eighth to one-quarter of an inch away from the egg pit (see fig. 18, *b*). As many as nine eggs have been found deposited through a single pit opening.

In about five days these eggs hatch, and the small larvæ issuing therefrom begin feeding upon the soft inner bark, and soon work their way through it, but do not enter the wood until they have attained considerable growth. During this period they make irregular galleries through the inner bark just next to the wood, deriving their entire sustenance from the bark and making no marks or cuttings upon the wood. In from eighteen to thirty-two days after hatching the larvæ mine into the sapwood (fig. 19). A few days previous to this they are to be found cutting rather broad, irregular paths upon the surface of the sapwood with their mandibles (fig. 19, *d*). This process is called "scoring." After making the entrance into the wood the larvæ come out again to feed upon the inner bark, evidently retiring into their holes to rest and for protection from their enemies. The chips cut in excavating the hole in the wood, as well as the excrement, are packed between the bark and wood and are not thrown

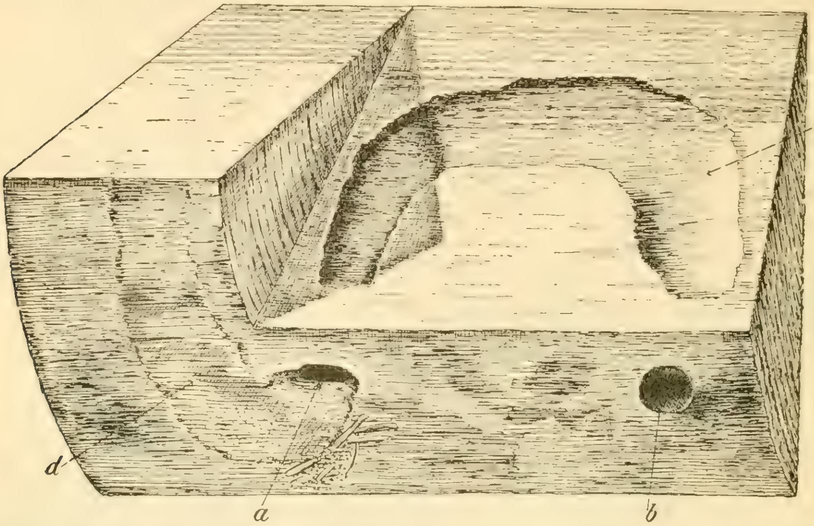

FIG. 19.—The pine sawyer. Gallery: *a*, Entrance hole in wood; *b*, emergence hole; *c*, pupal cell; *d*, surface scored by larva before entering wood. About natural size. (Original.)

out upon the ground, as appears to be the case with some other species. In moving about from the entrance of the hole in the wood to the place where food is obtained, very distinct channels are made through this mass of refuse (fig. 21). This habit appears to continue until the larva is ready to pupate, when, of course, it retires to the pupal chamber (fig. 19, *c*) already constructed, where it remains until the adult stage is reached. Previous to pupation the larva extends the gallery in the sapwood until the heartwood is reached. As a general thing the gallery here turns in a longitudinal direction for 2 or 3 inches, then turns again toward the surface, giving the entire gallery a U-shaped appearance (fig. 19). Sometimes the bottom of the "U" extends a short distance into the heartwood, but as a usual thing it merely reaches it. In the bottom of the "U" is to be found the pupal cell. The gallery is here greatly widened and enlarged in order to accommodate the insect while going through its

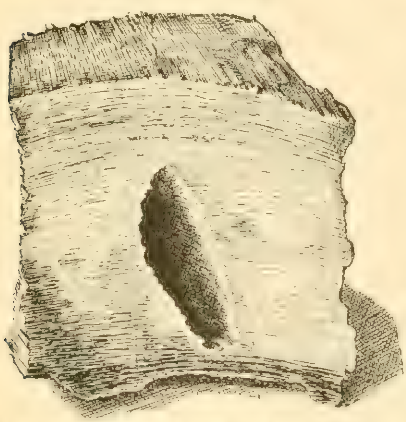

FIG. 20.—The pine sawyer: Cross section of pupal cell. About natural size. (Original.)

transformations (figs. 19, *c*, 20). The unfinished arm of the "U" is usually extended by the larva to within about one-quarter of an inch of the surface of the wood. When the larva pupates, the head of the pupa is turned toward the end of the chamber. When the pupa changes to the adult, the beetle extends the chamber to the surface of the wood and through the bark, if the bark is still upon the tree or

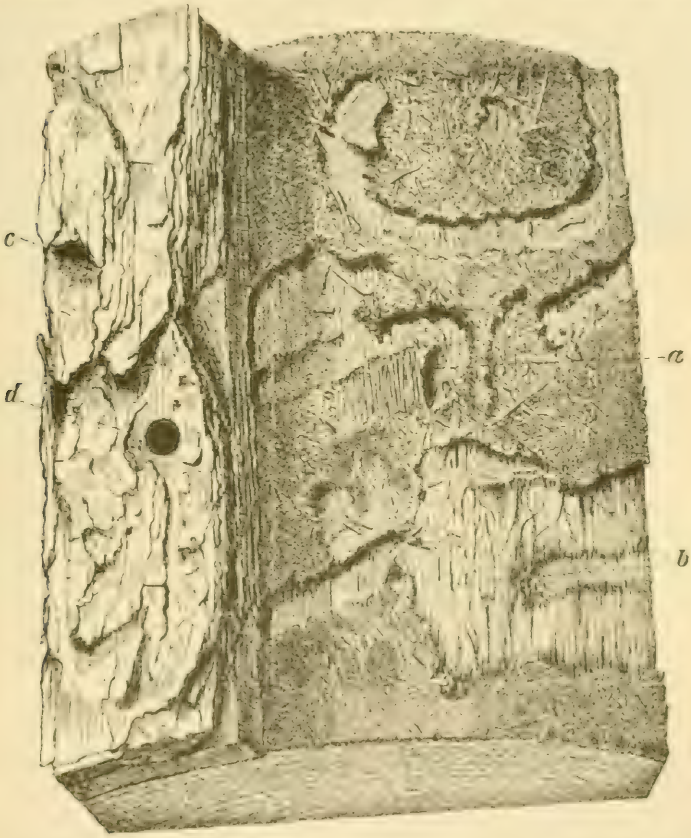

FIG. 21.—The pine sawyer: Section of pine showing, at right, mass of borings and refuse packed under bark (bark removed) by the larvæ and channels made through the mass by the larvæ. *a*, Entrance hole of larva in wood; *b*, scored surface of wood; *c*, egg pit; *d*, emergence hole. About one-half natural size. (Original.)

log, boring a perfectly round exit hole usually about three-eighths of an inch in diameter (figs. 19, 21, 22), thereby escaping to propagate the species in another tree or trees.

NATURAL ENEMIES.

Monohammus titillator is preyed upon by larvæ of the coleopterous family Trogositidæ; by the larva of an elaterid beetle of the genus Alaus, and by a species of Bracon which has been determined as new to science. None of these, however, has been powerful enough, so far, to appreciably thin the ranks of Monohammus. Following is the description, by Mr. H. L. Viereck, of the species of Bracon mentioned above:

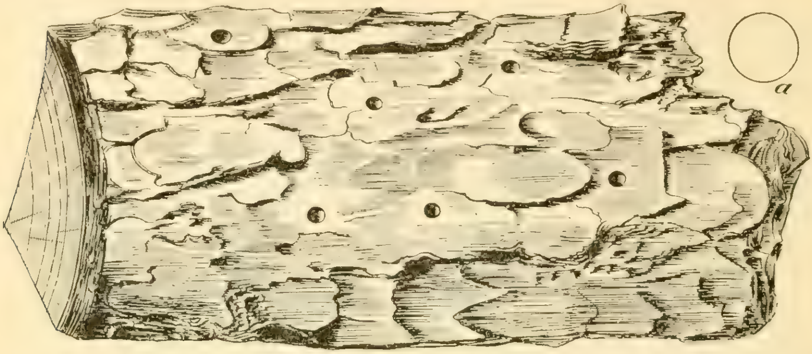

FIG. 22.—The pine sawyer: Emergence holes of young adults in bark. *a*, Natural size of emergence holes. (Original.)

BRACON (MELANOBRACON) WEBBI N. SP.[a]

Compared with *ulmicola* [b] this species differs as follows: Second dorsal abdominal segment without a triangular elevated area but with shallow, almost oblique impressions as diagrammatically represented in figure 23.

FIG. 23.—*Bracon* (*Melanobracon*) *webbi:* Dorsum of second abdominal segment. Greatly enlarged. (Original.)

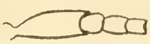

FIG. 24.—*Bracon* (*Melanobracon*) *webbi:* First four antennal joints. Greatly enlarged. (Original.)

Female: Length, 11^{mm}, exclusive of ovipositor, which is 6^{mm}; antennæ 69-jointed; proportions and relation of first four joints approximately as in figure 24; joints 4 to 55 subequal, becoming wider than long; joints 55 to 69 becoming longer than wide, the apical joint conical. Petiole of first discoidal cell about as long as second and third joints of antenna combined. Second dorsal abdominal segment perfectly smooth.

Type.—No. 12585, U. S. National Museum.

Type locality, Baxterville, Miss., March 19, 1909.

Hopk. U. S. No. 5896*a*; reared by Mr. J. L. Webb, of the Bureau of Entomology.

REMEDIES.

Fire.—During the logging operations upon the storm-felled timber near Baxterville, Miss., in 1908, the felled timber was burned over with the object of destroying the broods of the sawyer. Subsequent examinations of this burned-over area disclosed the fact that a very small percentage of the larvæ had succumbed to the heat. *This method is, therefore, not to be recommended.*

Scoring.—Several experiments were tried to determine the efficiency of "scoring," or removing a strip of bark along the upper surface of a log. In some instances salt was sprinkled along the

[a] By H. L. Viereck, Agent and Expert, Bureau of Entomology.

[b] 1906, Trans. Am. Ent. Soc., pp. 176–177.

scored surface, and in others the strip was covered with brush, these having been recommended locally as remedies. In not a single instance was the scoring, either with or without salt, found to deter the larvæ in the slightest degree. *This method is not recommended.*

Placing logs in water.—Investigation of the method of destroying the larvæ in infested logs by placing the logs in water was made at Lumberton, Miss., where logs from the storm-felled trees were placed in the mill pond. The water killed all the larvæ in the log, both between the bark and wood and in the wood itself. *This method is to be recommended wherever practicable.*

Barking the logs.—Barking the logs is effective up to the time the larvæ enter the wood, and for a short time thereafter—perhaps a week. As stated elsewhere, the first part of the life of the larva is spent between the bark and the wood, during which the larva feeds upon the soft inner bark. It is absolutely impossible for the larva to live for the first month of its existence without this soft inner bark to feed upon. Therefore, if the bark be removed from the log during this period all larvæ between the bark and wood will be destroyed. As stated elsewhere, the larvæ continue to feed upon the inner bark for several days at least, after first entering the wood. The writer determined by experiment that the barking of the log during the first few days after the larvæ have entered the wood was effective in destroying the larvæ, by cutting off their food supply. At this period the larvæ have not gone deeply into the wood, so that there would still be a saving if the barking were done at this time. Where this method is practiced as a remedy, it should be done within forty days after the eggs are laid. If trees are felled between March 1 and October 15, egg laying will probably commence at once after the trees are down.

An important point to be taken into consideration in this connection is whether or not logs and trees barked to destroy the sawyer can be taken to the mill before the sapwood decays from lying on the ground. As the greater part of the injury by the sawyer is confined to the sapwood, there will obviously be little or no saving in barking logs which can not be used before the sapwood is destroyed by decay.

The writer realizes, also, that in some cases barking may not be profitable for other reasons. The local conditions in regard to labor are often far from satisfactory. And it may be quite impossible to assemble enough laborers to bark all the trees felled by a heavy storm in time to save them from injury by the sawyer. It is also true that in cyclone-felled timber the trunks are often so piled up and entangled that it would be necessary to saw them into logs and separate them before they could be barked. However, taking all these points into consideration, the writer feels that in the majority of instances a great saving can be accomplished if the matter is promptly taken in hand, and as many trunks as possible barked before or shortly after the larvæ enter the wood. In each case the holder of storm-felled timber must decide for himself. If the cost of barking the felled trunks is low enough to give a fair profit on the material saved from injury, it is a simple proposition of business economy. In any case the matter should be given careful consideration before all effort to prevent loss from the ravages of the sawyer is abandoned.

SUMMARY OF REMEDIES.

If possible saw all storm-felled trunks into logs and place the logs in water before the larvæ enter the wood, or within forty days after the eggs are laid. If it is impossible to place the logs in water, they should be barked within forty days after the first egg pits are observed in the bark.

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SOME INSECTS INJURIOUS TO FORESTS.

INSECT DEPREDATIONS IN NORTH AMERICAN FORESTS AND PRACTICAL METHODS OF PREVENTION AND CONTROL.

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In Charge of Forest Insect Investigations.

INTRODUCTION.

It is the purpose of this part of the bulletin to give a summary of facts, conclusions, and estimates relating to the forest-insect problem as applied to North American conditions and to call attention to its importance in the future management of private, state, and national forests.

The matter is presented in as brief and concise a form as possible, in order that the information may be readily available to the general reader, as well as to the forester and student, and references are made to publications in which more detailed accounts may be found.

The statements and conclusions relating to the insects and their work and to methods for their control are based almost entirely on investigations and observations by the writer and by assistants in the Bureau of Entomology working under his direction, carried on in all of the principal forest areas of the United States. The historical data have been gathered from the publications listed on pages 96–97. The estimates of the amount and value of standing timber killed by insects and of the forest products destroyed and reduced in value through insect injuries to the crude and seasoned products are based on our published results of investigations (pp. 97–100), on unpublished notes, on technical and practical knowledge of the subject, and on the published forest statistics relating to the amount and value of timber, fire losses, etc. (pp. 100–101).

INSECT DEPREDATIONS IN NORTH AMERICAN FORESTS.

CHARACTER AND EXTENT OF DEPREDATIONS.

The records of notable depredations by insects on the timber supply of Europe during the past four hundred years, on that of the

United States during the past century, and especially those that have come under the observation of the writer and assistants engaged in forest insect investigations during the past eighteen years, furnish conclusive evidence that this class of enemies has been, and is now, an important factor in the destruction and waste of forest resources.

Insects Cause the Death of Trees.

It has been conclusively demonstrated that certain species of insects are the direct or primary cause of the death of forest trees of all ages, and that from time to time they multiply to such an alarming extent that their depredations assume the character of a destructive invasion, which results in the death of a large percentage of the best timber over thousands of square miles.

There are many species of barkbeetles which prefer to attack matured and healthy trees, and there are many examples of whole forests of century-old trees having perished from the girdling effect of the mines of the beetles, which are extended in all directions through the inner living bark on the main trunks of the trees. Indeed, we find among these bark-boring beetles the most destructive insect enemies of North American forests. Some notable examples of the depredations of these barkbeetles are given below.

The southern pine beetle.—In 1890–1892 a destructive invasion of the southern pine beetle (*Dendroctonus frontalis* Zimm.) extended from the western border of West Virginia through Maryland and Virginia into the District of Columbia, northward into southern Pennsylvania, and southward into North Carolina. In this area, aggregating over 75,000 square miles, a very large percentage of the mature and small trees of the various species of pine and spruce was killed by this beetle. In many places in West Virginia and Virginia nearly all the pine trees of all sizes on thousands of acres were killed, while shade and ornamental trees within the same area suffered the same as those in the forest. Since 1902 this barkbeetle has been more or less active in the Southern States from Virginia to Texas, and in some localities and during certain years it has killed a large amount of timber. Records of extensive destruction of timber in the Southern States are found dating back to the early part of the nineteenth century (Wilson, 1831). This species may be considered one of the most dangerous insect enemies of southeastern conifers and, therefore, a constant menace to the pine forests of the Southern States. (Hopkins, 1899*b*, 1903*b*, 1909*b*.)

The eastern spruce beetle.—During the period between 1818 and 1900 there were several outbreaks of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in the spruce forests of New York, New England, and southeastern Canada (Peck, 1876, 1878; Hough, 1882; Packard, 1890; Pinchot, 1899, p. 74; Hopkins, 1901*a*, 1909*b*).

This species caused the death of a very large percentage of the mature spruce over an area of thousands of square miles. In the aggregate many billions of feet of the best timber were destroyed. The larger areas of this dead timber furnished fuel for devastating forest fires, with the result that in most cases there was a total loss.

The Engelmann spruce beetle.—Another barkbeetle (*Dendroctonus engelmanni* Hopk.), similar in habits to *piceaperda*, has from time to time during the past fifty years caused widespread devastations in the Rocky Mountains region to forests of Engelmann spruce, in some sections killing from 75 to 90 per cent of the timber of merchantable size. (Hopkins, 1908*a*, p. 161; 1909*b*, pp. 126–132.)

The Black Hills beetle.—One of the most striking examples of the destructive powers of an insect enemy of forest trees is found in the Black Hills National Forest of South Dakota, where during the past ten years a large percentage of the merchantable timber of the entire forest has been killed by the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.). It is estimated that more than a billion feet of timber have been destroyed in this forest as the direct result of the work of this beetle. This destructive enemy of the western pine is distributed throughout the forests of the middle and southern Rocky Mountains region, where, within recent years, it has been found that in areas of greater or less extent from 10 to 80 per cent of the trees have been killed by it. (Hopkins, 1902*a*, 1903*b*, 1905*b*, 1908*a*, and 1909*b*, pp. 90–101.)

The mountain pine beetle and the western pine beetle.—The sugar pine, silver pine, western yellow pine, and lodgepole pine of the region north of Colorado and Utah, westward to the Cascades, and southward through the Sierra Nevadas are attacked by the mountain pine beetle (*Dendroctonus monticolæ* Hopk.) and the western pine beetle (*Dendroctonus brevicomis* Lec.), and, as a direct consequence, billions of feet of the timber have died. In one locality in northeastern Oregon it is estimated that 90 to 95 per cent of the timber in a dense stand of lodgepole pine covering an area of 100,000 acres has been killed within the past three years by the mountain pine beetle. Throughout the sugar-pine districts of Oregon and California, as the result of attacks by this same destructive barkbeetle, a considerable percentage of the largest and best trees is dead. (Webb, 1906; Hopkins, 1908*a*, 1909*b*, pp. 80–90.)

The Douglas fir beetle.—The Douglas fir throughout the region of the Rocky Mountains from southern New Mexico to British Columbia has suffered severely from the ravages of the Douglas fir beetle (*Dendroctonus pseudotsugæ* Hopk.), with the result that a large percentage of dead timber is found, much of which will be a total loss. (Hopkins, 1909*b*, pp. 106–114.)

Three other species of beetles, having destructive habits similar to those above mentioned, depredate on the pines of New Mexico and Arizona, and still another has contributed greatly to the destruction of the larch throughout the northeastern United States and southeastern Canada. (Hopkins, 1909*b*, pp. 49, 53, and 77.)

The hickory barkbeetle.—Within the past ten years the hickory barkbeetle (*Scolytus quadrispinosus* Say) has caused the destruction of an enormous amount of hickory timber throughout the northern tier of States from Wisconsin to Vermont and southward through the eastern Atlantic States and into the Southern States as far as central Georgia. (Hopkins, 1904*b*, pp. 314–317.)

The larch worm.—There are also many examples of widespread depredations chargeable to insects which defoliate the trees, thus contributing to their death. Notable among these are the depredations by the larch worm (*Nematus erichsonii* Hartig), which, during several extensive outbreaks since 1880, has killed from 50 to 100 per cent of the mature larch over vast areas in the northeastern United States and southeastern Canada. It is evident that the amount of merchantable-sized timber that has died as the result of defoliation by this insect will aggregate many billions of feet. (Packard, 1890, pp. 879–890; Pinchot, 1899; Hopkins, 1908*a*.)

Insect Injuries to the Wood of Living Trees.

It has been determined that insects of a certain class attack the wood and bark of living timber and that, while they do not contribute materially to the death of the trees or give much external evidence of their presence, they produce wounds in the bark and wormhole and pinhole defects in the wood which result in a depreciation in commercial value amounting to from 5 to 50 per cent. These defects in the wood are not detected until after the trees have been felled and the logs transported to the mill and converted into lumber. Thus to the actual damage to the lumber is added the expense of logging and manufacture of the defective, low-grade material, much of which must be discarded as worthless culls. (Hopkins, 1894*a*, 1894*b*, 1904*b*, 1905*a*, 1906*b*.)

The oak timber worm.—One of the most destructive of the class of depredators just mentioned is the oak timber worm (*Eupsalis minuta* Dru.). It enters the wood of the trunks of living trees through wounds in the bark and at the base of broken or dead branches and extends its "pinhole" burrows in all directions through the solid heartwood. The losses occasioned by this insect in the hardwood forests of the eastern United States are enormous and usually affect the wood of the finest examples of old trees. (Hopkins, 1894*a*, 1904*b*.)

The chestnut timber worm.—The chestnut throughout its range is damaged in a like manner by the chestnut timber worm (*Lymexylon sericeum* Harr.). Practically every tree of merchantable size is more or less affected, and a large percentage is so seriously damaged that the product is reduced to that of the lowest grade. It is estimated that the reduction in value of the average lumber product at any given time is not far from 30 per cent, thus involving extensive waste and an increased drain on the forest to supply the requirements for clear lumber. This insect also attacks the oaks, and especially the red oak, the older trees of which are often as seriously damaged as are the chestnut. (Hopkins, 1894*a*, 1904*b*.)

Carpenter worms.—The oaks, especially the white oak and the red oak, are seriously damaged by carpenter worms of the genus Prionoxystus. The holes made by these insects through the heartwood of the best part of the trunks are sometimes 1.5 inches in diameter one way by 0.75 inch the other, thus causing serious damage to the wood. These, with other large wood-boring beetle larvæ, sometimes infest the top part of the trunk and the larger branches of oak trees, where their continued work results first in the dead and so-called "staghorn" top and subsequently in broken, decayed, and worthless trunks. (Hopkins, 1894*a*, 1904*b*.)

Ambrosia beetles.—One of the commonest defects in white oak, rock oak, beech, whitewood or yellow poplar, elm, etc., is that known to the lumber trade as "grease spots," "patch worm," and "black holes." This defect is caused by one of the timber beetles or ambrosia beetles, *Corthylus columbianus* Hopk., which makes successive attacks in the living healthy sapwood from the time the trees are 20 or 30 years old until they reach the maximum age. Thus the black-hole and stained-wood defect is scattered all through the wood of the best part of the trunks of the trees. The average reduction in value of otherwise best-grade lumber amounts, in many localities, to from 25 to 75 per cent. The defect is commonly found in oak and elm furniture and in interior hardwood finish in dwellings and other buildings. (Hopkins, 1893*g*, 1894*b*, 1904*b*.)

The locust borer.—The locust, as is well known, suffers to such an extent from the ravages of the locust borer (*Cyllene robiniæ* Forst.) that in many localities the trees are rendered worthless for commercial purposes or they are reduced in value below the point of profitable growth as a forest tree, otherwise this would be one of the most profitable trees in the natural forest or artificial plantation and would contribute greatly to an increased timber supply. (Hopkins, 1906*b*, 1907*a*, 1907*c*.)

Turpentine beetles and turpentine borers.—While the softwood trees, or conifers, suffer far less than the hardwoods from the class of enemies which cause defects in the living timber there are a few notable examples of serious damage. There is a common trouble affecting the various species of pine throughout the country known as basal wounds or basal fire wounds. It has been found that a large percentage of this injury to the pine in the States north and west of the Gulf States and in the Middle and South Atlantic States is caused by the red turpentine beetle (*Dendroctonus valens* Lec.) and in the Southern States by the black turpentine beetle (*Dendroctonus terebrans* Oliv.). These beetles attack the healthy living bark at and toward the base of the trunks of medium to large trees and kill areas varying in size from 1 to 10 square feet. These dead areas are subsequently burned off by surface fires and are then generally referred to as fire-wounds. The further damage to the exposed wood by successive fires, decay, and insects often results in a total loss of the best portion of the tree, or a reduction in value of the lower section of the trunk of from 10 to 50 per cent. (Hopkins, 1904*a*, 1909*b*.) These and similar wounds in the bark of trees, including those caused by lightning and by the uncovering and exposure of the wood in turpentining, offer favorable conditions for the attack of the turpentine borer (*Buprestis apricans* Hbst.), the work of which, together with that of two or three others with similar habits, is very extensive, and causes losses amounting to from 10 to 50 per cent of the value of the wood of the best part of the trees thus affected. (Hopkins 1904*a*.)

The white pine weevil.—The abnormal development of white pine trees as the result of succesive attacks on the terminals of the saplings and young trees by the white pine weevil (*Pissodes strobi* Peck) is an element of loss of considerable importance, especially in mixed stands and in open pure stands of this timber. The value of such trees is reduced from 20 to 50 per cent below those of normal development, and there is an additional loss from the effect of their spreading branches or crowns in the suppression or crowding out of trees which would otherwise occupy the space thus usurped. (Hopkins, 1906*c*, 1907*d*.)

There are many other examples of insects which damage the wood and bark of living trees, but those mentioned should be sufficient to demonstrate the importance of insects in this relation.

Insect Injuries to the Wood of Dying and Dead Trees.

Timber dying from insect attack and other causes, including fire, disease, storms, etc., is attacked by certain wood-boring insects which extend their burrows through the sound sapwood and heartwood, and thus contribute to the rapid deterioration and decay of a commodity which otherwise would be available commercially during periods of from one to twenty years or more after the death of the trees, depending on the species of trees and on the character of the product desired. This loss often amounts to from 25 to 100 per cent during the period in which the dead timber would otherwise be almost as valuable as if living. (Hopkins, 1894*a*, 1901*d*, 1904*a*, 1905*a*; Webb, 1909.)

CONIFEROUS TREES.

Sawyers.—One of the most striking examples of the destruction or deterioration of the wood of dying and dead timber, familiar to all lumbermen, is the injury to fire-killed and storm-felled pine, fir, spruce, etc., caused by boring larvæ known as "sawyers." These borers hatch from eggs deposited by the adult beetles in the bark of the dying trees, and after feeding on the inner bark for a time they enter the solid wood and extend their large burrows deep into the heartwood. Fire-killed white pine is especially liable to this injury, and is often so seriously damaged within three or four months during the warm season as to reduce the value of the timber 30 to 50 per cent. The shortleaf, loblolly, and longleaf pines of the Southern States are damaged to a somewhat less extent, but instances are known in which more than one billion feet of storm-felled timber within limited areas were reduced in value 25 to 35 per cent within three months after the storm. (Webb, 1909.) The fire-killed and insect-killed sugar pine, silver pine, and yellow pine of the western forests are also damaged in a similar manner and the value of the product greatly reduced within a few months after the trees die. The aggregate losses from this secondary source in the coniferous forests of the entire country contribute largely to the annual waste of millions of dollars' worth of forest products which otherwise might be utilized. (Hopkins, 1905*a*, p. 385; Webb, 1909.)

Ambrosia beetles.—Wood-boring insects of another class, known as timber beetles or ambrosia beetles, cause pinhole defects, principally in the sapwood, although some of them extend their burrows into the heartwood. These insects make their attack in the early stage of the declining or dying of the tree, or before the sapwood has materially changed from the normal healthy condition, and often in such numbers as to perforate every square inch of wood. Thus the wood is not only rendered defective on account of the presence of pinholes, but the holes give entrance to a wood-staining fungus which causes a rapid discoloration and produces still further deterioration of the product.

The sapwood of trees dying from the attack of other insects or from fire, storm, or other causes is often reduced in value 50 per cent or more, and in some cases the value of the heartwood is reduced in a like manner from 5 to 10 per cent. (Hopkins, 1894*a*, 1895*c*, 1898*b*, 1904*a*, 1905*a*.)

Pinhole borers in cypress.—An example of the destructive work of insects which attack dying and dead trees is found in the cypress in the Gulf States, where these trees are deadened by the lumbermen and left standing several months, or until the timber is sufficiently dry to be floated. Upon investigation it was found that trees deadened at certain seasons of the year were attacked by the ambrosia beetles or pinhole borers, and that in some cases millions of feet of timber had been reduced 10 to 25 per cent or more in value. (Hopkins, 1907*b*.)

HARDWOOD TREES.

Roundheaded borers, timber worms, and ambrosia beetles.—The principal damage to dying and dead hardwood trees is caused by certain roundheaded wood-borers (Cerambycidæ) with habits similar to the sawyer, by the timber worms mentioned as damaging living timber, and by ambrosia beetles having habits similar to those that attack the sapwood and heartwood of conifers. All of the hardwoods suffer more or less, but the greatest damage is done to the wood of hickory, ash, oak, and chestnut, which are often reduced in value 10 to 25 per cent or more within the period in which it would otherwise remain sound and available for commercial purposes. (Hopkins, 1894*a*, 1904*a*, 1905*a*.)

INSECT INJURIES TO FOREST PRODUCTS.

Damage is caused by various species of insects which are attracted by the varying conditions prevailing at different stages during the process of utilizing the forest resources, from the time the trees are felled until the logs are converted into the crude and finished product and until the latter reaches the final consumer, or even after it is placed in the finished article or structure. As a result, additional drains are made on the timber to meet the demand for the higher grades of lumber and for other supplies to replace those injured or destroyed. From the writer's personal investigations of this subject in different sections of the country it is evident that the damage to forest products of various kinds from this cause is far more extensive than is generally recognized. This loss differs from that resulting from insect damage to standing timber in that it represents more directly a loss of money invested in material and labor. (Hopkins, 1894*a*, 1903*c*, 1904*a*, 1905*a*.)

CRUDE PRODUCTS.

Roundheaded borers, timber worms, and ambrosia beetles.—Round timber with the bark on, such as poles, posts, mine props, sawlogs, etc., is subject to serious damage by the same class of insects as those mentioned under injury to the wood of dying and dead trees. The damage is especially severe when material is handled in such a manner as to offer favorable conditions for attack (Hopkins, 1905*a*), as when the logs are left in the woods on skidways or in mill yards for a month or more after they have been cut from the living trees. Under such conditions there is often a reduction in value of from 5 to 30 per cent or more, due to wormhole and pinhole defects caused by roundheaded and flatheaded wood-borers and timber beetles. Frequently the insects continue the work in the unseasoned and even dry lumber cut from logs which had been previously infested. They also continue to work in mine props after they have been placed in the mine, and in logs and other material used for the construction of cabins, rustic houses, etc., and in round timbers generally.

The products from saplings, such as hickory hoop poles and like material, are often seriously injured or rendered worthless by roundheaded and flatheaded borers and wood boring beetles, sometimes resulting in a loss of from 50 to 100 per cent of the merchantable product. (Hopkins, 1905*a*.)

Stave and shingle bolts left in moist, shady places in the woods or in close piles during the summer months are often attacked by ambrosia beetles and timber beetles. The value of the product is often reduced, as a consequence, from 10 to 50 per cent or more. (Hopkins, 1894*a*, 1905*a*.)

Handle and wagon stock in the rough is especially liable to injury by ambrosia beetles and roundheaded borers. Hickory and ash bolts from which the bark is not removed are almost certain to be greatly damaged if the logs and bolts cut from living trees during the winter and spring are held over for a few weeks after the middle of March or first of April. (Hopkins, 1905*a*.)

Pulpwood, and cordwood for fuel and other purposes, cut during the winter and spring and left in the woods for a few weeks or months or in close piles after the beginning of the warm weather, are sometimes riddled with wormholes or converted into sawdust borings, causing a loss of from 10 to 100 per cent. One example reported from near Munising, Mich., represents a loss of $5,000 from injury to spruce and fir pulpwood cut in the winter and kept in piles over summer.

MANUFACTURED UNSEASONED PRODUCTS.

Ambrosia beetles and other wood borers.—Freshly sawed hardwood placed in close piles during warm, damp weather during the period from June to September is often seriously injured by ambrosia beetles. Heavy 2-inch to 3-inch stuff is also liable to attack by the same insects, even in loose piles. An example of this was found in some thousands of feet of mahogany lumber of the highest grade, which had been sawed from imported round logs and piled with lumber sticks between the tiers of plank. Native species of ambrosia beetles, principally *Pterocyclon mali* Fitch, had entered the wood to such an extent as to have reduced the value 50 per cent or more within a few weeks. Oak, poplar, gum, and similar woods often suffer severely from this class of injury, causing losses varying from 5 to 50 per cent. (Hopkins, 1905*a*.)

Lumber and square timbers of both soft and hard woods with the bark left on the edges are frequently damaged by flatheaded and roundheaded wood borers, which hatch from eggs deposited in the bark before or after the lumber is sawed. There are examples of losses from this character of injury amounting to from 20 to 50 per cent or more.

Telegraph and telephone poles, posts, mine props, etc., are frequently injured before they are set in the ground, especially if the bark remains on them during a few weeks after the middle of March.

SEASONED PRODUCTS IN YARDS AND STOREHOUSES.

Powder-post beetles.—Hardwood lumber of all kinds, rough handles, wagon stock, etc., made partially or entirely of sapwood, are often reduced in value from 10 to 90 per cent by a class of insects known as powder-post beetles. The sapwood of hickory, ash, and oak is most liable to attack. The reported losses from this source during the past five or six years indicate that there has been an average reduction in values of from 5 to 10 per cent or more. (Hopkins, 1903*c*, 1905*a*.)

Old hemlock and oak tanbark is often so badly damaged by various insects which infest dead and dry bark that in some tanyards as much as 50 to 75 per cent of the bark that is over three years old is destroyed. In one tannery in West Virginia it is estimated that more than $30,000 worth of hemlock bark was thus destroyed. (Hopkins, 1905*a*.)

FINISHED PRODUCTS.

The greatest loss of finished hardwood products, such as handle, wagon, carriage, and machinery stock, is caused by powder-post beetles. This is especially true of hickory and ash handles and like products in the large and small storehouses of the country, including the vast amount of material held in storage for the army and navy. When material of this kind is once attacked it is usually worthless for the purposes indicated, and therefore must be replaced with new material. In some cases losses have amounted to from 10 to 50 per cent, and it is estimated that the average losses have been as much as 10 per cent on nearly all sapwood material that has been in storage more than one year. (Hopkins, 1903*c*, 1905*a*.)

UTILIZED PRODUCTS.

Powder-post beetles, white ants, and other wood-boring insects.—The finished woodwork in implements, machinery, wagons, furniture, and the inside finish in private and public buildings are often seriously damaged by powder-post beetles, thus requiring increased demands for new material. (Hopkins, 1903*c*, 1905*a*.)

Construction timbers and other woodwork in new and old buildings are often so seriously damaged by powder-post beetles, white ants, and other wood-boring insects that the affected material has to be removed and replaced by new, or the entire structure torn down and rebuilt. (Hopkins, 1905*a*.)

Construction timbers in bridges and like structures, railroad ties, telephone and telegraph poles, mine props, fence posts, etc., are sometimes seriously injured by wood-boring larvae, termites, black ants, carpenter bees, and powder-post beetles, and sometimes reduced in efficiency from 10 to 100 per cent.

INSECTS IN THEIR RELATION TO THE REDUCTION OF FUTURE SUPPLIES OF TIMBER.

Insects not only reduce future supplies by killing the mature trees and destroying the wood of timber that is inaccessible for utilization, but through injuries inflicted upon trees during the flowering, fruiting, germinating, seedling, and sapling periods of early growth they prevent normal reproduction and development. (Hopkins, 1904*a*, 1906*c*.)

INTERRELATIONS OF FOREST INSECTS AND FOREST FIRES.

Investigations conducted by the writer and assistants in all sections of the country during the past ten years indicate to them quite conclusively that the average percentage of loss of merchantable timber in the forests of the entire country to be charged to insects during a five or ten year period is infinitely greater than most people realize. (Hopkins, 1906*a*, pp. 4–5, 1908*b*, p. 345, 1909*b*, pp. 5, 24; Forbes, 1909, pp. 51–52.)

Losses from forest insects.—The writer estimates (p. 70) that for a ten-year period the average amount of timber in the forests of the entire country killed and reduced in value by insects would represent an average loss of $62,500,000 annually.[a]

It has been estimated (Hopkins, 1905*b*, p. 5; 1908*a*, p. 162) that the Black Hills beetle killed approximately 1,000,000,000 feet b. m. of timber during a period of ten years, which at $2.50 per thousand would amount to an average of $250,000 annually. This is merely one example of very destructive depredations by a single species of barkbeetle in a single national forest.[b] (See also p. 70.)

Prof. Lawrence Bruner, state entomologist of Nebraska, at a meeting of the American Association of Economic Entomologists, held at

[a] *Losses from forest fires.*—It has been estimated that "on the average, since 1870, forest fires have yearly cost $50,000,000 in timber." (Cleveland, T., jr., 1909, p. 3.)

[b] It has been estimated that the losses of timber from forest fires on all of the National Forests of the United States from 1905 to 1908, inclusive, average only $165,062 annually. (Cleveland, T., jr., 1908, p. 541.)

Baltimore, Md., in December, 1908, spoke as follows: "I can agree with Doctor Hopkins that the insects are far more important in destroying our forests than fires." (Bruner, 1909, p. 53.)

Insect-killed timber as fuel for fires.—It has often happened that after insects have killed the timber over extensive areas the standing and fallen dead trees furnished fuel for great forest fires which have not only destroyed or charred the dead timber but killed the living timber and reproduction and swept on into adjacent areas of healthy timber. Indeed, abundant evidence has been found during recent investigations to indicate that some of the vast denuded areas in the Rocky Mountains and other sections of the country are primarily due to widespread devastation by insects, and that subsequent fires destroyed the timber and prevented reproduction. (Hopkins, 1906*a*.)

It is also evident that a considerable percentage of dead timber, and especially that found in coniferous forest regions, which has generally been believed to have been fire-killed is a result of primary attack by insects. This has been demonstrated in many cases by the pitch-marked galleries of the destructive barkbeetles on the surface of the wood of the old dead trees which had escaped subsequent fires.

Fire-killed timber injured by insects.—It is true that a vast amount of timber has been killed outright or has died as the direct result of forest fires, but in almost every case observed insects have contributed to a greater or less extent to the death of recently fire-injured trees which might otherwise have recovered, and especially to the rapid deterioration of the wood of a large percentage of the injured and killed trees. It is evident that in some cases fire-scorched and fire-killed timber has contributed to the multiplication of one or more of the insect enemies destructive to living timber, and thus the injury started by the fire may have resulted in a destructive outbreak of beetles. However, it is evident that this has happened only when the destructive beetle was already present in abnormal numbers in the forest surrounding the fire-swept area. Therefore, *it is believed that injuries by fire are not as a rule an important factor in contributing to subsequent depredations by barkbeetles.* Such fires, however, contribute to the multiplication of the insects which depredate on the bark and wood of dying and dead trees, so that in forested areas where fires are frequent the damage to the wood of such trees is more severe, and fewer injured trees recover on account of the abundance of secondary barkbeetle enemies which do not, as a rule, attack and kill living timber.

Destruction of insects by fire.—There is another important feature in the relation of insects and fire, in which the fire contributes to the destruction of the principal barkbeetle enemies of the living timber. This happens when the fire burns the timber while it is infested, thus effectually destroying the broods of the insects. It is perfectly plain that the dying and dead foliage of the beetle-infested trees and the dead bark on the trunks would contribute to the spreading of crown fires and thus the bark on the entire infested trunks would be sufficiently scorched to kill the insects. Therefore, complete fire control may easily contribute to more extended depredations by insects on the living timber, thus increasing, rather than diminishing, the need for insect control. However, the setting of fires or permitting them to burn for the purpose of combating insects should never be undertaken or permitted.

Durability of insect-killed timber.—Some of the matured larch trees which evidently died as a result of defoliation by the larch worm between 1881 and 1885, and which had escaped subsequent depredations by fire and wood-boring insects, were found by the writer in 1908 to be standing and sound enough to be utilized for railroad ties and many other purposes. Under similar conditions the heartwood of red spruce and white pine in the East, of Engelmann spruce in the Rocky Mountains, and of Douglas fir in the Northwest coast region have been found by the writer to be sound enough for profitable utilization for pulp wood, lumber, fuel, and other purposes from twenty to thirty years after it had been killed by insects or fire. Thus it is shown that timber killed by insects and fire would be available for utilization for many years were it not for injuries through the secondary attacks of wood-boring insects and the destruction of insect-killed timber by forest fires.

INTERRELATION OF FOREST INSECTS AND FOREST FUNGI.

Decay following injury by insects.—It is well known that the burrows in the bark and wood of living and dead trees and in the crude and finished products often contribute to the entrance of bark and wood decaying fungi. Deterioration and decay are thus far more rapid than would otherwise be possible. It is also known that trees injured and dying from primary attack by parasitic fungi are attractive to certain insects which breed in the bark and wood of sickly and dying trees, and that certain other complicated troubles affecting forest trees are the result of an intimate interrelation and interdependence of insects and fungi. There can be no doubt, however, that certain species and groups of both insects and fungi are independently capable of attacking and killing perfectly vigorous and healthy trees.

SUMMARY AND ESTIMATES RELATING TO CHARACTER AND EXTENT OF INSECT DAMAGE.

The killing of trees by insects; the damage by them to the wood of living, dying, and dead timber; the destruction of insect-killed timber by subsequent forest fires; the damage to fire-killed timber by insects; and the damage from decay resulting from insect injuries to the wood, have all been more or less continuous for centuries and are still going on in the forest and woodland areas of this country.

While these depredations are not always evident or important in all forests or localities, yet almost every year, somewhere in the forests of the country, there are widespread depredations.

In every forest and woodland there is an ever present but inconspicuous army of insects which require the bark, wood, foliage, and seeds of the various tree species for their breeding places or food. Thus, the accumulated but inconspicuous injuries wrought during the period required for the growth of a tree to commercial size go far toward reducing the average annual increment below the point of profitable investments.

The accumulated damage to crude, finished, and utilized products reduces the profits of the manufacturer, increases the price of the higher grades to the consumer, and results in an increased drain on the natural resources.

In any attempt to estimate in *dollars* or *feet, board measure*, the extent of losses or waste of timber supplies caused by insects there are many conflicting factors which contribute to the difficulty of arriving at accurate conclusions. The published information concerning the amount in board feet of standing timber in the country is admittedly only an estimate, as are also the published data relating to average stumpage value. The published statistics relating to the amount and value of forest products are of course more accurate, but until more complete data can be furnished by the forest experts on the various complicated phases of forest statistics, any figures given by the forest entomologist relating to the value of timber and commercial products destroyed or reduced in value by insects must be considered on the same basis as the other estimates, and as the best that can be presented on available evidence.

Standing timber killed and damaged by insects.—When we consider the amount of standing merchantable timber killed by insects and the amount of standing timber, living, dying, and dead, which has been reduced in quantity and value through their agency during a ten-year period, we would estimate that such timber represents an equivalent of more than 10 per cent of the quantity and stumpage value of the total stand of merchantable timber in the United States at any given time.[a] A certain percentage of such timber is a total

[a] The estimate of the area and stand of the present forests of the United States, as given in Circular 166 of the Forest Service, page 6, is two trillion five hundred billion feet (2,500,000,000,000) board measure. The average stumpage value has been given as $2.50 per one thousand feet b. m., making a total value of the standing merchantable timber of $6,250,000,000. Ten per cent of this amount would be $625,000,000, as the amount to be charged to insects for a 10-year period, or an average of $62,500,000 annually. As an example, it has been estimated that over 1,000,000,000 feet b. m. of timber was killed by the Black Hills beetle in the Black Hills National Forest within a period of ten years. This, at $2.50 per one thousand feet stumpage, would be an average of $250,000 annually in a single forest of 1,294,440 acres.

loss because of the impossibility of utilization; but in some cases a greater or less percentage can be, and in some cases is, utilized within the period in which it is of sufficient value to yield a profitable return on the cost of logging and manufacture, although its value is greatly reduced.

Reduction in the Nation's wealth.—When we consider the forest resources both in merchantable timber and young growth as an important asset of the Nation's wealth; as representing a given value to the people for direct utilization; as a cover to the soil for protection of the land from erosion; as protection of headwater streams and of game; and as contributing to the æsthetic value of health and pleasure resorts, it would be difficult indeed to estimate the amount or percentage of loss of timber or the reduction in the land values, in each case, chargeable to insects. It is plain, however, that in the aggregate it is considerably greater than when estimated on stumpage values alone.

Reduction in cash revenue.—When we consider the problem from the standpoint of direct utilization we can estimate the annual loss on a basis of mill values; but here again we meet with complications, since much of the damaged material is left standing or is discarded in the woods or at the mill without measurement. Therefore we are left to judge from our observations and knowledge of the general conditions as regards dead and damaged timber found in the forests of the country, and the information from lumbermen in different sections, as to the percentage of loss from defective timber. On this basis we can estimate that the amount of insect-killed and damaged timber left in the woods, plus the reduction in value of that utilized, to be charged to insects is not far from an equivalent of 10 per cent of the value of the annual output of forest products of all kinds, in the rough. The total value of the forest products of the United States in 1907 is given as $1,280,000,000; the losses from insect depredations would therefore represent an annual loss in a cash value of more than $100,000,000. (Hopkins, 1895*c*, 1904*a*.)

Reduction in value of finished and commercial products.—When we consider the aggregate loss to the manufacturers of the finished products, to the trade, and to the consumer from insect injuries to the wood, it is evident that it amounts to many millions of dollars in addition to the estimated loss of crude products, or at least 3 per cent of the mill value.

METHODS OF PREVENTION AND CONTROL.

The results of extensive investigations and of practical applications of the knowledge gained during recent years have demonstrated that some of the most destructive insect enemies of American forests and of the manufactured and utilized products can be controlled, and serious damage prevented, with little or no ultimate cost over that involved in forest management and business methods. (Hopkins, 1904*b*, 1905*a*, 1908*a*, 1909*b*.)

There are, of course, certain insects and certain injuries which, under present conditions and available information, can not be controlled or prevented, but it is very evident that if the information now available through the publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future it would result in the prevention of at least 30 per cent of the estimated annual waste of forest resources that has been caused by insects within recent years, and thus contribute greatly to the conservation of forest resources.

GENERAL PRINCIPLES OF CONTROL.

The ordinary spraying and similar methods employed in dealing with fruit and shade tree insects are, of course, not available for practical application in the case of forest trees. But there are other and less expensive methods of accomplishing the desired results.

In all efforts to control an outbreak or prevent excessive loss from forest insects it should be remembered that as a rule it is useless to attempt the complete extermination of a given insect enemy of a forest tree or forest product. Experience has demonstrated that it is only necessary to reduce and weaken its forces 75 per cent or more. It can not then continue an aggressive attack, but must occupy a defensive position against its own enemies until conditions resulting from avoidable negligence and mismanagement by the owners of the forests and manufacturers of forest products favor its again becoming destructive. Forest insects can thus be easily kept under control by good management.

The desired control or prevention of loss can often be brought about by the adoption or adjustment of those requisite details in forest management and in lumbering and manufacturing operations, storing, transportation, and utilization of the products which at the least expenditure will cause the necessary reduction of the injurious insects and establish unfavorable conditions for their future multiplication or continuance of destructive work.

It is, however, of the utmost importance that any adjustment or modification in management or business methods should be based on expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved and the essential features of the methods for their control. This should be supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care, and utilization of the forest and its resources, and still further supplemented by practical knowledge and experience relating to local conditions and facilities favorable and unfavorable for success in practical applications according to the recommended method or policy of control.

As has been shown, the mature or merchantable timber is the most susceptible to injury or death from the ravages of insects. Therefore, considered from the standpoint of insect control and the prevention of one of the greatest items of loss, it is important that such matured timber should be utilized before it begins to deteriorate, or before it reaches the stage of unprofitable growth.

For the greatest success in dealing with forest insects, it must be recognized that there are certain features in the habits and seasonal history of each species which differ to a greater or less extent from those of all other species, even of the same genus; that there are certain features in the characteristics of the various species of trees which differ from those of all other species; and that as a rule it is the technical knowledge of these peculiar features or characteristics of the trees and their enemies which furnishes the clew to successful methods of control.

There are also many peculiar features in the prevailing conditions in different localities, some of them favorable, others unfavorable, for the practical application according to a given method, so that while certain general advice may apply in a broad sense and be available for utilization by the practical man, whether owner, manager, or forester, without further advice, it is often necessary to diagnose a given case before specific expert advice can be given as to the exact cause and the most effective method or policy to be adopted, just as a physician must diagnose a case of illness or injury before prescribing the required treatment for his patient.

Therefore, in a consideration of the problem as to how far the waste of forest resources caused by insects can be prevented and how far the damaged timber can be utilized, we will attempt to give only general statements based on the results of our observations relating to some of the principal kinds of loss discussed in the first part of this paper, namely, by insects which (1) kill the trees, (2) cause injuries to the wood of living timber, (3) reduce future supplies, and (4) cause injuries to the manufactured products. In addition, we will consider the utilization of natural enemies of injurious insects, the utilization of damaged timber, and the present conditions and opportunities for success in the general control of forest insects.

CONTROL OF BARKBEETLES WHICH KILL TREES.

The barkbeetles which kill trees attack the bark on the trunk and destroy the life of the tree by extending their burrows or galleries in all directions through the inner living bark. The broods of young grubs or larvæ develop within the inner bark, on which they feed.

Those of some species develop to the adult stage within the inner bark and are exposed when the bark is removed, while those of other species transform to the adults in the outer corky bark and the larvæ are not exposed when the bark is removed. Some species have two or more generations in a season or annually, while others have but one, and in a few species it requires two years for a single generation to develop. (Hopkins, 1909*b*.)

The barkbeetles of the genus Dendroctonus represent the most destructive enemies of the principal coniferous tree species of American forests, and at the same time are among the easiest of control. The general requisites for success are embodied in the following rules:

(*a*) Give prompt attention to the first evidence of a destructive outbreak, as indicated by an abnormal percentage of yellow or red topped dying trees, and especially when such trees occur in groups of ten or more or cover large areas; (*b*) secure authentic determination of the particular species of insect responsible for the trouble; and (*c*) take prompt action toward its control according to specific expert advice, published or otherwise, on the best method for the destruction of the necessary 75 per cent or more of the insects in the infested trees.

Some of the methods to be adopted to meet the requirements of various local conditions are as follows:

(1) Utilize the infested timber and burn the slabs during the period in which the broods of the destructive beetles are in the immature stages or before the developed broods emerge from the bark; or

(2) Fell the infested trees and remove the bark from the main trunk and burn the bark if necessary;[a] or

(3) Remove the infested bark from the standing timber and burn the bark when necessary;[a] or

(4) Immerse the unbarked logs in ponds, lakes, or streams, where the bark will remain soaked long enough to kill the insects; or

(5) Remove the unbarked logs or products to a locality where there are no trees liable to attack within a radius of 20 miles or more.

Maintaining Control of Barkbeetles.

Future trouble of a serious nature from barkbeetles which kill trees can be prevented within a given forest or area of greater or less extent if an insect-control policy is adopted in connection with, or independent of, a fire-control policy by which groups of dying trees will receive similar prompt attention as that required for the prevention or control of forest fires.

In state and national forests.—In all forest reserves in which there is an organized force of rangers and fire wardens or patrols each

[a] If the broods develop to adults in the outer bark, it must be burned; if they develop in the inner bark and are exposed when the bark is removed, burning is not necessary. As a rule the burning of the tops to destroy the insects is not necessary.

officer should be furnished with instructions for the location of beetle-infested trees, and with equipment and directions for taking the necessary action whenever the conditions demand or warrant it.

In private forests.—Private forests should receive the same attention as public forests, but this is often far more difficult on account of intervening forests, where the owners either can not or will not give the matter the required attention. While it may be advisable to have some laws to govern the treatment of timber infested with a dangerous pest, when the owner refuses to take any action such a law should apply only to the more extreme cases or as a last resort on authoritative advice. It is probable that in most cases legislation will not be necessary, and more ultimate good will result without than with strict laws, especially when it can be made clear to the owner that his personal interests demand that he take the proper action and that, when necessary, his neighbors will render assistance, as is done in the case of a forest fire.

Inaccessible areas.—There are yet large inaccessible areas in the East and West where it is not practicable or possible at present to control the depredations by these beetles and which must therefore be left to the same natural adjustment that has been going on in all forests from their beginning. While under such natural control much of the older matured timber will be lost it will usually be replaced by young growth, either of the same species of trees or of a different species, so that under normal conditions the forest will be perpetuated; but under exceptional conditions and combinations of detrimental influences, such as secondary insect enemies, fire, drought, etc., extensive areas may be completely denuded, never to be reforested under natural conditions. Therefore it will evidently not be very long before it will pay to adopt insect-control policies even in the areas that are inaccessible for profitable lumbering.

Examples of Successful Control of Barkbeetles.

We have a sufficient number of examples of successful control of depredations by the destructive barkbeetles to demonstrate the practicability of the advice based on the results of recent entomological investigations.

Control of the eastern spruce beetle.—The control of an alarming outbreak of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in northeastern Maine in 1900 and 1901 was effected by the concentration of regular logging operations into the areas of infested timber and placing the logs in lakes and streams and driving them to the mills on the Androscoggin River. Thus, with little or no additional expense, there was a saving to one firm, according to its estimates, of more than $100,000.

Control of the Black Hills beetle.—An extensive outbreak of the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.) in the vicinity of Colorado Springs, Colo., in 1905–6, which was threatening the living pine timber of the entire section, was brought under control through the efforts of the private owners of forests and those of forest officials in the adjoining National Forests. It was accomplished by cutting and barking about 1,000 beetle-infested and beetle-killed pine trees. The cost of the operations was largely, if not entirely, covered by the utilized felled timber, although there was considerable unnecessary expense involved through the felling and barking of trees from which the beetles had emerged and from the unnecessary burning of the bark and tops.

The successful control of another serious outbreak of the Black Hills beetle, in 1906, on an extensive private estate in southern Colorado, was effected through the efforts of the owners, who had some 500 infested trees felled and barked within the necessary period to destroy the broods. A large percentage, but not all, of the infested timber was thus treated. These operations were so successful that not a single infested and dying tree could be found when the area was inspected in 1908. In this, as in the other case, considerable unnecessary expense was involved in the burning of the bark and tops, but the value of utilizable timber was evidently more than enough to pay all expenses. It is evident that in this case a destructive invasion was prevented.

The most striking example of success relates to a large estate near Idaho Springs, Colo., and in the adjoining Pike National Forest. In May, 1907, it was found that some 63,000 feet of standing timber on the estate was infested by the Black Hills beetle, and the owner was advised by the Bureau of Entomology that unless the ravages were checked at once the beetle would kill the timber not only on this estate but that on the adjoining estates and National Forest, and that therefore radical action should be taken according to the recommendations and detailed instructions given relating to a necessary control policy. No action was taken, however, before the first of the following July, and therefore not in time to prevent the broods of beetles from swarming from the infested trees and extending their ravages. In December, 1907, another examination of the timber was made, and it was found that instead of 65,000 feet of timber in the old infestation there was nearly four times as much timber involved in the new, or over 250,000 feet. The owner was again notified of the serious character of the outbreak, and further suggestion made that if the logs from the infested trees were converted into lumber and the slabs burned before May, 1908, it would result in the protection of the remaining living timber. Immediate steps were then taken by the owners to carry out the original recommendations. An expert in locating infested timber, working under instructions from this Bureau, gave instructions to the manager of the estate in locating and marking the infested trees and in the essential features in the methods of utilization to destroy the necessary number of beetles; he also marked infested timber on an adjoining estate and on the National Forest. Five months later, in May, 1908, this expert reported that the larger clumps of infested trees on the estate had been converted into lumber and the slabs burned, and that the marked trees on the adjoining estate and National Forest had been cut and barked. In November, 1908, another inspection of the forest on the estate and surrounding area was made by the expert, and on December 1 he reported as follows:

Nothing could be more satisfactory than the results obtained by the cutting of the infested timber on the estate. Your recommendations and instructions submitted to the owner, and carefully followed by the manager of the estate, have clearly demonstrated that insect infestation can be controlled, and at no expense to the owner of the timber involved; in fact a very satisfactory price was realized, resulting in a net profit, I understand, of over $5 per thousand feet, board measure, on the 240,000 feet cut. This, of course, does not include the profit of the milling operations, but for the logs sold at the mill, after deducting the expenses of cutting and logging. The sawmill was owned and operated by an Idaho Springs firm, and the manufactured article sold in that town. I spent six days on the estate, November 18 to 23. After a very thorough examination of the timber, I found only three infested trees, isolated individuals, and over a mile from where the large clumps of infested trees were cut. With the exception of those three trees, there is no new infestation on the estate. I also examined the adjoining lands, but no new infestation was observed. The infested trees which I marked in December, 1907, had been cut and barked. On the Pike National Forest, contiguous to the first mentioned estate, where you will remember I marked some clumps of infested trees, no new infestation was found, not one tree.

This most gratifying result demonstrated two important things: One, that an extensive outbreak by the most destructive barkbeetle enemy of the pine timber of the central Rocky Mountain forests, involving in this case more than 1,000 infested trees, can be controlled without expense, and even at a profit, whenever the conditions are favorable for the utilization of the infested timber; the other, that the essential details of the recommendations and expert advice, based on the results of scientific research, can be successfully applied by a manager of a private forest or by the rangers of national and state forests. It also indicates quite conclusively that the widespread depredations in the Black Hills National Forest could have been prevented with very little expense to the Government if the matter had received prompt attention in 1901, when the first investigations were made and essentially the same recommendations submitted. But, through the lack of public appreciation of the importance of the problem at the time, and the lack of sufficient authority and funds later, the outbreak was allowed to extend beyond practical control, and in consequence a large percentage of the timber of the entire National Forest has been killed. There were, then, no forcible examples of the practical value of such recommendations based on scientific research, and no other argument was effective in arousing public interest in the threatening character of the outbreak or confidence in scientific advice or methods of control. Now we have several examples demonstrating the practicability of forest-insect control in America which should lead to confidence in the results of scientific research as a basis for success in practical application.

Control of the hickory barkbeetle.—The complete control of the hickory barkbeetle (*Scolytus quadrispinosus* Say), which threatened the total destruction of the hickory trees on Belle Isle Park, at Detroit, Mich., in 1903, was effected by felling and removing the infested trees and converting them into merchantable products, all without cost to the park commission. (Hopkins, 1904*b*.)

CONTROL OF INSECTS WHICH CAUSE DEFECTS IN LIVING TIMBER.

The class of insects which causes defects in the wood of living timber can be controlled to a greater or less extent, depending upon local conditions, and a large percentage of the losses prevented through the adoption of certain requisite details in forest management. Of these the following are especially important:

(1) The utilization of all of the defective and infested timber that will pay expenses for manufacture into merchantable products, such as lumber, cordwood, etc.

(2) The burning of infested timber and waste material not available for use, including dead standing and fallen timber, to remove the breeding places of insects like the oak timber worm and the chestnut timber worm, which go from the dead to the living timber.

(3) The prevention of wounds of any kind in the bark of living trees.

(4) The prevention of future losses by the practice of improved forestry methods which will eliminate favorable conditions for injury and contribute to a perpetual supply of vigorous, healthy timber to be utilized before it passes the stage of profitable increment.

PREVENTION OF INJURY TO DYING AND DEAD TREES.

A large percentage of the injury to the wood of insect, fire, and lightning killed trees and those killed or dying from injuries by storms, disease, etc., can be prevented as follows:

(1) By the prompt utilization of such timber within a few weeks or months after it is dead or found to be past recovery.

(2) By removing the bark from the merchantable portions of the trunks within a few weeks after the trees are dead (the work to be done either before or after the trees are felled).

(3) By felling the trees and placing the unbarked logs in water.

(4) By the adoption of a system of forest management which will provide for the prompt utilization of all trees which die from any cause.

PREVENTION OF LOSS FROM INSECT INJURIES TO NATURAL AND ARTIFICIAL REPRODUCTION.

The successful control of the insects which destroy or prevent the normal development of natural reproduction is a far more difficult problem than that presented by other classes of insect injuries, but in this as in the others a great deal can be accomplished toward preventing the reduction of future supplies.

Much can be accomplished in nurseries and small plantations by the adoption of the ordinary methods of controlling farm and orchard insects, but in the natural forests reliance must be placed largely on systems of forest management which will bring about unfavorable conditions for the work of the more important enemies. (Hopkins, 1906*c*.)

Utilization of Immune and Resistant Varieties and Races of Trees.

Certain individuals representing varietal or racial forms of trees of a given species are sometimes found to be either immune or decidedly more resistant to the insects which are destructive or seriously injurious to the life or wood of other individuals or varieties of the same species. This fact suggests the importance of recognizing the well-known principle of improvement by selection. Thus, selecting seed or cuttings from such immune and resistant trees for artificial propagation, or taking great pains to leave such trees in commercial or selection cuttings for natural reproduction, will undoubtedly be an important step toward providing against damage and loss in the future. (Hopkins, 1906*b*, 1907*a*, 1907*c*, 1907*d*.)

PREVENTION OF INSECT INJURIES TO FOREST PRODUCTS.

The problem of artificial control and prevention of insect injuries to forest products offers less difficulties perhaps than that relating to many other branches of the general subject of forest-insect control. In most cases the principle of prevention is the only one to be considered, since the damage is done soon after the insects enter the wood, and therefore it can not be repaired by destroying the enemy.

Crude Products.

The proper degree of moisture found in the bark and wood of newly felled trees, saw logs, telegraph poles, posts, and like material, cut in the fall and winter and left on the ground or in close piles during a few weeks or months in the spring and summer, or during the period when the particular species of injurious insects are flying, are some of the conditions most favorable to attack. The period of danger varies with the kind of timber and the time of the year it is felled. Those felled in late fall and winter will generally remain attractive to ambrosia beetles and adults of round and flat headed borers during March, April, and May. Those felled during the period between April and September may be attacked in a few days after they are felled, but the period of danger from a given species of insect may not extend over more than a few weeks. Thus certain kinds of trees felled during certain seasons are never attacked, while if they are felled at other times and seasons the conditions for attack may be most favorable when the insects are active, and then the wood will be thickly infested and ruined. The presence of bark is absolutely necessary for successful infestation by most of the wood-boring grubs, because the eggs and young stages must occupy the inner and outer portions before the latter can enter the wood. Some ambrosia beetles and timber worms will, however, attack barked logs, especially those in close piles or otherwise shaded or protected from rapid drying. A large percentage of the injury to this class of products can be prevented, as follows:

(1) Provide for as little delay as possible between the felling of the tree and its manufacture into rough products. This is especially necessary with trees felled from April to September in the region north of the Gulf States and from March to November in the latter, while the late fall and winter cuttings should all be worked up by March or April.

(2) Do not leave the round timbers in the woods or on the skidways during the danger period, or, if this is unavoidable, take every precaution to facilitate the rapid drying of the inner bark by keeping the logs off the ground, in the sun, or in loose piles, or else, if possible, the opposite extreme should be adopted and the logs kept in water.

(3) Remove the bark within a few days after the trees are felled, from poles, posts, and other material which will not be injured by checking or season cracks.

(4) Take advantage of the proper months or seasons in which to fell or girdle different kinds of trees to avoid danger.

Damage to products cut from saplings and left with the bark on can be prevented by transporting the material from the woods soon after it is cut, so that it will not be left in piles or bundles in or near the forest during the season of insect activity. Damage may also be prevented by care not to leave the material stored in one place for several months.

Pinhole damage to stave and shingle bolts cut during a warm season can be prevented by removing the bark from the timber as soon as it is felled and by converting the bolts into the smallest practicable dimensions and piling them in such a manner as to facilitate rapid drying.

Damage to unseasoned handle and wagon stock in the rough can be prevented by taking special precautions to provide against the same favorable conditions for attack as mentioned in connection with round timbers. This is especially necessary with hickory and ash if cut during the winter and spring.

Damage to pulpwood and cordwood can be prevented to a great extent by placing the sticks of wood in triangular or crib piles immediately after they are cut from the trees, especially if the timber is cut during the danger period or must be held for a few months during the warm season. Peeling or splitting the wood, or both, before it is piled will also provide against damage from insects.

Manufactured Products.

UNSEASONED PRODUCTS.

Freshly sawed hardwood lumber placed in close piles during warm, damp weather in the period from July to September, inclusive, presents the most favorable conditions for injury by ambrosia beetles. In all cases it is the moist condition and retarded drying of the lumber which induces attack. Therefore any method which will provide for the rapid drying of the lumber before or after piling will tend to prevent loss. It is important, also, that heavy lumber should, as far as possible, be cut only in the winter and piled so that it will be well dried out before the middle of March.

The damage to lumber and square timber when the bark is left on the edges or sides can be prevented by removing the bark before or immediately after the lumber is sawed, or by sawing and piling the material during the winter, or if sawed at other times it should be piled so that rapid drying will be facilitated.

SEASONED PRODUCTS.

Unfinished seasoned products.—Injury by powder-post beetles to dry hardwood lumber and other material in stacks or storehouses can be prevented as follows:

(1) Have a general inspection of the material in the yards and storehouses at least once a year, preferably during November or February, for the purpose of (*a*) sorting out and destroying or otherwise disposing of any material that shows the slightest evidence of injury, as indicated by the presence of fine powdery boring dust, and (*b*) sorting out and destroying all old and useless sapwood material of any kind that will offer favorable breeding places for the insects.

(2) Prevent the introduction into the lumber yards or storehouses of any infested material, remembering that the insect may be thus distributed to or from all parts of the world.

(3) Adopt a system of classification of all dry or seasoned hardwood stock which will provide for (*a*) the separation of the pure heartwood material from the pure and part sapwood material; (*b*) classification of all kinds of wood most liable to attack, such as hickory, ash, oak; (*c*) the successive utilization or sale of the older material (remembering that material one year old or over is far more liable to injury); (*d*) providing against the accumulation of refuse material in which the insects could breed; and (*e*) treating the best material with linseed oil or kerosene to prevent attack.

Finished seasoned products.—Damage to finished handles, oars, spokes, rims, hubs, wheels, and other unpainted wagon, carriage, machinery, and implement stock in factories, wholesale and retail storehouses, and army and navy stores can be prevented by the adoption of the same general rules as those given under rough products. In addition, damage can be controlled and prevented in the following manner:

Sort out and (*a*) destroy all articles showing the slightest evidence of powder-post injury, or (*b*) treat with kerosene oil such infested and slightly injured articles as may be tested for required strength and found to be of sufficient value for retention, placing the same in quarantine for a sufficient time to determine whether the treatment is successful.

Damage by powder-post insects to many kinds of articles can be prevented and at the same time the material otherwise benefited by treating the sapwood with linseed oil or kerosene, either by immersing it in the oil or by applying the oil with a brush, the application to be made as soon as possible after the articles are finished from recently seasoned, uninjured stock.

Past and Present Conditions of Powder-Post Injury.

Up to 1906 there were a great many reports of extensive losses of valuable material from the ravages of powder-post beetles which were seriously affecting all industries involved in the manufacture, sale, and utilization of the classes of hardwood products affected by them. In response to these reports and accompanying appeals to the Department of Agriculture for information on causes and remedies, the problem was thoroughly investigated and specific advice and instructions relating to practical methods of control and prevention have been widely disseminated, both through publications of the Department and special correspondence.

Reports of present conditions from our principal correspondents, together with the less frequent requests for advice, indicate that the disseminated information has been extensively utilized and that it has been worth many millions of dollars toward eliminating the losses and reducing the drain on the limited supply of the kinds of timber required to replenish the damaged and destroyed material.

The army and navy stores of handles, tent poles, wheelbarrows, oars, and many other hardwood articles have suffered severely from powder-post damage, involving an enormous loss, but the carrying out of the information already supplied has evidently contributed greatly toward the elimination of this source of loss to the Government.

Tan Bark.

Damage to hemlock and oak tan bark by the class of insects which in some cases has been so destructive to these products in the past can be easily prevented without cost, as follows:

(1) Utilize the bark within three years from the time it is taken from the trees.

(2) Prevent the accumulation in the yards and store-sheds of old bark and waste material in which the insects can breed.

These simple methods have been extensively adopted since their recommendation in correspondence and publications between about 1894 and 1904, and afford one of the most striking examples of the value of expert information on the peculiar habits of insects and of how millions of dollars can be saved without cost through a simple adjustment in methods of utilization.

Utilized Products.

Damage and loss from insect injuries to timber and other woodwork in structures of various kinds, to telephone and telegraph poles, posts, railroad ties, mine props, etc., can be prevented to a large extent through the adoption of the proper methods of management or of treating the material with preservatives before and after it is utilized.

TIMBERS AND WOODWORK IN STRUCTURES.

Injuries to timbers and woodwork in dwellings, outbuildings, bridges, etc., by powder-post insects can be prevented as follows:

(1) Use nothing but heartwood for the concealed parts most liable to damage.

(2) If it is necessary to use all or part sapwood material, attack can be prevented by treating the sap portions with kerosene, coal tar, creosote, or linseed oil. Facilities for future treatment can be provided wherever the rough or finished woodwork is exposed, as in outbuildings, bridges, etc., if care is taken to expose the sapwood portions.

(3) If the untreated timbers and woodwork in old buildings show evidence of attack, the affected portions should be given a liberal application of kerosene.

Damage by white ants, or termites, can often be prevented in the following ways:

(1) By the use of nothing but sound wood for underpinning and foundation timbers and the removal of decaying timbers from old structures.

(2) By preventing moist conditions of the wood in any part of the structure and especially that in foundation timbers.

(3) By the treatment of timbers necessarily exposed to moist conditions with creosote, zinc chlorid, corrosive sublimate, etc.

(4) If the timbers become infested, further progress of insect damage can be prevented by removing the badly damaged parts and soaking the remainder with kerosene, fumigating with bisulphid of carbon, and by removing any adjacent decaying or other wood in which the insects have been breeding or may breed, such as logs, stumps, etc.

Log cabins and rustic work.—Damage by bark and wood boring insects to the unbarked logs and poles used in rustic cabins, summer houses, fences, etc., can be largely prevented by cutting the material in October and November and utilizing it at once, or by piling it off the ground or under cover in such a manner as to offer the best facilities for the rapid and thorough drying of the inner bark before the middle of March or the 1st of April following. If these necessary precautions are not taken, and there is evidence that insects are at work in the bark and wood, the damage can be checked by injecting bisulphid of carbon through natural or artificial openings in the affected bark, and immediately stopping these and other openings with putty or a similar substance.

Poles, posts, piles, ties, mine props, and similar products.—Insect damage to poles, posts, and similar products can be prevented to a greater or less extent by the preservative treatments which have been tested and recommended by the Forest Service for the prevention of decay. These should be applied before the material is utilized for the purposes intended, or, if it be attacked after it has been utilized, further damage can be checked to a certain extent by the use of the same substances.

It is often of prime importance to prevent injury from wood-boring insects, for the reason that such injuries contribute to more rapid decay. Therefore anything that will prevent insect injury, either before or after the utilization of such products, will contribute to the prevention of premature deterioration and decay.

UTILIZATION OF NATURAL ENEMIES AND FACTORS IN THE CONTROL OF INJURIOUS INSECTS.

Were it not for the natural checks and natural factors of control of some of the more destructive insect enemies of forest trees and forest products, artificial control would in many cases be impossible, and the depredations would evidently be far more continuous and complete. These natural factors in the control of the depredating insects consist of parasitic and predatory insects, diseases of insects, birds, adverse climatic conditions, etc. While one or more of these beneficial factors exert a continuous and powerful influence toward the prevention of a more extensive waste of forest resources, it has been repeatedly demonstrated that they can not be depended on to prevent widespread devastations or to otherwise work for the best interests of the private or public owner by protecting the best trees and the best tree species. The insects and birds which prey upon the depredating insects also have factors to contend against, consisting of insects, birds, diseases, and climatic conditions. Therefore under normal conditions the tendency is toward the preservation of a balance between the warring factors, but frequently the enemies of the trees get the ascendancy and take on the character of an invasion, which may continue for two or three or even ten years before the balance is again adjusted through the influence of the natural enemies or diminished food supply. Thus a vast amount of timber or of a given forest product may be destroyed before the factors of natural control can prevail.

It is evident that the most effective utilization of the factors of natural control will be through the alliance with them of the owner of the forest in the artificial reduction of the enemies of the trees rather than by efforts to make the natural enemies of the injurious insects his allies through artificial introduction or dissemination. The former is accomplished by the adoption of methods of combating the invaders which will reduce and weaken their forces below their power of prosecuting aggressive movements and attacks, or, as previously stated, to reduce their numbers to the point where they must occupy a defensive position against their natural enemies and be dependent for their supplies of food and breeding places upon that furnished through avoidable mismanagement of the forests and manufacturing operations. Thus the owner of the forest can contribute greatly toward the preservation of a balance which will be to his material benefit. On the other hand, he may in the future, as in the past, contribute greatly to the multiplication of the depredating insects and to greatly increased losses caused by them, through neglect or a disregard of available information on the fundamental principles of insect control in the management of forests and manufacturing enterprises.

Beneficial Insects.

The beneficial insects comprise those which are internal or external parasites of the immature or mature stages of the injurious insects, and predators which feed on the young or adults of insects either before or after they make their attack on the trees or products. These two beneficial factors are doubtless far more effective in the long run than any other agencies of natural control. Yet they, in combination with all other factors, can not be always relied upon to render continued and efficient control. They can, however, be relied upon to respond to artificial assistance in reducing the numbers of the depredators.

Beneficial Diseases of Insects.

It is very evident that the parasitic fungi and bacteria which sometimes cause epidemics among injurious insects often exert a powerful influence toward the control of extensive outbreaks or invasions of insect enemies of forests. Indeed, it appears that the greatest service rendered by this class of natural enemies is in the frequent sudden appearance of an epidemic which kills off a destructive species of insect after the latter has increased to such numbers and extended its depredations over such vast areas as to be far beyond the control of man or his insect and bird allies. Numerous examples of this kind of natural control are found in the sudden ending of widespread depredations by various species of caterpillars and sawfly larvæ which defoliate deciduous and coniferous trees. As a rule, however, the beneficial effects of the diseases of insects prevail only after the injurious insects have increased to excessive numbers. Therefore this factor of insect control can not be depended upon to hold the insects in check or prevent outbreaks. The fact, however, that it operates on a class of insect enemies of the forest (defoliators) which at present can not be controlled by any known artificial methods renders the services of the diseases all the more valuable.

It is believed that with further knowledge of nature's method of propagating, perpetuating, and disseminating the diseases which cause epidemics among insects, they may be utilized more or less successfully through artificial propagation and dissemination to prevent threatened invasions of defoliating insects.

Beneficial Birds.

It is very evident that certain kinds of birds, such as woodpeckers, render valuable service toward the natural control of destructive bark and wood boring insects. They appear to render the greatest service, however, where but few trees are being killed or injured, because their concentrated work on such trees may contribute toward the prevention of an abnormal increase of the insects. They also render some service as allies of the other beneficial factors which assist in artificial control. It is evident, however, that where many hundreds or thousands of trees are being killed the comparatively limited number of birds in any forest under the most favorable conditions could have little or no beneficial effect. Therefore, while the birds should be classed among the valuable friends of the forest, and should be protected, it is plain that they can not, even with the utmost protection, always be relied upon to protect the forest against destructive ravages of insects.

We must remember, in this connection, that there are complicated interrelations between birds, injurious insects, and beneficial insects which do not necessarily always operate to the benefit of the forest. In fact, it may sometimes be quite the reverse. Therefore, in order to derive the greatest benefit from the conflict between the birds, the insect enemies of the trees, and the insect friends of the trees, we must utilize our knowledge of the factors which are contributing toward the preservation of a balance, so that whenever the enemies of the forest threaten to get beyond natural control we may enter the field through artificial means and endeavor to force them back to their normal defensive position.

Beneficial Climatic Conditions.

The benefits to be derived from climatic conditions which are detrimental or destructive to insect enemies of the forest, while sometimes very great, are necessarily unreliable, and thus can not be depended upon to assist in artificial control. In fact, the very condition which may contribute to the destruction of one depredator may favor the multiplication of another.

UTILIZATION OF WASTE CAUSED BY INSECTS.

When we come to consider the vast amount of standing timber in the forests of the country which has been injured or killed by insects, and will go to waste if it is not utilized within a limited period, we realize that there are great possibilities in its utilization as a means of preventing the reduction of future supplies of living healthy timber. It is all the more important that the insect-infested timber should be utilized, because in so doing we can contribute more perhaps than in any other way to the reduction of the insects to or below their normal numbers, and thus provide against serious injury in the future, as well as to the maintenance of control.

PRESENT CONDITIONS AND OPPORTUNITIES.

Unfortunately, the examples of management, or rather mismanagement, which are contributing to an extension or increase of waste are far in excess of those which under proper management are contributing to the reverse. This is due in a large part to the conditions that have prevailed in American forests in the past that have rendered it impracticable to adopt improved policies of forest management, but at present it is largely due to a lack of appreciation of the importance of the subject, and of the opportunities to prevent such losses, when it is not only practicable but possible to do so, and when it will, at the same time, yield large returns on the necessary additional expense. This is especially true in thousands of farmers' woodlots and private holdings in the States east of the Mississippi River, in which from 25 to 90 per cent of all of the serious injury of the past can be prevented in the future with little or no additional expense over that required for ordinary good forest management.

Forest Entomology as Applied to American Forests.

It is only within the past eleven years that any attempt has been made toward a systematic investigation of the insect enemies of the forest trees and forest products of the entire country. The state of knowledge of the subject previous to that time can be judged by the fact that a number of the most destructive enemies of forest trees are found to be new to science, and that nothing whatever was known of the habits and seasonal history of a large number of the more important known species which are common enemies of forest trees and forest products, while scarcely anything was known in regard to practical methods of controlling the principal enemies of the forest and its products, or of preventing losses from their ravages as applied to conditions in this country.

PRESENT KNOWLEDGE.

Within the past ten years forest-insect investigations have been conducted by the Bureau of Entomology of the Department of Agriculture in all of the principal forest regions of the United States, and have led to the following results:

Results of investigations.—Satisfactory progress has been made toward the attainment of some of the fundamental objects of the investigations, one of which has been the laying of a substantial foundation for forest entomology in this country on which future progress can be made along the lines of acquiring, disseminating, and applying information of immediate practical value in the protection of our forest resources.

Acquired and new information.—The principal insect enemies of the forests and forest products of North America have become known, and the general character and extent of their depredations have been ascertained.

The more important facts in the life history, habits, and practical methods of control relating to some of the more destructive insects have been determined.

A mass of original data has been collected relating to forest insects in general, including not only those which are destructive or injurious, but also those which are beneficial or neutral in their relation to the forest, as represented by a collection of more than a million specimens of insects and their work.

As a direct result of the investigations of forest insects during the past six years, at a cost of less than $53,000, there has been accumulated a reserve fund of information now available through publications, correspondence, and field demonstrations which, if properly utilized for practical application, would evidently prevent from 10 to 30 per cent of the annual losses at a very small cost.

Disseminated information.—In addition to information disseminated in all sections of the country through correspondence, lectures, demonstrations, exhibitions, etc., the published information, based on results of investigations conducted by the West Virginia Agricultural Experiment Station and by the Bureau of Entomology of the U. S. Department of Agriculture during the past eighteen years, is represented by over 1,300 pages, 99 plates, and 340 figures. (See list of publications.)

NEEDS.

The work that has been done is only a beginning in the vast field of forest entomology. There is need of more systematic work (or so-called pure science) on the different stages of the thousands of species of injurious and beneficial insects involved. *This is absolutely necessary in order to have the further scientific basis of facts on which to build the structure of complex details necessary to success in practical application in its broadest sense.*

There is need of further detailed study of habits and seasonal history of the species of injurious and beneficial insects, as well as of the local and other conditions favorable and unfavorable for their multiplication and work.

Further information is desirable on the principal factors of natural control of injurious insects, in order that it may be better utilized to facilitate artificial control.

There is special need of more general information and public interest in the subject of losses from insect depredations on standing timber and timber products, and a better realization of the possibility and practicability of preventing losses.

Looking to this end, there is need of further demonstration and educational work along the lines which will bring the matter to the attention of the man in the woods, sawmill, factory, or trade who is in direct touch with the local conditions and business methods.

There is a special need of more experts in forest entomology, and there will be an increasing demand for such experts in the future, to organize and take charge of insect-control policies in state forests, in public parks, in the more extensive private or commercial forests, and in extensive manufacturing enterprises, and to give instructions to students in forestry schools and forestry departments in state and other institutions of learning.

The need of trained and experienced experts in forest entomology for all of this class of work can not be too strongly urged. There is perhaps no branch of economic or applied science which requires more technical knowledge and practical experience as a basis for proper investigations and authentic instructions and advice than forest entomology, and there is perhaps no other feature in the science and practice of forestry in which advice and application based on insufficient knowledge is so dangerous.

There is quite a general recognition of the importance of guarding against contagious diseases, of the necessity of consulting a physician in cases of serious illness, and of relying on authorized pharmacists to fill the prescription, and then administering the prescribed treatment according to directions, but it is a notable fact that there are comparatively few persons who, even when deeply interested in preserving the health of the forest, have heretofore recognized the importance of guarding against insect epidemics or of consulting an expert forest entomologist in case of a threatened or existing outbreak. It has often happened that when such advice has been sought and received, the treatment was not administered according to the recommendations but changed to suit the ideas of some one entirely ignorant of the facts and principles upon which it was based. This has often resulted not only in failure to accomplish the desired end, but has contributed to an aggravation of the trouble and increased loss. The determination of the cause of specific troubles affecting the individuals of a given species of forest tree or an injury to a given type of product is just as complicated and requires the same elements of experience, training, and skill as that required for the determination of the cause of a given disease or the character of a given injury affecting man. It is just as important to know the cause or character of injury in the former as it is in the latter, in order to prescribe the specific treatment which will yield the desired results.

Therefore, in order to make the best progress toward preventing future waste of our forest resources from depredations by insects, every one interested in the subject, and especially those in authority in the public and private institutions of investigation and learning, should see to it that the instructions to students and the information given out to the public is not only the best available but that it is limited to the range of expert knowledge of the subject possessed by the instructor or investigator.

Elementary and Technical Knowledge of Forest Entomology for the Forester.

While it may be desirable that every professional forester should have an expert knowledge of forest entomology, it is rarely possible, even under exceptionally favorable conditions, for him to acquire more than the necessary elementary knowledge, and even this has not been possible under the conditions which have necessarily prevailed in the forest schools, and in the practice of forestry, in this country. Little or no time has been available for acquiring the necessary information from subsequent study and practical experience. Therefore this feature in the education of the American forester has been practically neglected.

PRESENT REQUIREMENTS OF INSTRUCTION.

As long as expert forest entomologists and authentic text-books based on American insects and conditions are not available for giving a complete course in technical and applied forest entomology the requirements of such a course should be limited to instruction in elementary entomology, and in elementary principles of applied forest entomology, which will give the necessary foundation for intelligent observations and utilization of available information as required in future practice.

CONCLUSION.

There is conclusive evidence that insects have been in the past, and are now, important factors in the waste and reduction of timber supplies, and will continue to be such in the future (pp. 57–58).

They attack perfectly healthy trees of all ages and kill them (p. 58).

They have at times killed a large percentage of the best timber over thousands of square miles of heavily forested lands (pp. 58–60).

They reduce the value of living timber and that of crude and finished products (pp. 60–66).

The accumulated evidence through many years of investigation and observation in the principal forest areas of the entire country by the writer and the field assistants in forest insect investigations furnishes the basis for the following summarized statements and estimates:

A large percentage of pine and spruce timber was killed by the southern pine beetle in 1890–1892 over an area of 75,000 square miles in West Virginia, Maryland, Pennsylvania, Virginia, and North Carolina (p. 58).

Billions of feet of matured spruce have been killed by the eastern spruce beetle during the past half century in the northeastern United States and southeastern Canada (p. 58).

A large percentage of the matured Engelmann spruce of the Rocky Mountains region has been killed by the Engelmann spruce beetle within the past fifty years (p. 59).

A large percentage of the pine timber of merchantable size in the Black Hills National Forest and other national and private forests of the central Rocky Mountains region has been killed during the past ten years by the Black Hills beetle (p. 59).

A large percentage of the best matured pine timber of the region north and west of Colorado and Utah has been killed within the past twenty years by the mountain pine beetle and the western pine beetle (p. 59).

A large percentage of the matured Douglas fir, or red fir, of the Rocky Mountains region has been killed by the Douglas fir beetle (p. 59).

The supply of hickory timber in the forests and woodlots of the States east of the Mississippi River has been greatly reduced by the ravages of the hickory barkbeetle (p. 60).

Practically all of the matured eastern larch has been killed over vast areas in the northeastern United States and southeastern Canada by the larch worm and eastern larch beetle (p. 60).

The wood of living timber has been rendered defective by wood-boring insects to such an extent as to reduce the value of a vast amount of standing timber from 50 to 75 per cent (p. 60).

Rapid deterioration of the wood of dying and dead trees has been caused by wood-boring insects, often amounting to from 25 to 100 per cent during the period in which it would otherwise be available for utilization (p. 62).

Crude manufactured and finished forest products have been damaged by insects to such an extent as to cause an estimated average annual loss of 10 per cent of its mill value (pp. 64–67).

Insects are the cause of greatly reducing our forest resources by killing the inaccessible timber; by reducing the quantity through injuries to the wood of living and dying timber; by preventing normal reproduction and development of future supplies, and through destroying forest products.

GENERAL ESTIMATES OF AMOUNT OF DAMAGE CAUSED BY FOREST INSECTS.

The results of extensive observations during the past ten years in the principal forested areas of all sections of the country, and during an additional eight years in West Virginia, indicate to the writer that the amount of standing timber killed by insects, together with the standing living, dying, and dead timber reduced in quality and value by them in the forests of the country, to be found at any given time, has been not far from 10 per cent of the total stand of merchantable-sized timber (pp. 70–71).

Considering the forest in its broadest sense as a source of national wealth of a given value for all purposes, including direct utilization, protection of land from erosion, protection of headwater streams, protection of game, and as contributing to the real and æsthetic value of health and pleasure resorts, it is evident to the writer that the total damage caused by insects has been equivalent to an average additional 5 per cent of the value of the merchantable-sized timber of the entire country (p. 71).

Considering the problem of insect damage to standing timber and crude products on the basis of direct utilization of the forest resources, it is evident that the reduction in value below that of healthy timber or sound products at the time of utilization, including losses from handling defective material, has amounted to an equivalent of at least 10 per cent of the average annual mill value of the aggregate output of forest products of all kinds. This, of course, includes the killed and damaged merchantable-sized timber considered under the estimate relating to standing timber, given above. Since the killed and damaged standing timber is involved in any given annual output, this estimate on a basis of utilization represents more nearly a direct reduction in cash values (p. 71).

The writer estimates that the annual loss caused by insects injurious to finished and utilized products, including the consequent increased drain on the forest resources to replace that prematurely destroyed by insects, is equivalent to at least 3 per cent of the original or mill value.

HOW LOSSES CAN BE PREVENTED.

The results of extensive investigations and of practical applications during recent years have demonstrated that some of the most destructive insect enemies of American forests and of manufactured and utilized products can be controlled and serious damage prevented with little or no ultimate cost over that involved in good forest management and business methods.

It is evident that if the information now available through publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future it will result in the prevention of an equivalent of at least 30 per cent of the estimated annual waste of forest resources that has been caused by insects within recent years and thus contribute greatly to the conservation of the forest resources. This can be accomplished as follows:

(1) By the adoption or adjustment of certain requisite details in forest management, in lumbering and manufacturing operations, and in storing, transporting, and utilizing the products which, at the least expense, will bring about the necessary reduction of the injurious insect and unfavorable conditions for their future multiplication or destructive work.

(2) By the adoption of policies of control, based upon expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved, and methods for their control, supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care, and utilization of the forest and its resources and still further supplemented by practical knowledge and experience relating to local conditions and facilities favorable and unfavorable for successful application according to a given method or policy of control.

(3) By reliance on technical advice furnished by recognized experts in forest entomology and forestry as a basis for success in practical application by the owner or forester.

(4) By utilization of so-called matured timber, and especially dense or pure stands of such timber, thus removing one of the favorable conditions for rapid deterioration through attacks by wood-boring insects or death through the attack of destructive bark-boring or defoliating insects.

(5) By the utilization of a knowledge of the principles of natural control as a means of contributing to the efficiency of artificial control.

(6) By prompt recognition of the first evidences of the work or destructive outbreaks of the principal insect depredators, by authentic identification of the species involved, and by prompt action in adopting the proper method or methods of control for the prevention of losses.

It should be remembered that as a rule it is useless to attempt the extermination of an insect enemy of the forest or its products. It is only necessary to reduce and weaken its forces at least 75 per cent, so that it can not continue an aggressive invasion, but must occupy a defensive position against its own enemies and become dependent upon favorable conditions resulting from avoidable negligence and mismanagement by the owners of the forests and the manufacturers of forest products.

While beneficial insects, beneficial birds, and beneficial diseases exert a continuous and powerful influence toward the prevention of a more extensive waste of forest resources, it has been repeatedly demonstrated that they can not be depended upon always to prevent widespread devastations or otherwise to work for the best interests of the private or public owner by protecting the best trees and the best tree species.

The best way to utilize the factors of natural control is to become their allies and assist in the reduction of the enemy, rather than to try to make them our allies through artificial introduction or dissemination.

A large percentage of the waste caused by insects can be prevented by the utilization of infested material, and at the same time, without additional expense, this will contribute greatly to the control of insects which cause such waste and also prevent injuries and depredations in the future.

Under past conditions the poor management or neglect of the average forest has contributed to the increase of depredations by insects.

Under present conditions of better management of local forests and of the more progressive manufacturing enterprises much is being accomplished toward the reduction of losses. In the average forest, and in the average business enterprise dealing with forest products, present conditions are little better than in the past. This is largely due to a lack of appreciation of the importance of the subject and failure to realize the opportunity and practicability of preventing a large percentage of the loss.

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INDEX.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN NO. 58, Part I.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

THE LOCUST BORER.

BY

A. D. HOPKINS,
In Charge of Forest Insect Investigations.

ISSUED JUNE 13, 1906.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 27, 1906.

Sir: I have the honor to transmit herewith the manuscript of a paper entitled "The Locust Borer," prepared by Dr. A. D. Hopkins, in charge of forest insect investigations, and comprising a summary of information from published accounts supplemented by data secured by recent investigations. It deals more particularly with practical methods of controlling this, our most important enemy of the black locust, and is designed to be of service to owners of plantations and forests, as well as to investigators, in the prevention of injuries to this useful tree. It is the first contribution to a series of papers to be published as a bulletin under the title "Some Insects Injurious to Forests." I recommend its publication as Bulletin No. 58, Part I, of this Bureau.

Respectfully,

C. L. Marlatt,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATE.

TEXT FIGURES.

SOME INSECTS INJURIOUS TO FORESTS.

THE LOCUST BORER.

(*Cyllene robiniæ* Forst.)[a]

By A. D. Hopkins,

In Charge of Forest Insect Investigations.

OBJECT OF PAPER.

The object of this paper is to give a summary of the more important published information, supplemented by recently determined new facts relating to the locust borer and methods of controlling it, which will be of service to the investigator in the determination of additional facts, and to the owners of plantations and forests in suggesting methods of preventing losses.

ECONOMIC IMPORTANCE OF THE INSECT.

The economic importance of the well-known locust borer as affecting the growth of the black locust or yellow locust (*Robinia pseudacacia*) is fully realized by everyone who is interested in this valuble forest and shade tree, and the urgent need of additional information on the subject is indicated by the frequent inquiries of correspondents and by the recent articles in newspapers, journals, and special publications which have been called forth by the proposed extensive commercial planting of the locust by railroad and other companies and by individuals.

INVESTIGATIONS.

In connection with the general study of insects injurious to forest trees, the locust borer has received considerable attention by the writer since 1890.[b] In March, 1905, a plan of cooperation between the

[a] Order Coleoptera, Family Cerambycidæ.

[b] From 1890 to 1892 for the West Virginia Experiment Station, and since 1902 for the U. S. Department of Agriculture.

Bureau of Entomology and the Forest Service in the investigation of insect enemies of the black locust was proposed and adopted, by which the subject is receiving special attention from the viewpoint of both the forester and the entomologist, with the primary object of practical results.

CHARACTER OF THE INSECT AND ITS WORK.

The locust borer is a whitish, elongate, so-called "round-headed" grub or larva (fig. 1), which hatches from an egg (fig. 2) deposited by a black or brown and yellow striped long-horned winged beetle (fig. 3) found on the trees and on the flowers of golden-rod from August to October. The eggs are deposited in the crevices of the bark of living, growing trees from August to October, and the young borers (fig. 2, *b*, *c*) hatching therefrom mine into the outer portion of the living inner bark (fig. 5), where they pass the winter, and in the spring bore through the bark into the sapwood and heartwood. Here they transform in July and August to pupæ (fig. 4) and in August and September to adult beetles, which soon emerge from the trees and deposit eggs for the next annual generation of borers and beetles.

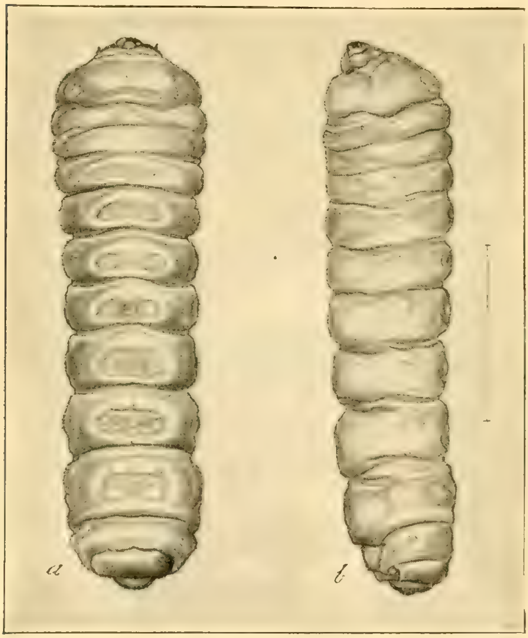

FIG. 1.—The locust borer (*Cyllene robiniæ*): *a*, larva, dorsal view; *b*, same, lateral view. Line at right represents natural length (original). The larva in profile should show minute prothoracic feet.

The injury to the trees (Pl. I) consists of wounds in the bark and sapwood which, if sufficiently severe or repeated year after year, result in either a stunted worthless growth or the death of young and old trees, while the numerous worm holes in the wood reduce its commercial value or render it worthless.

The presence of the insect in injurious numbers is indicated (1) by the frequency of the adults on the golden-rod flowers and on the trees, from August to October; (2) by the slight flow of sap and by the brownish borings where the young larvæ are at work in the bark, during April and May; (3) by the whitish sawdust borings lodged in

WORK OF THE LOCUST BORER.

a, Section of young tree 3 inches in diameter; *b*, section of young tree 2 inches in diameter which was broken off near surface of ground; *c*, *d*, section of branch from badly damaged tree, showing healing wounds in surface of wood; *e*, transverse section of same; *f*, *g*, sections of branches one-half inch in diameter or less, showing in each the total lengt[h of] burrow in which a larva developed and transformed to the adult beetle. (Origina[l].)

the rough bark, in the forks of the tree, and on the ground around the base of the trunk, during May, June, and July; (4) by the breaking down of the branches and young trees, and by the sickly appearance of the young twigs and leaves in July and August.

This insect appears to be present and more or less injurious in all of that part of the United States which is east of the Great Plains and north of the Gulf States. Published information and reports of forest officials and others indicate that in Oklahoma and Indian Territory and west of the Great Plains the locust is now quite free from injury by the borer; but that these regions will remain exempt is by no means certain.

EXTENT OF DAMAGE OR LOSS.

So extensive is the damage to natural growth, artificial plantations, and shade trees that in some sections within the natural range of the tree in the Eastern States, but particularly in the Middle West, where both the tree and the insect have been introduced, it is considered unprofitable to grow the tree for shade or timber, and in such sections the natural sprout growth is often considered a pest rather than otherwise.

FIG. 2.—The locust borer (*Cyllene robiniæ*): *a*, eggs; *b*, *c*, larvæ from hibernation cells. Much enlarged (original).

The loss resulting from defective timber, stunted growth, and the death of trees is represented by the difference in value between the damaged growth or product and the same if uninjured and healthy. This, if expressed in dollars, would represent a large sum.

POSSIBILITIES OF PREVENTING LOSSES.

There are sections, especially in the natural home of the tree, where, as has been frequently observed by the writer and others, the damage is not sufficiently severe to seriously affect the vitality of the trees or the commercial value of the product; and our present knowledge of the insect and of methods of preventing losses from its ravages indicates that in properly selected localities, and under proper forestry methods of management, the tree, so far as this insect is concerned, can be grown successfully on an extensive scale, and can be made to yield most satisfactory returns.

HISTORICAL REFERENCES.

The first reference to this insect, according to Fitch, is a figure and description by Pitiver in his Gozophylacium, published in London in 1702. Drury figured it in 1770, and the following year, 1771, Forster gave it the specific name of *robiniæ*, under which it is at present recognized. It has been referred to many different genera, but is now recognized as belonging to the genus Cyllene. Both Drury and Forster received it from the "Province of New York," and referred to it as inhabiting the locust tree (*Robinia pseudacacia*). It is therefore evidently an American species.

Some of the principal writers who have contributed important facts on the life history, habits, distribution, and remedies are: Dearborn, 1821; Harris, 1826–1841; Fitch, 1858–1863; Walsh, 1865–1867; Riley, 1867; Lintner, 1890; Schwarz, 1890; the writer, 1891–1898; Felt, 1901–1905; Cotton, 1905; White, 1906, and others. (See list of publications, p. 15.)

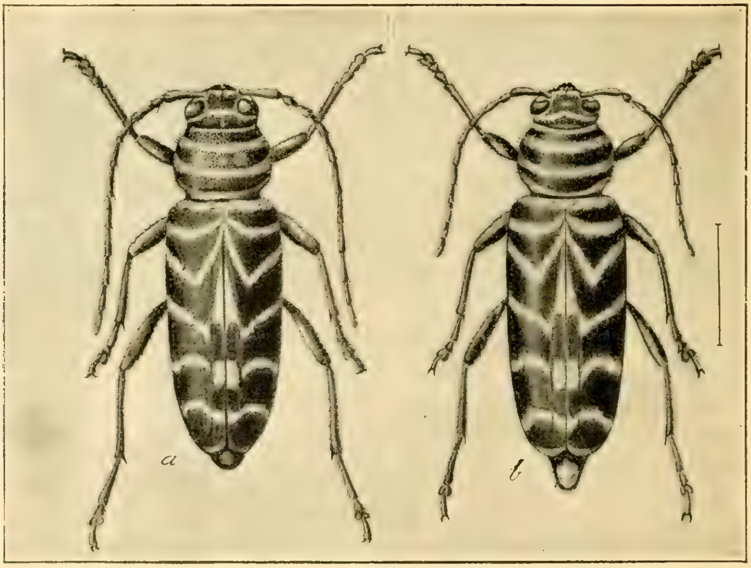

FIG. 3.—The locust borer (*Cyllene robiniæ*): *a*, male beetle; *b*, female beetle. Much enlarged (original).

REVIEW OF PUBLISHED DATA.

Gen. H. A. S. Dearborn was the first to record the more important facts in the life history and habits of the insect. Indeed, so complete and accurate were his observations that comparatively little has been added by subsequent writers, who have extensively quoted and repeated them. He found the beetles on the trunks of trees from the 1st to the 25th of September, the females depositing their "snow white" eggs in the crevices of the bark, four to nine in each place. These eggs hatched before cold weather, and "the young larvæ just buried themselves in the tender inner bark," where they remained until about the 1st of April, when they commenced boring, and soon passed into the solid wood. He stated that it could always be ascertained when and where the borers were at work by the oozing of sap from the wounds made by them. By the 20th of July the larvæ attained their full size, by the 28th some of them changed to pupæ, and the perfect insects were on the trees September 3. These observations were made on his grounds near Roxbury, Mass., during several years previous to 1821, when they were reported in a letter to John Lowell, and published, together with an account of his unsuccessful experiments with whitewash, mortar, and plaster, in the Massachusetts Agricultural Journal, Volume VI, 1821, pages 270–275.

Col. T. Pickering, in a letter to Mr. Lowell the same year and published in the same volume, stated that there were trees in New Hampshire uninjured by the borer, as well as in some of the Southern States; that he had observed the stems of young trees in Washington, D. C., infested, while in Georgetown (D.C.) he saw large thrifty trees uninjured; and he concluded that natural growth in groves was much less liable to injury than transplanted growth.

FIG. 4.—The locust borer (*Cyllene robiniæ*): *a*, pupa, ventral view; *b*, same, dorsal view. Much enlarged (original).

Fitch, writing in 1858, stated that numbers of specimens were sent to him year after year from Indian Territory.

Schwarz (1890) observed that in and around the District of Columbia the insect lives in large colonies, affecting all trees of small groves, while long hillsides full of locust are not infested.

R. S. Kellogg, in his discussion of forest planting in western Kansas, says:[a]

> By locating plantation on good ground and giving it first-class care, the trees will reach fence-post size before the borers do much damage. They should then be cut and utilized. The rapid sprout growth will soon make a new crop. A stump sprout sometimes attains a height of 10 feet the first season. Handled in this manner, black locust can be profitably raised in many places where it is altogether unsuited for a permanent tree.
>
> At present borers are a menace to black locust trees throughout western Kansas and Nebraska, though there are occasional local areas that are not affected. They

[a] Bul. 52, Bur. Forestry, U. S. Dept. Agric., 1904.

have so far done little damage in southwestern Kansas, but they are moving both southward and westward. They are abundant at Pratt, Kinsley, Dodge, and Scott, and are appearing at Medicine Lodge, Coldwater, Meade, and Garden City. Yet of the numberless trees that have been killed or seriously injured nearly all reached a size that could well be used for posts or stakes before succumbing. This shows that black locust may be successfully grown in commercial plantations if cut as soon as large enough for posts. * * *

Just south of the Kansas line, in Woods County, Okla., black locust grows remarkably well, and has not yet been molested by borers.

Cotton (1905) observed that in Ohio injury was greater in single trees and plantations of considerable size than in natural forests.

Dearborn found that whitewashing the trees in April and filling the holes with mortar in July was not entirely successful as a remedial measure, but he suggested cutting out and burning infested trees in April and protecting the young, thrifty trees. Harris suggested the collection of the beetles by children, and Fitch, the planting of goldenrod to attract the beetles, so that these could be collected and destroyed. Lintner suggested the application of soap solution and carbolic acid to prevent the beetles from depositing eggs, and the cutting out of young larvæ when their presence is indicated by sap and borings. Riley suggested destroying the young borers as soon as hatched. The writer recommended severe pruning in March, and clean culture was recommended by Felt.

The insect has been recorded from Canada southward to Pontchartrain, La., Texas, and Indian Territory, and westward into Nebraska.

Some of the records of destructive ravages are the following: Peck (1818), Harris (1826), in New England; Fitch (1858), in New York; Rogers, Reed, and Bethune (1855 to 1867), in Canada; Walsh (1866), in Illinois and Kansas; Laurent (1893), around Philadelphia; the writer (1891 to 1898), in West Virginia; Smith (1898), in New Jersey; Cotton (1905), in Ohio; White (1906), in the Mississippi Valley, about twenty years after extensive planting was begun by settlers.

REVISION OF PUBLISHED DATA.

Some of the published records relating to the insect which have been frequently quoted or repeated require, according to the writer's observations, some amendments and corrections.

It would appear that normally but a single egg is deposited in a place, rather than clusters of four to nine. The female does not pierce the bark or place her eggs in the cambium layer. The larvæ do not enter the sapwood before winter, but, as observed by Dearborn and verified by the writer, remain in the outer portion of the inner bark. Records of the insect infesting honey locust are probably due to the fact that the black locust is sometimes referred to under this name, which is the correct one for an entirely different tree. It appears now that its attack is confined entirely to Robinia. It is not necessary that a tree or branch should be some inches in diameter before it is damaged, for the writer has found full-grown larvæ in sprouts and branches less than one-half inch in diameter.

In the writer's opinion, all attempts to cultivate locust in the eastern United States *should not be abandoned* on account of the borer, although this has been recommended by some recent writers. It has been stated that the locust would probably not be injured by the borer in the southern limit of its range and in the country west of the Great Plains. While this may be true, precaution should be taken to prevent its introduction into such localities, since it is not improbable that if the insect be introduced and become established it may prove even more destructive there than in its natural home, as was demonstrated in the Mississippi Valley.

Nearly all methods heretofore recommended are subject to practical application to shade trees and small plantations only; therefore there is special need for suggestions of practical methods of combating the insect and preventing losses in large commercial plantations and in natural forest growth, and it is hoped that this paper will contribute something of value along this line.

OBSERVATIONS BY THE WRITER, 1890–1905.

Adults were collected on golden-rod flowers at Piedmont, Md., and Mineral County, W. Va., on August 25, 1890, and on golden-rod and locust leaves at Morgantown, W. Va., September 16 and 17, 1891. Young larvæ were found mining in living bark of trees at Kanawha Station, W. Va., May 1, 1891, and on May 20 the same larvæ had entered the wood, but a great many had died.

It was frequently noted that the locust in the forests of Chestnut Ridge in Monongalia and Pendleton counties, Laurel Hill in Preston County, and especially on Rich Mountain in Randolph County, W. Va., showed but slight damage by the borers. Similar observations were made in many other sections of the State, while in near-by and widely separated sections the damage was found to have been severe and continuous during the life of some of the older trees. In 1898 it was observed that badly damaged shade trees near Morgantown, W. Va., which had been severely pruned in March and April had recovered, and the crowns were renewed by dense, vigorous, healthy growth, which suggested this method of treating badly damaged shade trees.

On October 9, 1904, it was found that the locust in the vicinity of Chevy Chase, Md., was but slightly damaged by the borer, although beetles were found in numbers on golden-rod and feeding on sap from wounds in bark of living sumac. This habit of feeding on sap is of special interest from the fact that it suggests the possibility of killing the beetles by means of a bait of some poisoned substance which would be attractive to them.

On May 23, 1905, it was found that the locust trees of all sizes in the open and in dense thickets along the old canal on Arlington Farm, Virginia, were thickly infested with the borers, which were all in the wood and ranged in size from quite small to nearly full grown. The ground around some of the trees in the open and on the borders of the groves was found to be covered with the sawdust borings to the depth, in some cases, of an inch or more, and the larvæ could be distinctly heard at work in the wood. Some of the young trees had been literally honeycombed and were broken off at the ground, others had many branches broken and hanging by the bark or fallen from the tree, and some other trees had the leaves turning yellow and dying, while one isolated tree in a field had failed to put forth leaves on some of the branches. Some infested branches cut on this date and placed in a box in the laboratory were found on July 12 to contain fully matured adults, and on July 20 they began to emerge, thus showing that the larvæ will complete their development in the wood after it is cut from the tree and becomes perfectly dry. Indeed, this record shows that the dry condition contributes to the rapid development of the insect, for on the same day (July 20) on which the beetles were found in the box, the trees from which the branches had been cut were examined and found to contain nothing but larvæ. Some more branches were cut on this date and placed in a tin can, where they were kept moist. The first beetles emerged from these on August 24, or more than thirty days after adults had emerged from the dry branch. On August 30 many adults had emerged. September 20 ten living adults and many dead ones were taken from the can, and on October 2 several more dead ones were removed.

When the trees were examined on July 20, a larva was found mining in a two-year-old branch less than one-half inch in diameter, and the cocoon of a parasite of the borer was found in one of the mines, but the adult parasite was not reared. Many dead borers were found in their mines in the trunks and branches surrounded by a white powdery fungus.

The trees were again examined on September 14, when adults were found abundant on the foliage, branches, and stems, and also on flowers of golden-rod. Adults and pupæ were also found in considerable numbers in the dead wood of broken branches, as well as in the living wood, and dead larvæ were frequent. Larvæ of an elaterid (click beetle) were quite frequent in the wood, where they had evidently been feeding on the locust borer.

Examination during August, 1905, of the locust on a hill near Kanawha Station, W. Va., where this tree forms the principal growth over old abandoned fields and in the adjacent forests, showed that the damage by the borer was very slight in trees of all sizes. On August 26 many adults and a very few pupae, but no larvae, were found in small trees in the valley, while the large trees in the same locality were but slightly damaged.

OBSERVATIONS BY MEMBERS OF THE FOREST SERVICE.

The following notes by Mr. S. N. Spring, forest assistant in the Forest Service, were submitted October, 1905, as a contribution to the results of cooperative studies. Early in July the work of the borer was noticed in the central portion of Westmoreland County, Pa. The first adult insect was seen on August 29. Evidence of the work of this insect was found in the localities investigated, but, for the most part, it was not serious enough to prevent the planting of locust for fence posts. To the north and west of Greensburg, in Westmoreland County, and in Allegheny County many roadside trees were badly bored. The work of the borer is slight on Chestnut Ridge and Laurel Hill, where locust thrives. Posts and pit props cut in these mountains show slight injury only. In the few places where injury was found to be great, within the area studied, the trees were dying, and many branches were broken off where the trees had been extensively bored by this insect. Owing to the fact that places of serious injury were so few, it was impossible to carry out any observations that would be of value in a study of immunity. In general the locust on the two high ridges thrived better than those on the lower elevation of Westmoreland and Fayette counties, and less injury due to this insect was found among the trees on the ridges.

Mr. J. W. Fetherolf, of the Forest Service, informed the writer, on January 26, 1905, that a grove of black locust planted in Salt Lake City, Utah, prior to 1850, is still in a thrifty condition and apparently free from all insect injury. The same can be said about this species seen elsewhere in the Salt Lake Valley.

Mr. Wesley Bradfield, of the Forest Service, informed the writer that he found the adult beetles common on badly damaged trees, 5 to 8 years old, near Marshall, Mich., in August, 1905; also, that according to his observation the locust in the southern quarter of Michigan was seriously damaged, while in the northern three-quarters, especially toward Lake Michigan, it was not.

RECENT OBSERVATIONS BY THE WRITER.

On March 11, 1906, it was found at Arlington Farm, Virginia, that the young larvae had passed the winter in minute cells which they had excavated in the outer layers of the living bark and just beneath the outer corky bark (fig. 5), as recorded by Dearborn. So common were these hibernating larvae in the trees that in the bark of some of them there were fifteen or twenty within an area of a few square inches;

but of the several hundred examined there was only one larva in a place, which would indicate that the eggs are not deposited in clusters, but that they are scattered about in the crevices, so that each larva occupies a separate hibernating cell. The slight wound thus produced in the outer layer of the living bark results in a small dead area surrounding the cell. This dead and brown condition was found, on the date mentioned, to have penetrated the thick inner bark to the wood.

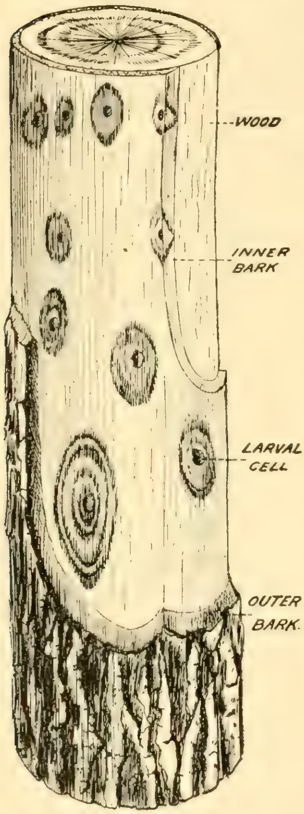

FIG. 5.—The locust borer (*Cyllene robiniæ*): Hibernation or larval cells in outer portion of living inner bark. About natural size (original).

This condition evidently facilitates the operation of the young larva in boring through the inner bark to the wood, which a healthy condition of the immediately surrounding bark might prevent. It is not improbable that this small area of dead bark may be caused by a plant disease, which finds its way to the living plant tissue through the slight wound made by the larvæ and which, if this be so, may contribute greatly to the death of badly infested trees.

The young larvæ were found in nearly every case in the part of the bark which had not been injured previously, thus indicating that the female deposits her eggs where the bark is perfectly healthy and not in or around the old scars. Indeed, the habit of the larvæ appears to render this quite necessary for their more or less isolated work. It was particularly noted that the remaining unaffected bark of the trees which had suffered most from previous generations of the insect was thickly infested with hibernating larvæ, while that of near-by large trees which had escaped previous injury contained very few, thus indicating that from some cause there are individual trees which are more or less immune. This fact, which has been so often observed, suggests the importance of experiments in the propagation of immune stock by means of seed or root cuttings from immune trees growing among badly infested ones.

The hibernating habits of the larvæ also suggest a simple method of destroying them, namely, the cutting and barking of the trees during the period between the first of November and the first of May. The simple removal of the bark, without burning, is sufficient to kill the larvæ.

It should be remembered that all the holes found in a tree and all other damage by the borer are not the work of one generation, but usually that of repeated annual attack during the life of the tree: also, that a burrow in the sapwood of a young tree remains the same burrow in the heartwood of the old tree, without change, except in the healing of the original entrance: therefore the number of borers and the amount of damage each year is not so great as it might appear, and, while each female is doubtless capable of depositing more than a hundred eggs,[a] it would appear from the writer's observations that only a small percentage of the larvæ hatching from them survive the bark-infesting stage or complete their development to the adult stage. This suggests that any method of management which will insure the destruction of a large number of larvæ and beetles each year will reduce the damage to a point where there will be practically no loss.

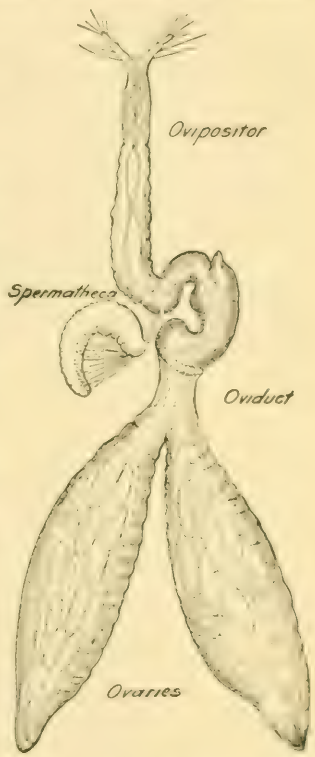

FIG. 6.—The locust borer (*Cyllene robiniæ*): Reproductive organs of female beetle. Highly magnified (original).

SUGGESTIONS FOR CONTROLLING THE INSECT AND PREVENTING LOSSES.

With our present knowledge of the life history and habits of the locust borer, it would appear that the following suggestions might be of practical value in the control of insects in large plantations and forests.

The fact that the young larvæ from eggs deposited during the summer remain in the outer bark during the winter and do not enter the wood until the following May suggests that if locust for all purposes were cut between November and May, the bark removed from that portion which is of value, and the remainder burned, it would destroy vast numbers of the insects and contribute greatly toward the protection of the remaining growth.

The fact that badly infested trees may be detected during May, June, and July by the ejected sap and borings, suggests this simple method of locating such trees, which should be cut close to the ground and burned, before the first of August, to destroy the borers before

[a] An examination of the ovaries (fig. 6) of beetles collected in August shows that they may contain as many as fifty mature eggs at one time, in addition to a large number of immature ones.

they transform to the adult beetles and emerge. If preferable, the same end may be accomplished by burning the tops and worthless parts and by submerging the valuable parts in ponds or streams until the borers are killed.

DAMAGE TO CUT WOOD AND DANGER OF INTRODUCTION INTO NEW LOCALITIES.

As we have shown that after the borers have once entered the wood they may complete their development in the cut and dry branches, they will evidently do so in posts or other material manufactured from trees cut between the first of May and the middle of September; therefore, it is plain that locust should not be cut during this period for any purpose except to destroy the borers, or, if it should be necessary to cut it, the tops should be burned and the logs submerged in ponds or streams for a few days before they are shipped or manufactured. This is very important both to prevent damage to the manufactured material and the introduction of the insect into the far West and other sections of the country which are at present free from it.

PROPER LOCATIONS FOR EXTENSIVE PLANTATIONS.

The fact that there are many sections and localities of greater or less extent within the natural home of the locust and its insect enemies where, from some unknown cause, the tree grows to large size and old age without perceptible injury from borers and other insects, suggests the importance of selecting such localities for any proposed extensive operations in the line of artificial plantation, or utilization of natural growth. It will be found, however, that no area of considerable extent, even in such localities, is entirely free from this and other destructive insect enemies, and that certain precautions and well-planned methods of management with reference to their control will be necessary.

PRELIMINARY REQUISITES.

In the first place it is necessary, in order to provide against future losses from the borer, that a thorough survey be made in May and June, not only of the area to be utilized but of the entire neighborhood for a radius of a mile or more from its borders, for the purpose of locating and destroying scattering trees and groves which are more or less seriously infested or damaged by the borer. It would seem that the control of such large areas, by purchase or under a plan of cooperation between the owners of the land or trees, is one of the most important requisites for success in preventing future losses from the ravages of this and other insects in small as well as large plantations.

In fact, it is the writer's opinion that, with this precaution properly and continuously carried out, locust may be successfully protected from the borer in any locality.

SUBSEQUENT MANAGEMENT.

In the subsequent management of plantations and of natural forest and sprout growth it is important each year to locate and destroy the worst infested trees for the purpose of killing the borers in the wood, and to conduct the thinning and commercial cutting operations during the period between November of one year and May of the next in order to destroy the eggs and young before they enter the wood.

Worthless, scrubby, borer-infested trees should be killed outright by stripping the bark from 4 or 5 feet of the lower stem during August to prevent sprouts and seed production from them and at the same time to destroy the eggs and young borers. Trees deadened in this manner, as was demonstrated near Morgantown, W. Va., some years ago, may be so completely killed that not a single root sprout will appear. Therefore this method is of special value in preventing sprout reproduction from inferior individual trees.

COLLECTING THE BEETLES FROM GOLDEN-ROD FLOWERS.

Collecting the beetles from golden-rod flowers, by means of insect sweep nets, before they deposit their eggs, would be advisable, even for the protection of large plantations, and, as has been suggested, the planting of patches of the plant, or the cutting of all but certain strips and patches of natural growth for this purpose, would serve to concentrate the beetles where they could be caught in the nets and destroyed by emptying them into a pail containing water covered with a film of kerosene.

POISONED BAIT.

Experiments should also be made with poisoned baits, as suggested on pages 7–8.

SUGGESTIONS FOR PROPAGATING BORER-RESISTANT TREES.

FROM SEED (SEXUAL METHOD).

The fact that some trees are, to a greater or less extent, immune from attack or injury by the borer, while adjacent ones in the same grove are attacked year after year and seriously damaged, suggested the idea of breeding races and varieties of the species which would be permanently immune. This suggestion was included in the plan for cooperative investigation mentioned on pages 1–2. It was then thought that if the seed for general planting were collected from immune trees found growing among badly damaged ones, a much larger percentage of the product would resist attack and, by continuing this method of selection and breeding, immune varieties could in time be established. There are, however, some serious difficulties to be overcome by this sexual method, especially that of cross-fertilization and variation and the very long time required to get definite verified results.

FROM ROOT CUTTINGS (ASEXUAL METHOD).

It has since occurred to the writer that insect-resistant varieties might be secured by a much shorter method, namely, that of propagating from root cuttings and possibly from twig cuttings. By this simple method of asexual propagation a large number of offspring, in every respect like the parent stock, may be secured at once for the starting of experiments to determine whether or not the asexual product of trees which have not been injured by the borer will produce plantations equally as immune. The writer's experience in the establishment of improved varieties of timothy by this method leads him to believe that insect-resistant varieties of locust can be established. If so, the principal difficulties in the problem of preventing losses from the ravages of the borer will be solved.

It should be mentioned in this connection, however, that it is possible that the borer, if deprived of the trees which are most attractive to it, may gradually adapt itself to the more resistant ones and become more or less injurious to these, and that other insect enemies may be troublesome. There will be so many advantages, however, in propagating from healthy vigorous stock that, in the writer's opinion, the matter should receive immediate attention, and selection and propagating experiments should be started at once. The success of the effort will depend largely on the proper selection of immune trees from the worst infested groves or sections rather than from those growing in partially immune localities.

Domestic animals and cultivated plants have been improved by selection and breeding to meet almost every need and requirement of man, and it is well known that some races and varieties are much less susceptible to injury by disease and enemies than are others. It is reasonably certain, therefore, that the locust will not be an exception, but that it will yield to the breeders' manipulations and may be made to produce insect-resistant varieties and forms specially fitted to supply the different needs of commercial planting, shade, and ornament.

In the meantime, much of immediate practical value and importance may be accomplished by following the suggestions herein contained for the direct control of the insect in extensive plantations and in natural forest growth.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY — BULLETIN No. 58, Part II.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

THE WESTERN PINE-DESTROYING BARKBEETLE.

BY

J. L. WEBB,

Special Field Agent, Forest Insect Investigations.

Issued August 18, 1906.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., May 28, 1906.

Sir: I have the honor to transmit herewith the manuscript of a contribution, by Mr. J. L. Webb, on the Western Pine-destroying Barkbeetle. It has special reference to the results of investigations by Mr. Webb in central Idaho in 1905, but relates also to the results of other investigations and to available information on the insect and methods of combating it. I recommend its publication as Part II of Bulletin No. 58 of this Bureau. The figures and plates are necessary for the illustration of the text.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

SOME INSECTS INJURIOUS TO FORESTS.

THE WESTERN PINE-DESTROYING BARKBEETLE.

(*Dendroctonus brevicomis* Lec.)[a]

By J. L. Webb,

Special Field Agent, Forest Insect Investigations.

INTRODUCTION.

The object of this paper is to give available information on this insect and methods of combating it, with special reference to the results of investigations by the writer during the summer of 1905 in central Idaho.

The need of the investigations was suggested in a letter dated August 10, 1904, from Mr. Gifford Pinchot, forester of the U. S. Department of Agriculture, to Dr. L. O. Howard, chief of the Bureau of Entomology, as follows:

> I learn from the Payette Lumber and Manufacturing Company, one of the Weyerhaeusers, whose land lies on the Payette River north of Boise, that the pine in their holdings is said to be dying from the attacks of insects. If it were possible for you to assign Doctor Hopkins, or one of his assistants, to make examination of this region, unless it has already been done, I should greatly appreciate it, and I should likewise appreciate your sending to Mr. Edgar M. Hoover, general manager of that company at Boise, any information you may have bearing on this subject.

In response to this request the matter was referred by Doctor Howard to Dr. A. D. Hopkins, in charge of forest insect investigations, for attention, and Mr. H. E. Burke, an assistant, was instructed to make preliminary investigations in October of the same year. In May, 1905, the writer was assigned to this work, with instructions from Doctor Hopkins to make a detailed study of the forest insects of the region, with special reference to determining the following points: (1) The relation of the several species of insects to the dying of the trees; (2) the number of species involved, the relation of each to primary and secondary attack, and the life histories of the primary and secondary enemies; (3) the extent of the infested area, the percentage of timber killed each year during the past two or three years within given areas, the approximate losses, etc.; (4) the relation of logging operations to

[a] Order Coleoptera, family Scolytidæ.

depredations by insects in adjoining forests, and the relation of time of felling timber in regular logging operations to attack by Dendroctonus and other bark and wood boring insects.

Accordingly, investigations were begun by the writer on May 17, 1905, with headquarters at Centerville, Idaho, and continued until October 10, 1905.

DEATH OF THE PINE CAUSED BY THE WESTERN PINE-DESTROYING BARKBEETLE.

Observations by the writer served to confirm the conclusion of Mr. Burke that the primary enemy was a barkbeetle identified by Doctor Hopkins as the western pine-destroying barkbeetle (*Dendroctonus brevicomis* Lec.).

CHARACTER OF THE INSECT AND ITS WORK.

The adult insect is a stout, brownish-winged beetle (fig. 7) from one-eighth to three-sixteenths inch in length, which attacks the living trees in swarms, and burrows into the living bark, through the inner layer of which each female excavates winding galleries (fig. 8 and Pls. II, III) in which to deposit eggs. These galleries serve to cut off the natural movement of the sap and completely girdle and kill the tree. In the vicinity of Centerville, Idaho, the eggs, deposited during June, July, or August, in little niches in the sides of the galleries, hatch within 4 or 5 days into small whitish larvæ (fig. 9), which mine at right angles from the primary gallery through the outer layers of the inner bark until they have completed their growth, which requires from about 20 to 30 days. They then bore into the outer corky bark (fig. 12, *a*) where they excavate little cells in which to transform, first to the pupa (fig. 10) and later to the adult. When the broods of the first generation have thus developed—in about 60 or 70 days—they bore out through the bark and fly to other trees to repeat the process and continue their depredations.

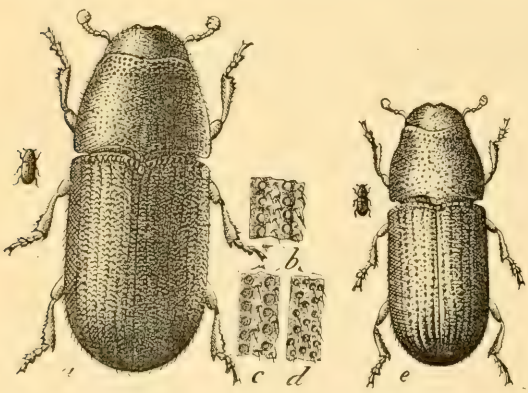
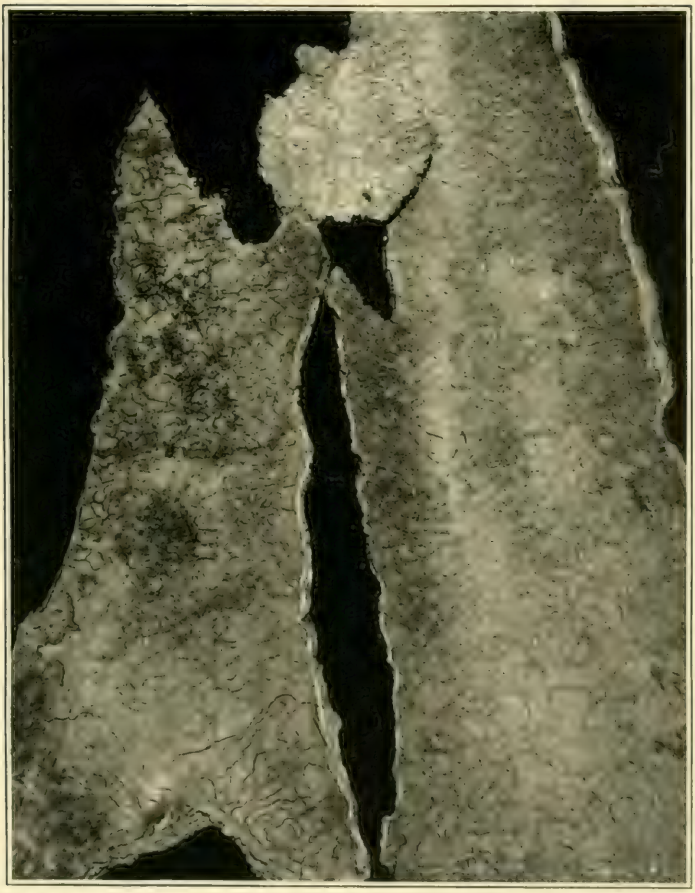


FIG. 7.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): *a*, adult female; *b, c, d*, details of punctuation; *e*, adult male. Natural size at left (original).

The presence of this destructive insect in a forest is indicated (1) by dead and dying trees scattered about or in clumps or large patches. (The dying ones, with fading yellowish and reddish foliage, are called

WORK OF THE WESTERN PINE-DESTROYING BARKBEETLE IN BARK REMOVED FROM KILLED TREE; ALSO FAINT MARKS ON SURFACE OF WOOD. (ORIGINAL.



WORK OF THE WESTERN PINE-DESTROYING BARKBEETLE. REMOVED FROM KILLED TREE. (ORIGINAL

"sorrel tops," and the dead ones, with reddish-brown foliage, are called "red tops," or, if with bare branches or broken tops, are known as "black tops" or "broken tops;"[a] (2) by small masses of resin (pitch tubes, figs. 11 and 12, *c*) in the crevices of the bark of recently attacked living trees, as well as in those of the dying and dead ones; and (3) the presence of the species is determined by removing the bark from the dying and dead trees and finding the characteristic galleries (fig. 8 and Pls. II, III).

FIG. 8.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): Galleries in the inner bark. (Original.)

It must be remembered, however, that there are many different kinds of insects, some of them closely resembling the destructive species, always found in dying pine trees. Therefore, for the general observer to be positive in the matter, specimens of insects and work should be sent to the Bureau of Entomology for authentic identification.

DISTRIBUTION.

The insect is found in southern Idaho throughout, and its range extends to the northern part of the State. It is recorded from California, Oregon, and eastern and western Washington, and, according to Doctor Hopkins, a variety occurs in Arizona and New Mexico and attacks the western yellow pine (*Pinus ponderosa*) and the sugar pine (*Pinus lambertiana*).

EXTENT OF DAMAGE AND LOSSES.

With our present knowledge of the destructive work of this insect, it is evident that a vast amount of timber has been killed by it during the past ten years within the range of its distribution. It is estimated that each year for the past two or three years, from 2 to 5 per cent of the matured standing bull pine timber within the section investigated in the summer of 1905 has died as the result of its ravages.

POSSIBILITIES OF PREVENTING LOSSES.

With our additional knowledge of the life history and habits of the beetle, we are able to suggest practical methods of controlling it and of preventing a large percentage of the losses heretofore caused by its depredations.

[a] See Bul. 56, Bur. Ent., U. S. Dept. Agric. The Black Hills Beetle.

EARLY HISTORY OF THE SPECIES.

LeConte, in 1876, described the species under the name *Dendroctonus brevicomis* from a single specimen collected in middle California. Dietz, 1890, considered *D. brevicomis* the same as the southeastern species, *D. frontalis* Zimm. Hopkins, 1899, concluded that it was distinct from *D. frontalis*, and therefore that the old name should be retained.

It appears that previous to 1899 nothing had been recorded in regard to the habits and life history of this insect, and that, therefore, the earliest records were made in 1899 by Hopkins, who found it associated with dying sugar pine and western yellow pine at McCloud, Cal., on April 21, 1899, and the next day at Grants Pass, Oregon, with several hundred pine trees which had evidently died from its attack. On May 20, also, at Buckeye (near Spokane), Wash., many trees were found which were dying, or had died, as evidenced by the abundance of the insects and the extent of their work, and on June 6, at Cedar Mountain, Idaho, Doctor Hopkins found it in the bark of pine trees which had been defoliated the previous year by the caterpillars of the pine butterfly (*Neophasia menapia* Feld.). He found also that this beetle was quite intimately associated with the destruction of a large amount of timber only partly defoliated by the caterpillars.

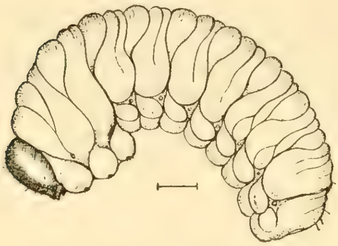


FIG. 9.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): Larva. Line below represents natural length (original).

Under his discussion of the principal scolytid enemies of the forests in the Northwest, Doctor Hopkins refers to this species as follows:[a]

> *Dendroctonus brevicomis* Lec. was found to be a most destructive enemy of the yellow pine (*Pinus ponderosa*) in northern California, southern and eastern Oregon, northeastern Washington, and western Idaho. A large amount of some of the finest timber in all of these localities had died within the past seven or eight years, evidently as a direct result of attacks by this bark beetle. It was also found to attack and prevent the recovery of trees injured by defoliating insects and other causes. Its habits and the character of its galleries appear to be identical with those of *Dendroctonus frontalis*, which is noted for its destruction of vast quantities of pine and spruce timber in West Virginia and adjoining States between 1890 and 1893. It is killing the western yellow pine just as *D. frontalis* commenced to kill the eastern yellow pine (*Pinus echinata*) before it spread to all the other pines and spruce. Therefore, just as *D. frontalis* has proven to be the most destructive enemy of eastern conifers, the western representative of this species will doubtless prove to be, under similarly favorable conditions, equally as destructive to the western forests in which the conifers predominate.
>
> Among the most important features observed regarding the habits of this beetle was the fact that it is attracted to trees girdled by settlers and farmers in the process of clearing land, and that in the bark of such trees it breeds and multiplies in sufficient numbers to enable it

[a] Bul. 21, n. s., Div. Ent., U. S. Dept. Agric., 1899.

to attack and kill the timber in adjoining healthy forests. Indeed, my observation leads me to conclude that a considerable number of girdled pine trees may easily form a nucleus for a destructive invasion by it.

In the same bulletin, under the head of "The western yellow pine," he says:

It has in *Dendroctonus brevicomis* a most pernicious enemy, which penetrates and excavates winding galleries through the living bark of the finest trees, thus speedily causing their death. Very many trees have died and are dying from this cause, and the dead ones are contributing to the spread of forest fires.

Specimens of the insect and its work occupied a prominent place in the exhaustive exhibit of insect enemies of forests and forest products at the Louisiana Purchase Exposition at St. Louis, in 1904, and the Lewis and Clark Centennial Exposition at Portland, Oregon, in 1905, and were referred to in the catalogues of the exhibits by the Bureau of Entomology.[a]

OBSERVATIONS BY HOPKINS, 1899-1904.

The following summary relating to this species, prepared by Doctor Hopkins from his field notes, includes many facts which have not been published and which have a direct bearing on the life history and habits of the species in different sections of the country where it is found:

McCloud, Cal., April 21, 1899.—Work and dead adults were discovered in a sugar pine log, evidently from a tree which was dying when felled; also dead parent adults in primary galleries, and larvæ and pupæ abundant in outer bark of large dying western yellow pine with the characteristic appearance of eastern pines when dying from the attack of the destructive pine barkbeetle, *D. frontalis*. A few immature adults were found in the outer bark, and evidence that some had emerged. This evidence was in the form of apparent exit holes in the bark, which may have been ventilating holes from main galleries, for with our present knowledge it is not likely that any adults could have emerged so early.

Grants Pass, Oregon, 1899.—On April 24 numerous dying western yellow pine trees were found here scattered through the forest where a severe windstorm had blown down much large timber on September 24, 1895. Young adults, larvæ, and pupæ were found in the outer bark of the standing trees which had evidently been attacked and had commenced to die the previous fall. April 25, numerous trees were observed which died the fall before and others which were not yet dead. One group of 30 young trees about 2 miles north of town were dying at the top, the leaves turning yellow and brown. All trees, without exception, were either infested or had been infested with *D. brevicomis*, and every indication pointed to this species as primarily to

[a] Buls. 48 and 53, Bur. Ent., U. S. Dept. Agric.

blame for the trouble. There were many trees which had been dead for from 3 to 10 years, and in the bark of those dying within the past 4 years traces of the characteristic galleries of *D. brevicomis* were found. No large bodies of timber had died, but the dead and dying trees were scattered all through the forest. A few examples of adults were found mining in living bark of a dying tree, where they had evidently passed the winter, since none of the broods had sufficiently matured to emerge. April 26, eight large trees—five western yellow pine and three sugar pine—which had evidently died in 1897, were observed in the Slate Creek Valley. The western yellow pine exhibited abundant work of *Dendroctonus brevicomis*, and the sugar pine the work of both this and a larger species of the same genus (*D. monticolæ*).

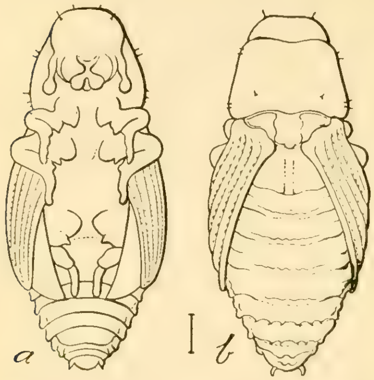


FIG. 10.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): *a*, pupa, ventral view; *b*, same, dorsal view. Vertical line in center represents natural length (original).

Buckeye, Wash. (*near Spokane*), *May 22.*—A small western yellow pine tree, evidently killed by the insects, was found. None of the brood had emerged, having died in the bark, possibly from the effects of unfavorable climatic conditions. In another tree killed by this species at this place, young living adults were found.

Cedar Mountain, Idaho (*near Moscow*), *June 4.*—The bark of western yellow pine trees defoliated by pine butterfly larvæ was found to be infested by larvæ and pupæ of *D. brevicomis*. Dead parent adults, also, were found in the primary galleries.

Mariposa County, Cal., June 9, 1904.—Fragments of dead adults were found in primary galleries in bark of a large western yellow pine tree, evidently killed by this species.

Yosemite Valley, California, June 13, 1904.—Western yellow pine trees cut between September 20 and 24, 1903, were found to be thickly infested with larvæ of this species from eggs evidently deposited in September or October.

OBSERVATIONS BY H. E. BURKE, 1904.

From October 20 to 26, 1904, Mr. Burke found the work of this species on western yellow pine quite abundant in the region of Smiths Ferry, Idaho. Under date of October 26 he records observations regarding this barkbeetle in a western yellow pine tree 3 feet in diameter felled some time during that summer; the foliage and bark were living, but red borings on the bark showed where insects had entered. Adults of the Dendroctonus were present in short winding galleries in the living inner bark, two adults to a gallery. Eggs occurred singly in niches on the sides.

He estimated that as a result of the work by this insect near Smiths Ferry 30 per cent of standing timber was dead and 5 per cent was dying. This was at the worst point of infestation, but scattered dying timber was found all over Boise and Payette basins. The same condition extended into the Bitter Root Forest Reserve.

OBSERVATIONS BY THE WRITER, 1905.

The investigations by the writer during the summer of 1905, so far as they related to this species, were mainly for the purpose of determining the principal facts in its life history and habits in the vicinity of Centerville and Smiths Ferry, Idaho. The results may be summarized as follows:

LIFE HISTORY AND HABITS OF THE INSECT.

HIBERNATION.

While it is probable, as observed by Hopkins at Grants Pass, Oregon, that a few parent adults which enter the bark in the fall may pass the winter in that stage, it appears that it is in the young to matured larval stages that the insect normally passes the winter, each individual in a separate mine or cell in the outer corky bark of the tree in which it developed the previous summer and fall. The earliest observations at Centerville were made on May 18, when larvæ, pupæ, and young adults were found. Some of the larvæ were small, but the majority of them were mature and ready to change to pupæ. The pupæ and adults had evidently transformed from larvæ since the beginning of activity in the spring.

The latest date on which larvæ of the hibernating broods were found was June 13. Pupæ were found as late as July 3, and adults July 7. It is therefore evident that the majority of the over-wintering broods develop to the adult stage by about the middle of June, but broods from eggs deposited late in the fall may not develop until nearly the middle of August. Adults begin to emerge in the latter part of May and continue to do so through June and July and into August. Thus the period of activity of the hibernating broods at Centerville is probably from the first warm days in April and May until about the last of July—approximately 90 days—the majority, however, coming out in June and in early July.

FIRST GENERATION.

The first generation at Centerville begins with the first eggs deposited, apparently about the last of June, by the adults developed from hibernating larvæ and pupæ. These eggs hatch in about 4 days after deposition. The principal egg-laying period for this generation is evidently between the latter part of June and the first part of August.

It would appear that the length of time spent in the larval state is from 31 to 35 days. Sometimes, however, a few individuals of this first generation, either from retarded development or other causes, do not go through their transformations with the rest of the broods, but remain as larvæ all through the fall and winter, evidently changing to pupæ in the following spring.

The length of time spent in the pupal stage is approximately 15 days. Pupæ of this generation were observed in different broods from August 14 to September 6.

The first adults, evidently of this generation, were observed in the bark August 14. The length of time spent in the bark after reaching this stage appears to be from 7 to 14 days. It is difficult to tell just when the emergences cease, as the last individuals of the brood come out scatteringly. Thus, on October 10 a few adults were still found in the bark. As this was the last observation, it is not known whether adults emerged later in the fall or whether they passed the winter in the bark before emerging; but the latter was probably the case. In one tree under observation eggs were deposited July 6 and the broods developed and emerged by August 28, a period of 53 days. Thus it appears (1) that the first generation begins with eggs deposited probably in the latter part of June; (2) that the majority of the broods develop and emerge by the first part of September (a period of about 60 days), but that some may continue to develop and emerge until in October; and (3) that possibly some pupæ and young and matured adults may hibernate along with the larvæ. Thus it may require 300 to 390 days or more for the complete development and emergence of some individuals of the first generation.

SECOND GENERATION.

Eggs deposited by adults of what appears to have been the first generation were found August 26 and as late as September 13. It will therefore be seen that there is a partial overlapping of the periods of the two generations.

Larvæ were found as early as September 4, and on October 10, when the last observation was made, some larvæ were apparently full grown.

No pupæ or adults of this generation were found up to the time of the writer's last observations—on October 10, 1905. Mr. Burke found adults, but probably of the first generation, excavating galleries and depositing eggs as late as October 26, 1904. Thus it appears that the second generation, beginning with the first eggs deposited by adults of the first generation, passes the winter in the larval stage and develops and emerges by the middle of the following June to the first part of July. It therefore occupies a period of about 315 to 330 days, including about 60 days of activity in the fall, 165 days of hibernation, and 90 to 105 days of activity in the spring and early summer.

It is probable that at higher elevations and farther north the majority of the broods would not develop in much less than a year's time and that at more southern and warmer localities in the Pacific Coast region there would be two complete generations and possibly a partial third.

F... 11.—The western pine-destroying barkbeetle *Dendroctonus brevicomis*): Pitch tubes on bark of tree. (Original)

HABITS.

When first transformed, in May and June, the young beetles have very soft, delicate tissues. They therefore remain in their pupa cases until their bodies are fully hardened or chitinized. When nearly ready to emerge, the adults bore their way almost to the surface of the bark (fig. 12, *a*), but pause before emerging, appearing to rest in the burrows they have just made. They do not, however, hollow out the space immediately adjoining the pupa case, as is the habit of another species of this genus. When quite ready to emerge, the beetles continue their burrows out through the remaining portion of the bark. The individuals of a brood do not appear to emerge simultaneously, but they come forth at irregular intervals until all are out, leaving the bark thickly punctured with small, round, clean-cut holes, as shown in figure 12.

After leaving the tree or trees in which they went through their transformations the beetles fly away to find trees in which to deposit eggs. They may select trees close at hand or may fly quite a long distance before making a selection. They will also enter the living bark of recently felled trees. Large numbers of the beetles usually settle upon a few trees close together and crawl about upon the bark from near the base to about two-thirds of the distance to the tree's top, seeking suitable places for entrance. Crevices in the bark are favorite places with them for this purpose. The female appears to bore the entrance hole in the bark, and may or may not be closely followed by her mate. In some cases where galleries had just been started, females were found alone, that is, one female to a single gallery. In others, the female was followed by the male. As the first incision is made into the living inner bark, the tree begins exuding pitch to cover the wound made by the intruding beetle. This pitch or resin collects at the mouth of the entrance hole in the form usually known as a pitch tube (figs. 11 and 12, *c*). Where the attacking force of beetles is small, the efforts of the tree to heal these wounds not infrequently succeed, the flow of pitch being so great as to overcome and suffocate the beetles. In such cases the dead beetles may be found in the pitch masses after the tree has recovered. Where the attacking force is large, however, the flow of pitch does not seriously hinder the beetles. After completing the egg laying, the parent adults remain for some time in the galleries and excavate irregular branching burrows toward the end farthest from the entrance, where they remain until they die.

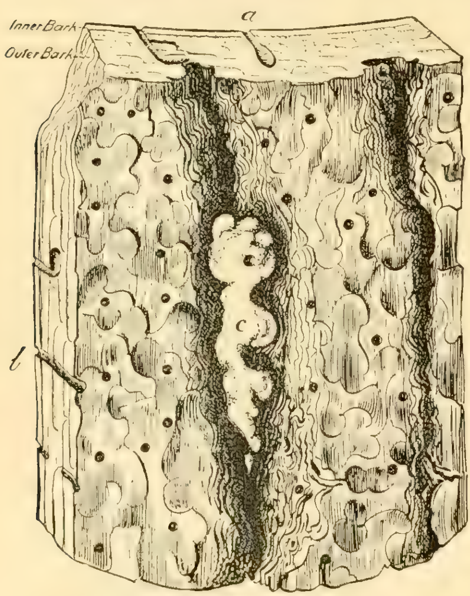


FIG. 12.—The western pine-destroying barkbeetle (*Dendroctonus brevicomis*): *a*, hibernating or transformation cell; *b*, exit burrow; *c*, pitch tubes and exit holes. (Original.)

After successfully effecting their entrance into the bark, the females excavate, through the inner layer of bark, winding, irregular galleries, which run into and cross each other many times (fig. 8). The eggs are laid at the sides of the gallery, each in a little niche hollowed out to receive it and packed in with the borings made in excavating the gallery.

Almost immediately after hatching the larva begins feeding upon the cambium surrounding the niche in which it hatched. For a few days it remains in the cambium, then bores out toward the outer bark. As it progresses, it is at the same time growing, and this growth is indicated by its constantly widening mine or burrow, which is made larger to accommodate the size of the body. Having reached the outer bark, it hollows out an oval space or pupa case, in which to go through its transformations.

NATURAL ENEMIES.

INSECTS.

Larvæ of the predaceous beetles of the genus Clerus, which are known to prey upon Dendroctonus larvæ, were quite common in and under the bark of the infested trees, and they doubtless help to some extent in keeping down the numbers of the barkbeetles.

BIRDS.

Birds contribute their part also in destroying larvæ and pupæ. The work of woodpeckers was found upon most of the trees which had been killed by *D. brevicomis*, and these birds had evidently destroyed a large percentage ot the insects in some of the trees.

METHODS OF COMBATING THE INSECT.

FIRST RECOMMENDATIONS.

The following information and recommendations relating to this insect and methods of preventing losses from its ravages were conveyed by Doctor Hopkins to Mr. E. M. Hoover, of Boise, Idaho, manager of the Payette Lumber and Manufacturing Company, in a letter dated January 23, 1906, and afterwards published, with Mr. Hoover's reply, in a local newspaper.

Our special field agent, Mr. J. L. Webb, has submitted his report on forest insect investigations in the vicinity of Centerville and Smiths Ferry, Idaho, during the past summer, and it will interest you no doubt to know that the insect which is primarily to blame for the death of pine trees was located and thoroughly studied by him.

He found that the broods of the destructive species pass the winter in the grub state in the bark of trees which died during the late summer and fall and that they do not transform to the v inged form and emerge until after the 1st of May. Therefore the method of combating the pest is simply to cut the infested trees any time between the 1st ot October and the 1st of May and to remove the bark from the main trunk and burn it.

It is necessary to burn the bark in order to kill the broods of this insect, because they occupy the intermediate portion between the inner surface and the outer scale portion; hence the drying of the removed bark will not kill them as it would if they occupied the inner moist portion.

The infested trees can be located (1) by the yellowish and light reddish brown color of the foliage; (2) by cutting into the bark as high up on the trunk as a man can reach with an ax to determine whether the middle portion of the bark is infested with the small white grubs, which are about three-sixteenths of an inch long. If these are found, it will be conclusive evidence that the tree has been killed by the beetle and is infested with its broods. It must be remembered that there are hundreds of other kinds of insects which occupy the *inner* portion of the bark and wood of such trees, but none of the smaller ones pass the winter in the *outer* bark. * * *

Perhaps the most important thing for you to do as a preliminary to any definite action you may take in the matter is to have a number of intelligent cruisers make a survey of your holdings for the purpose of locating the principal sections in which trees have died during the past summer and the location of the larger clumps and patches of infested trees within such sections; then, if the locations of the infested areas and clumps are indicated on a map, it will aid materially in planning effectual operations. If you could conduct your logging operations in these sections and utilize the infested trees the desired results would be accomplished without much expense. It is not necessary that all scattering infested trees should be felled and barked, but it is of the greatest importance that all of the larger clumps and patches within the worst infested areas should be thus treated within the period mentioned. If this can not be done this year, the work of locating infested areas should be conducted next summer (1906), in order that the more important sections may receive attention next fall and winter.

We shall hold ourselves in readiness to give you further information and suggestions on subjects which may not be clear to you, and whenever there is doubt about the insect or its work specimens should be sent to us for authentic identification.

In response to this letter, Mr. Hoover wrote:

We are most gratified with the information given us and feel that it will be of much value to us in our woods operations. * * *

The ferreting out of the insect pest and advising a way to combat it is a work of great value to the country and of especial interest to all persons interested in forests, and we wish to add our word of appreciation of the service of your Bureau.

Your letter is clear and explicit, and we will be glad to take advantage of your suggestions in our logging operations and have conveyed the information to other lumber companies operating in this vicinity.

Doctor Hopkins has, since then, prepared the following additional recommendations and summary:

TRAP TREES.

With our present knowledge of the life history of the western pine-destroyer and its habits of attacking girdled and felled trees, it is evident that trap trees[a] may prove effective in keeping the insect under control, especially in localities where only a few trees are being killed each year or after a large number of the infested trees have been felled and barked in a badly infested locality.

The time to girdle and fell trees to catch the first generations would be about the middle of June, the bark to be removed and burned in about 20 to 25 days, or before the broods emerge. Girdled or deadened trees are prepared by the "girdle to heartwood" method—that is, cutting through the sapwood all around the trunk 3 or 4 feet above the base or as high above the base as convenient to chop; for this purpose large, inferior trees should be selected.

Felled trees should be lodged or allowed to fall on logs, rocks, etc., so that the prostrate trunks will be as far as possible from the ground. Trees prepared in this manner will usually be attacked by swarms of the beetles, which will excavate galleries in the bark and deposit their eggs. After the eggs have hatched and the larvæ are about full grown, the removal and burning of the bark will effectually destroy the broods and thus contribute greatly to reducing the numbers of the beetles—

[a] Living trees girdled or felled at the proper time to attract the flying beetles to them and away from healthy trees.

which must occur in large numbers before they can attack and kill a tree. Some of the living trees in the immediate neighborhood of the trap trees may be attacked by beetles attracted to the vicinity by the felled or girdled trees. These should be felled and treated the same as trap trees.

If the conditions appear to warrant it, additional trees should be girdled or felled about the first part of August to catch the second brood. These may be barked, to kill the broods, any time between the first part of October and the first part of the following May.

SUMMARY.

HABITS AND LIFE HISTORY.

The western pine-destroying barkbeetle usually attacks and kills the best examples of western yellow pine and sugar pine.

If neglected and under certain conditions favorable to the species, it is capable of devastating the pine forests over large areas. The broods of the beetle pass the winter in the outer bark of trees killed by it the previous summer. The adults of the overwintering broods emerge and fly in May, June, and July, the beginning and ending of the period varying with the seasons, latitude, and altitude.

The first eggs from the first generation are deposited in June or July, and in some of the warm localities possibly as early as the middle of May. In localities intermediate between the colder and warmer regions the majority of the adults of the first generation evidently develop and emerge in August, but some individuals may remain in the trees until June of the next year.

The first eggs of the second generation are evidently deposited in August and September, depending on locality, and it would appear that in intermediate localities all of the broods of this generation pass the winter (hibernate) in the larval stage in the outer bark. In the warmer localities some of them may develop and emerge in the fall, while in the colder localities there may be but one generation.

The first evidence of attack on living trees is the presence of pitch tubes (figs. 11 and 12, *c*) on the bark or of reddish borings lodged in the crevices and around the base of the tree.

During the fall, winter, and following spring, after a successful attack, the infested trees will be indicated by the fading yellowish and reddish leaves.

The work of the insect will be indicated by the winding galleries through the inner bark (fig. 8). Trees from which the broods have emerged will be indicated by large numbers of small holes through the outer bark (fig. 12).

REMEDIES.

The principal areas of infestation and the principal patches of infested trees should be located in September and October.

Beginning with the first part of October, the infested trees should be felled and the bark removed from the main trunk and burned, these operations to be completed by the first part of the following May.

If all of the trees within a given area can not be thus felled and treated, the work should be concentrated on the larger clumps and patches of infested trees.

The cost per tree for cutting, barking, and burning the bark will range from about 30 cents to $1, depending on locality and accessibility.

Summer cutting, except in regular logging operations, is undesirable, since the cutting of a few trees in the midst of a large forest may attract the insects from a long distance, and thus result in extensive depredations in bodies of timber which it is most desirable to protect.

TRAP TREES.

In sections where it is known that the beetle is killing some of the timber, trap trees should be provided in June and August. Ordinarily, 4 or 5 inferior living trees within each section, on which there is evidence of the work of the beetle, should suffice.

Trap trees should not be prepared unless it is reasonably certain that the bark will be removed and burned before the broods of the beetles develop and emerge, otherwise such trees may contribute to the destruction of a larger amount of timber.

STORM-FELLED OR LIGHTNING-STRUCK TREES.

Storm-felled and lightning-struck trees are a menace to a healthy forest within the distribution of this insect, since they serve as breeding places and centers of infestation. Therefore, whenever practicable, such trees should be watched, and if found infested with broods of this beetle, they should be treated as recommended for infested and trap trees.

PUBLICATIONS RELATING TO THE WESTERN PINE-DESTROYING BARKBEETLE.

1876. LeConte, J. L.—The Rhynchophora of America North of Mexico. Proc. Am. Philos. Soc., Vol. XV, Dec., p. 386. Species described.

1890. Dietz, W. G.—Notes on the species of Dendroctonus of Boreal America. Trans. Am. Ent. Soc., Vol. XVII, p. 32. Revision notes.

1899. Hopkins, A. D.—Preliminary Report on the Insect Enemies of Forests in the Northwest. Bul. No. 21, n. s., Div. Ent., U. S. Dept. Agric., pp. 13–15. First notes on habits.

1904. Hopkins, A. D.—Catalogue of Exhibits of Insect Enemies of Forests and Forest Products at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. Bul. No. 48, Div. Ent., U. S. Dept. Agric., p. 18. Character of work described.

1905. Currie, R. P.—Catalogue of the Exhibit of Economic Entomology at the Lewis and Clark Centennial Exposition, Portland, Oregon, 1905. Bul. No. 53, Bur. Ent., U. S. Dept. Agric., pp. 74 et seq. Reprinted from Bul. 48.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN NO. 58, Part III.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

ADDITIONAL DATA ON THE LOCUST BORER.

BY

A. D. HOPKINS,

In Charge of Forest Insect Investigations.

ISSUED MARCH 5 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., February 5, 1907.

Sir: I have the honor to transmit herewith a manuscript entitled "Additional Data on the Locust Borer," prepared by Dr. A. D. Hopkins, in charge of forest insect investigations of this Bureau. It comprises a partial revision of Part I of Bulletin No. 58, and additional information based on the results of investigations carried on since that part was issued. I recommend that it be published as Bulletin No. 58, Part III, of the Bureau of Entomology.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

SOME INSECTS INJURIOUS TO FORESTS.

ADDITIONAL DATA ON THE LOCUST BORER.

(*Cyllene robiniæ* Forst.)[a]

By A. D. Hopkins,
In Charge of Forest Insect Investigations.

This part of Bulletin 58 contains a partial revision of Part I, with additional information based on the results of subsequent investigations by the writer and one of his assistants, Mr. W. F. Fiske.

SEASONAL HISTORY.

The data under this head refer to the District of Columbia and vicinity, latitude 39°, altitude 10 to 90 feet above tide.

HIBERNATION.

Hibernation begins soon after the larvæ hatch from eggs deposited at various times from August to October, and the period is passed as minute larvæ, scarcely longer than the eggs from which they hatch, in small individual hibernating cells excavated by them just beneath the corky bark and in the outer layers of the living bark on the main trunk of the larger to small trees or small saplings, and larger to small branches.

ACTIVITY OF THE OVERWINTERED LARVÆ.

Activity of the overwintered larvæ begins in April, or with the beginning of the movement of the sap in the bark and just before the leaf buds open. In 1906 activity began April 11; on April 13 the more advanced individuals had entered to the wood, on the 16th were grooving the surface, and on the 25th some of them had entered the wood. By May 11 nearly all of them had entered the sapwood and some of them had extended their burrows into the heartwood and were rapidly

[a] Order Coleoptera, Family Cerambycidæ.

increasing in size and very active, so that by May 20 some of them were more than half grown. They continued actively feeding and growing until after the middle of July, when they began to transform to pupæ and continued transforming during August until all had transformed, probably by the 1st of September. The pupæ begin transforming to adults about the 1st of August and continue transforming probably into September, although the principal transformation is in August.

ACTIVITY OF THE ADULTS.

The adults begin to emerge as early as the 7th of August, and continue emerging until the last of September, the greater number coming out during the last part of August and the first half of September. Evidently all beetles are out by the first week in October.

The females begin to deposit eggs within a few hours after they emerge. The principal period of oviposition appears to be between the middle of August and middle of September, but oviposition continues until in October. The eggs hatch within eight or ten days after they are deposited, and the young larvæ excavate their hibernating cells and remain dormant until the following spring.

VARIATION IN SEASONAL HISTORY BETWEEN DIFFERENT LATITUDES AND ALTITUDES.

Phenological investigations of plants and insects by the writer[a] during the past ten years indicate that the average difference in the dates of occurrence of the different stages of *Cyllene robiniæ* at different latitudes and altitudes in the eastern United States will not be far from four days later for each degree north of latitude 39° and for each 400 feet of altitude above Washington at the same latitude, or four days earlier for each degree south of latitude 39° at the same altitude.

Thus, at latitude 43° in central New York, or central Michigan, with altitude the same as at Washington, the dates would be about sixteen days later, and at altitudes of 1,000 feet at latitude 43° they would be about twenty-six days later; at the same altitude as that of Washington at latitude 35° in southern North Carolina and Tennessee they would be about sixteen days earlier or at 1,600 feet elevation about the same. Thus we would have about thirty-two days' difference between localities at the same altitude in central New York and southern North Carolina. We would also have thirty-two days' difference between Washington and localities at latitude 39° and altitudes of 3,200 feet in the mountains of Virginia and West Virginia.

[a] Bull. 50, W. Va. Agric. Exp. Sta., 1898, pp. 17, 18, and Bul. 67, 1900, pp. 241–248, with map.

HABITS OF LARVÆ AND ADULTS.

When a larva begins activity in the spring it molts and proceeds to excavate an independent food and entrance burrow through the dead area of bark surrounding the hibernating cell or through the living bark immediately surrounding the dead area, until it reaches the cambium. It then excavates an irregular groove or cavity in the outer sapwood, returning frequently to the outer cell or opening to push out the borings and apparently to get relief from the exuding sap. A large per cent of the larvæ die before any further progress is made, but survivors grow rapidly and soon succeed in overcoming the many obstacles, including natural enemies, resistance of the tree, etc., and enter the sapwood. From this stage on until the larvæ have attained their full growth they are very active and destructive. Their food consists principally of the nutritious substances of the bark and wood, and probably of the liquids flowing into the burrow, but they do not hesitate to kill and feed upon each other when two or more come in contact within the same burrow. The fact that the entire development often takes place in a burrow scarcely more than twice the length of a matured larva indicates that food must be obtained from some source other than the wood and bark. Throughout its active life the larva frequently returns to the inner and outer bark to enlarge the burrow, and push out its borings, so that the burrow when completed is of a diameter throughout sufficient to allow the passage back and forth of the full grown larva. When full grown the larva enlarges the inner end of the burrow, plugs the outer portion with boring chips, and in due time transforms in succession to the pupa and adult. When the adult is fully matured it escapes through the exit prepared by the larva. Immediately after a female emerges she is joined by one or more males, and within a few hours, or within twenty-four hours, she proceeds to deposit eggs. She runs about over the bark investigating the crevices, by means of her ovipositor, to locate those most suitable for an egg. Sometimes as many as twenty places are critically examined before one is selected, and it appears that but one egg is deposited in a place by the same female, but other females may find the same place and each deposit an egg, so that sometimes several eggs are found in one crevice. As a rule, however, there is but one. The faculty of the female in locating the most suitable place for an egg by means of the sensitive palpi on the tip of the ovipositor is remarkable.

The beetles feed principally on pollen from the flowers of golden-rod, but are very fond of any sweet liquid, such as sugar sirup placed on the trunks of the trees. They are found during the day on the trunks, branches, and foliage of the locust, and during their principal period of activity, from toward the last of August to the middle of September, they are especially common on the golden-rod flowers. Mr. Fiske determined that they were also actively copulating and depositing eggs as late as 10 o'clock at night.

The attack of this insect is apparently confined to the black or yellow locust (*Robinia pseudacacia*).

ECONOMIC FEATURES.

DESTRUCTIVE CHARACTER OF THE WORK.

The destructive character of the work of the locust borer is a matter of great economic importance. This insect attacks the otherwise perfectly healthy trees, and in addition to causing the detrimental wormhole defects in the wood it often kills the trees or renders an otherwise valuable product worthless except for fuel. It is much more destructive in some localities and sections than in others, and also much more destructive to some trees in the same grove than it is to others. It is more destructive also to young saplings and the branches of medium-sized trees than to the larger trees.

The death of a tree is caused principally by injuries to the inner bark and cambium, resulting from repeated attacks. Injuries to the wood alone do not result in the death of trees except when all of the wood is practically destroyed or sufficiently injured to cause the tree to fall or be broken down by the wind.

The commercial value of the wood product is diminished or destroyed by the wormhole defects, but for certain purposes, as, for instance, fence posts, a limited number of such defects are not detrimental, except so far as they may contribute to decay.

EVIDENCES OF ATTACK.

The first evidence of attack is fine brownish boring dust and wet spots on the bark, first observed in April, when the overwintered larvæ begin to enter the inner bark. As soon as the larvæ begin to groove the surface of the wood and enter the sapwood, their presence, in addition to the wet spots, is indicated by yellowish boring dust mixed with liquids and the gum-like exudations. After all of the larvæ have entered the wood their presence is plainly shown by the quantities of yellowish boring dust lodged in the loose bark on the trunk, in the forks of the tree or branches, and around the base. At this stage, usually about the middle of May, the badly infested trees which will die are plainly indicated by the failure of the leaf buds to open, or by the dwarfed or faded and sickly appearance of the foliage, and toward the last of the month and until the larvæ have completed their work in July, by the breaking down of the branches and small trees.

FAVORABLE AND UNFAVORABLE CONDITIONS FOR DESTRUCTIVE WORK.

Favorable conditions for the destructive work of the borer appear to be found in the presence of isolated trees and groves in the open in localities where golden-rod is present or abundant; also, where less resistant varieties of the tree prevail.

Unfavorable conditions are found in forest growth or large areas of pure stands, or mixed stands where the locust predominates; also, in plantations and groves where resistant varieties prevail, and where there is no golden-rod or other favorite food for the beetles. It is also found that coarse, thick bark is less favorable than the thinner bark on old and young trees and saplings.

NATURAL ENEMIES.

INSECTS.

Several predaceous insect enemies of the larvæ have been observed, but so far no true parasites have been discovered. A large elaterid larva (*Hemirhipus fascicularis* Fab.) appears to be the principal enemy of the borer after the latter has entered the wood. It resembles the borer somewhat, but is easily distinguished by the more flattened and shiny body, long prothoracic legs and two curved spines on the last abdominal segment. This predaceous larva is frequently found in the empty mines of the Cyllene larvæ, therefore it is evidently an enemy of considerable importance.

A slender, cylindrical, whitish, footless dipterous larva of an undetermined species is sometimes found in the mines in the wood, and, according to an observation made by Mr. Pergande, it may attack and kill the borers.

Whitish, flattened larvæ of the nitidulid genus Ips, with prominent branched hooks on the last abdominal segment, are common in the sap at the entrance of the mines and in the burrows made by the young borers in the inner bark and outer wood. They are supposed to be sap feeders, but the writer found they would attack and devour young Cyllene larvæ when confined together in a bottle. Therefore it is possible that they kill a great many of the young borers before these enter the wood, which may account, in part, for the disappearance of such a large number of the young borers while in the bark-boring stage.

It was also demonstrated that if several young Cyllene larvæ of various sizes were placed together in a small vial, the larger ones would kill and eat the smaller ones. It is probable, therefore, that when several larvæ hatch from a cluster of eggs and but one survives—which is usually the case—the larger or stronger one has killed the weaker ones.

DISEASE AND SAP FLOW.

Dead larvæ are frequently found in the mines, covered with white flour-like spores, and sometimes these spores are so common that a perceptible cloud rises from the wood when it is split open. Experiments in placing some of the spores with healthy uninjured larvæ in bottles, as well as with those in the normal position in the wood, resulted in the death of the larvæ and the development of apparently the same disease, while the duplicate larvæ kept under the same conditions, but without contact with the spores, remained normal and healthy. Therefore this is a fungus which will kill the borers and one which is evidently of considerable importance.

The profuse flow of sap together with a gummy substance in the wounds made in the living bark and cambium is evidently detrimental to the normal progress of the young larvæ and apparently many of the latter are thus destroyed.

METHODS OF CONTROL.

It should be remembered that all the holes found in a tree and all other damage by the borer are not the work of one generation, but usually that of repeated annual attack during the life of the tree; also, that a burrow in the sapwood of a young tree remains the same burrow in the heartwood of the old tree, without change, as long as the tree exists, except in the healing of the original entrance. The number of borers and the annual amount of damage is not so great, therefore, as might appear, and, while each female is capable of depositing a hundred eggs, only a small percentage of the larvæ hatching from them survive the bark-infesting stage or complete their development to adults. This suggests that any method of management which will insure the destruction of a large per cent of the surviving larvæ and beetles each year will reduce the damage to a point where there will be practically no loss.

With our knowledge of the life history and habits of the insect it is now possible to make definite recommendations and suggestions for its control. Some of those of immediate practical importance are as follows:

TIME TO CUT LOCUST TO DESTROY THE YOUNG LARVÆ.

The cutting of locust for all purposes, including thinning operations and for private or commercial use, should be done during the period between the 1st of October and the 1st of April, the bark removed from the crude product, such as posts, poles, and the like, and the tops and thinnings burned. The removal of the bark from all desirable portions of the trunks of the trees felled during this period is important and necessary in order to destroy the larvæ before they enter the wood. The work in all cases should be completed before the leaf buds begin to swell on the living trees in the spring.

DESTRUCTION OF INFESTED TREES AND WOOD.

When it is desirable to simply remove and destroy, by burning or otherwise, the badly infested and damaged trees to kill the broods of larvæ, the work should be done in May and June, when all such trees can be easily recognized by the boring dust, fading leaves, broken branches, etc., and must be completed before the beetles begin to emerge. Perhaps the best rule, applicable to all localities, latitudes, and elevations, is to complete the work by the time the flowers have all fallen from the trees, which will vary between different altitudes and latitudes from about the middle of May to the last of June. Another rule would be to complete the work before the earliest varieties of golden-rod begin to show evidences of flowering. This, however, would be the latest that the work should be done, because the beetles begin to emerge by the time the first golden-rod flowers appear.

SPRAYING THE TRUNKS AND BRANCHES TO KILL THE YOUNG LARVÆ.

Experiments have demonstrated that the hibernating larvæ may be killed by spraying the trunks and branches with a strong solution of kerosene emulsion. Therefore, when it is practicable or more desirable to adopt this method for the protection of small plantations, groves, or shade trees, the spraying should be done in the fall or winter, not earlier than November 1, and not later than April 1—in other words, during the dormant period of the tree. The following paragraphs, relative to the preparation of kerosene emulsion, are taken from Farmers' Bulletin No. 127, by C. L. Marlatt:

Kerosene emulsion (soap formula)—

Kerosene	gallons..	2
Whale-oil soap (or 1 quart soft soap)	pound..	½
Water	gallon..	1

The soap, first finely divided, is dissolved in the water by boiling and immediately added, boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three to five minutes' pumping the emulsion should be perfect, and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well made, the emulsion will keep indefinitely, and should be diluted only as wanted for use.

For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means.

The use of whale-oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, and does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and 1 quart of it may be taken in lieu of the hard soaps.

In limestone regions, or where the water is very hard, some of the soap will combine with the lime or magnesia in the water and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed. * * *

For use on locust trees dilute 1 gallon of emulsion with 2 gallons of soft water.

Pure kerosene and pure petroleum will effectually kill the insects, but may do some damage to the bark of the trees.

Experiments with carbolic emulsion indicate that this preparation is of no value to kill the young larvæ.

POISON BAIT.

Experiments showed that the beetles would feed readily on poisoned bait, such as sugar, sirup, or molasses with some arsenical mixed in, when this was smeared on the trees. Such baits are fatal to the beetles, but the danger of killing honeybees is so great that their use is not recommended in localities where honeybees are kept.

DAMAGE TO CUT WOOD AND DANGER OF INTRODUCING THE INSECT INTO NEW LOCALITIES.

We have determined that after the borers have once entered the wood they may complete their development in the cut and dry branches; they will evidently do so, therefore, in posts or other material manufactured from trees cut between the 1st of May and the middle of September; from this it is plain that locust should not be cut during this period for any purpose except to destroy the borers, or, if it should be necessary to cut it, the tops should be burned and the logs submerged in ponds or streams for a few days before they are shipped or manufactured. This is very important, both to prevent damage to the manufactured material and the introduction of the insect into the far West and other sections of the country which are at present free from it.

SELECTION OF LOCATIONS FOR EXTENSIVE PLANTINGS.

The fact that there are many sections and localities of greater or less extent within the natural home of the locust and its insect enemies where, from some unknown cause, the tree grows to large size and old age without perceptible injury from borers and other insects, suggests the importance of selecting such localities for any proposed extensive operations in the line of artificial planting, or utilization of natural growth. It will be found, however, that no area of considerable extent, even in such localities, is entirely free from this and other destructive insect enemies, and that certain precautions and well-planned methods of management with reference to the control of the latter will be necessary.

MANAGEMENT OF PLANTATIONS TO PREVENT INJURY.

In the first place it is necessary, in order to provide against future losses from the borer, that a thorough survey be made in May and June, not only of the area to be utilized but of the entire neighborhood for a radius of a mile or more from its borders, for the purpose of locating and destroying scattering trees and groves which are more or less seriously infested or damaged by the borer. It would seem that the control of such large areas, by purchase or under a plan of cooperation between the owners of the land or trees, is one of the most important requisites for success in preventing future losses from the ravages of this and other insects in small as well as large plantations. In fact, it is the writer's opinion that, with this precaution properly and continuously carried out, locust may be successfully protected from the borer in any locality.

In the subsequent management of plantations and of natural forest and sprout growth it is important each year to locate and destroy the worst infested trees for the purpose of killing the borers in the wood, and to conduct the thinning and commercial cutting operations during the period between October of one year and April of the next, in order to destroy the young borers before they enter the wood.

Worthless, scrubby, borer-infested trees should be killed outright by stripping the bark from 4 or 5 feet of the lower stem during August to prevent sprouts and seed production from them, and at the same time to destroy the eggs and young borers. Trees deadened in this manner will usually be so completely killed that not a single root sprout will appear. Therefore this method is of special value in preventing sprout reproduction from inferior individual trees.

SELECTING AND BREEDING BORER-RESISTANT TREES.

The fact that some trees are more or less resistant to attack or injury by the borer, while adjacent ones in the same grove are attacked year after year and seriously damaged, suggests breeding races and varieties of the species which would be permanently resistant.

Breeding experiments have been begun in cooperation with the Bureau of Plant Industry and the Forest Service, but it will require several years to get definite results. In the meantime, however, it is important that seed and cuttings for commercial planting should be selected, as far as possible, from trees which show least damage from the borer and are otherwise vigorous and healthy. From a well-established principle in the heredity of plants and animals, this practice of propagating from the best examples must certainly yield better results than would follow a disregard of the character of the trees from which seed or root propagations are made.

For reference to literature, and other information not included in this paper, the reader is referred to Part I of this bulletin, pages 1 to 16.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 58, Part IV.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

THE SOUTHERN PINE SAWYER.

BY

J. L. WEBB, M. S.,

Agent and Expert.

Issued November 10, 1909.

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GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., August 26, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "The Southern Pine Sawyer," prepared by Mr. J. L. Webb, of this Bureau, and to recommend it for publication as Part IV of Bulletin No. 58 of the Bureau of Entomology. It is the result of special investigations by Mr. Webb, and relates to a subject of much economic importance to the timber interests of the Southern States and especially of sections in which the pine timber is damaged by storms. The results of these investigations and the information contained in this paper make it possible to avoid a large percentage of the losses from damage by the sawyer which heretofore have seemed inevitable.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

SOME INSECTS INJURIOUS TO FORESTS.

THE SOUTHERN PINE SAWYER.

(*Monohammus titillator* Fab.)

By J. L. WEBB, M. S., *Agent and Expert.*

INTRODUCTION.

Monohammus titillator, or the southern pine sawyer, has been known to systematic entomology for over a century. It is somewhat surprising to note, therefore, that scarcely anything is to be found in literature upon the economic importance of this insect, which may truly be said to be one of the most destructive enemies of the crude product of pine forests, especially in the Southern States. Of late years the increasing number of severe storms, so destructive to pine forests in the Southern States, has provided such excellent breeding places for the sawyer in felled trunks and standing stubs that its work is now known to every lumberman in that section of the country as one of the worst injuries to his industry with which he has to contend. The increasing demand by these lumbermen for exact information in regard to the insect rendered necessary a personal investigation of the seasonal history, habits, and facilities for control. To that end the writer spent the months of July and August, 1908, in southern Mississippi, near the town of Baxterville, for the purpose of studying the insect and its habits and conducting a few experiments to determine the best remedy for combating it. Subsequently trips were made to this region in October, 1908, and March, 1909. Investigations were also made, in the latter part of July, 1908, in a district near Kentwood, La., that had been visited by a cyclone, and in a similar district near De Queen, Ark., in October, 1908. The results of these investigations are given in the following pages.

The writer desires to acknowledge, in this connection, the courtesy and kindness of Mr. E. McLennan, of Hattiesburg, Miss., general agent for a company controlling timber land in that vicinity, in furnishing trees on the company's property to be felled for use in seasonal history experiments.

HISTORY.

In 1775 Fabricius published a short description of the adult from a specimen in the British Museum, calling it *Lamia titillator,* and gave its habitat as "Carolina." He also published short descriptions under the same name in 1781 and 1787. Somewhere between 1788 and 1793, the exact date unknown, Linnæus, in the Systema Naturæ, edited by Gmelin, published a short description under the name *Lamia titillator* Fab. In 1792 Fabricius again published a short description of *titillator,* and also published a description of *Lamia dentator,* with "Carolina" as habitat. The latter name has since been placed in synonymy. Olivier, in 1795, published a short description and figure of the adult under the name *Cerambyx titillator* Fab. He gives it the common name "Capricorne chatouilleux" or the "long-horned tickler," and the habitat as "Carolina." At the same time he published a short description and figure of *Cerambyx carolinensis* (common name, the Carolina longhorn), which has since been made a synonym of *titillator,* and gave the habitat as South Carolina. Somewhere between 1795 and 1811, the exact date not being known, the same author published short descriptions of *Lamia titillator* and *Lamia carolinensis,* giving the habitat of the former as "Carolina," and of the latter as South Carolina. In 1805 Beauvois published a short description and figure under the name *Lamia dentator.* In 1835 Serville described the genus Monohammus, and placed *dentator* and *carolinensis* in it, without mentioning *titillator.* Le Conte, in 1854, published a short description and placed *dentator* and *carolinensis* in synonymy. In this connection he says: "Olivier's *carolinensis* very obviously is the female of his *titillator.* * * * It is common in the Southern States."

In 1862 Harris, in his Insects Injurious to Vegetation, published a short description, with a figure and a note on the habits of adults, but stated that the kind of tree the "grub" inhabited was unknown to him. In 1873 Le Conte published a description of *Monohammus minor,* which has since been made a synonym of *titillator.* At the same time he published a short description of *M. titillator.* Of the genus Monohammus, he says: "The species infests pine trees throughout the whole extent of the United States and contiguous northern regions." In the same year Bowditch, under the name *M. dentator,* published short descriptions of the larva, pupa, and adult, and a short note on seasonal history and habits. He found it infesting *Pinus mitis* (*echinata*) in Massachusetts. In 1885 Horn published a short description under the name *M. titillator* and placed the names *carolinensis, dentator,* and *minor* in synonymy. He gave the distribution as from Canada to Washington Territory and south to Florida. In 1899 Hopkins published a short note on the occurrence of this species resting upon pitch and scrub pine trees at Tibbs Run, near Dellslow, W. Va. In the same year Chittenden published a a short account of the destructive habits of the species of the genus Monohammus. J. B. Smith, in his Insects of New Jersey, published the same year, mentions this species as occurring throughout the State on pine in June and July. In 1906 Felt, in his Insects Affecting Park and Woodland Trees, under the name *M. titillator* (common name, tickler), published a very short description, saying further that it was met with in very small numbers [in New York] in 1901 on both white pine and hard pine.

DISTRIBUTION.

The records of the Bureau of Entomology indicate that this species is to be found over the whole eastern half of the United States, from Maine to Texas. As stated in the historical notes, Doctor Horn gave the distribution as from Canada to Washington Territory, and south to Florida, but I have not been able to verify his statement as to the northern and western limits of distribution.

HOST PLANTS.

So far as known, this species attacks only pine trees, not favoring any one species of pine, but apparently attacking all species of pine trees within its range of distribution.

CONDITION OF TREES ATTACKED.

Only felled or injured trees are attacked by this species. So far as known, healthy standing trees are never in any danger whatever from this source.

INJURY TO PINE FORESTS BY STORMS.

In September, 1906, a high wind accompanied by rain, blowing steadily for two or three days, uprooted a vast amount of pine timber in the southern part of Mississippi.

In May, 1907, near Tuscaloosa, Ala., a storm occurred which felled about 800,000 feet of pine timber.

On April 24, 1908, a cyclone of huge proportions passed through Mississippi and Louisiana, tearing down a swath of timber from 1 to 2 miles wide (fig. 13). The cyclone passed through some of the finest pine forests in these States, thus bringing down or breaking off many millions of feet of timber. It is quite probable that the same storm did damage in Arkansas. At any rate, two storms occurred in Arkansas, one in April and one in May, 1908, both of which were very destructive to pine timber. During the fall and winter of 1908 two or three more storms occurred in the same State which doubtless contributed to the destruction of the pine forests.

INJURY TO STORM-FELLED TIMBER BY THE SOUTHERN PINE SAWYER.

Practically all timber felled by the storm of September, 1906, became infested by the sawyer. When the writer reached Baxterville, Miss., July 6, 1908, the broods had all matured and emerged from these trees. In this vicinity, where most of his investigations were carried on, from 75 to 90 per cent of the trees felled by the storm of April 24, 1908, were infested by the sawyer. Adults were at that time actively engaged in laying eggs in the uninfested trunks

FIG. 13.—The effect of the storm of April 24, 1908. (From a photograph taken near Baxterville, Miss.)

and stubs. This continued for the balance of the summer, so that it is safe to say that a very small percentage of the pine timber injured by this storm escaped infestation. The damage to each log infested is the work of the larvæ or grubs which mine in and through the sapwood, and even penetrate the heartwood, making large unsightly holes which cause the lumber made from this portion of the log to be thrown into the very lowest grade, known to the lumbermen as "No. 2 common."

PECUNIARY LOSS.

Approximately 25 per cent of the lumber in each log infested by the sawyer is seriously damaged. The pecuniary loss may therefore be computed as follows: Lumber undamaged by insects was worth, in 1908, \$19 a thousand feet b. m. at the mill in southern Mississippi. When infested by the sawyer the 25 per cent damaged was reduced in value to \$7.50 a thousand.

It is estimated that in the storm of September, 1908, 2,000,000,000 feet of timber were blown down. In the 1907 storm, in Alabama, 800,000 feet were blown down, and in the storm of April 24, 1908, which passed through two or three States, 180,000,000 feet were blown down. This gives us 2,180,800,000 feet of timber blown down by these three storms. Practically all of this storm-felled timber was damaged by the sawyer.

As stated above, 25 per cent of each log damaged is reduced from \$19 a thousand feet to \$7.50 a thousand feet; therefore we may consider that 25 per cent of the whole, or 545,200,000 feet b. m. was reduced from \$19 a thousand to \$7.50 a thousand. At \$19 a thousand this amount of timber would be worth \$10,358,800. At \$7.50 it would be worth \$4,089,000. The difference between these two sums is \$6,269,800. Therefore, if this timber had been used, or could have been used before the sapwood decayed, the last figure given would represent the total loss chargeable to the sawyer.

CHARACTER OF THE INSECT.

Adult.—The adult (fig. 14) is an elongate beetle varying from 16^{mm} to 31.5^{mm} in length and from 5 to 10^{mm} in width. The color is a mottled gray and brown. In the male the horns, or antennæ, are very long, often being two or three times the length of the beetle. In the female they are much shorter than in the male, but are still somewhat longer than the body.

Egg.—The egg (fig. 15) is elongate-oval, approximately 4^{mm} long, by 1.5^{mm} in diameter at the middle. The color is opaque white. There are two distinct coverings, which correspond to the outer and inner shells of the egg of a fowl. The outer is known as the chorion (fig. 15, *a*, *d*), and the inner as the amnion (fig. 15, *b*). At one end is found a depression or little round hole, which is known as the micropyle (fig. 15, *c*). Under a high-power microscope the chorion is seen to be very prettily sculptured on its outer surface (fig. 15, *e*).

Larva.—The larva (fig. 16) is an elongate, footless, white grub with powerful jaws or mandibles for boring through the wood. The size varies considerably in different individuals and according to age. The largest at maturity have been found to measure slightly over 60^{mm} in length and 9^{mm} in breadth at the broadest point (the pro-

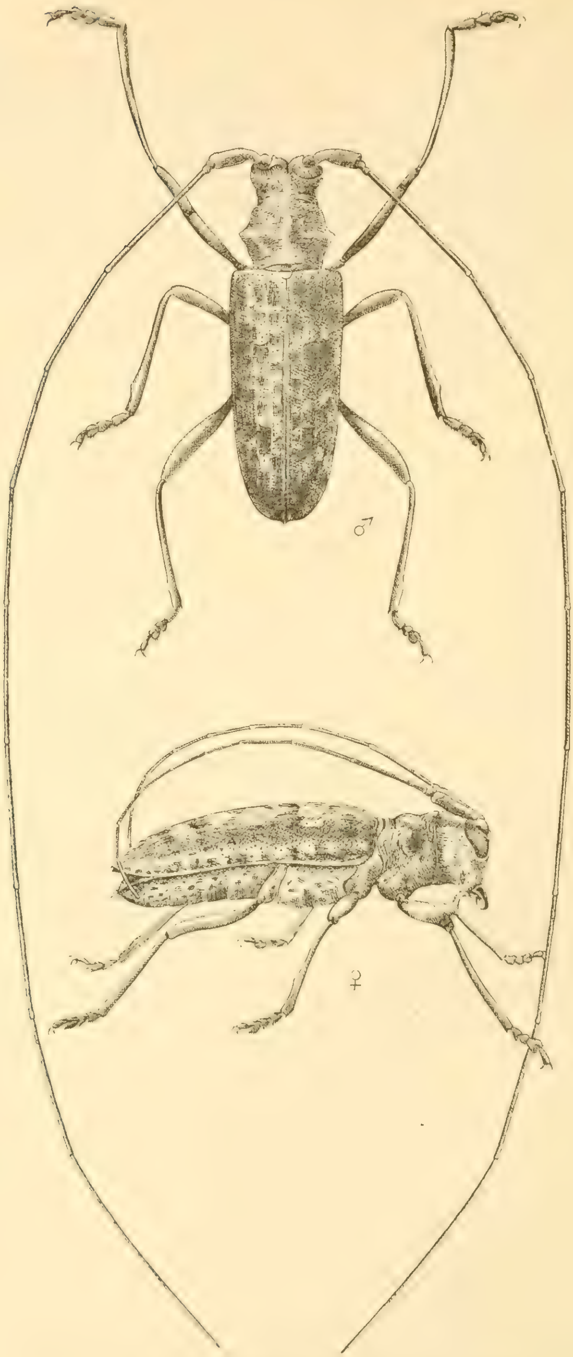

FIG. 14.—The pine sawyer (*Monohammus titillator*): ♂, Male; ♀, female. Enlarged about one-third. (Original.)

thorax). Larvæ which develop into the smaller sized adults are, of course, much smaller than this at maturity. The body is divided into 14 well-marked segments. The first is the head. The following three constitute the thorax, the first being the prothorax, the second the mesothorax, and the third the metathorax. The following 9 segments constitute the abdomen, and are designated as the 1st, 2d, 3d, etc., abdominal segments. The last segment is called the anal segment. The head (fig. 16, *a*) is considerably longer than broad, and is capable of being deeply retracted into the thorax. The prothorax, upon the anterior part of the upper or dorsal surface, is smooth and shining, but the posterior part has an opaque leathery appearance. This opaque surface is dotted over by small shining spots more or less longitudinally elongate in shape. The mesothorax is smooth upon the upper or dorsal surface, but on the lower or ventral surface is found a double transverse row of fine fleshy granules. On the extreme anterior portion of the side of this segment is found a transverse, oval, brown spot. This is the first spiracle or breathing pore. On the

FIG. 15.—The pine sawyer. Egg, greatly enlarged. *a*, Chorion; *b*, amnion; *c*, micropyle; *c*, same, highly magnified; *d*, sculpture of chorion. (Original.)

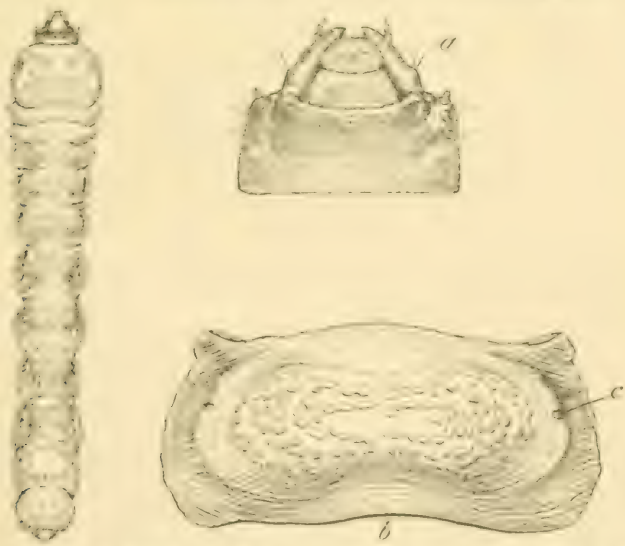

FIG. 16.—The pine sawyer. Larva, slightly enlarged; *a*, Fore part of head; *b*, second abdominal segment; *c*, abdominal spiracle. *a*, *b*, Greatly enlarged. (Original.)

metathorax a double transverse row of granules occurs, both on the dorsal and on the ventral surface, but there is no spiracle upon this segment. On the first 7 abdominal segments there are 4 rows of granules on the dorsal surface (fig. 16, *b*), and 2 on the ventral. The last 2 segments are free from granules. On the anterior half of the side of each abdominal segment except the last, a spiracle (fig. 16, *c*) similar to that on the mesothorax, except that it is much smaller, is to be found. In mature larvæ each abdominal segment bears a longitudinal fold on each side, known as the pleural fold. On immature larvæ the pleural folds on the first 2 abdominal segments are so obscure as to be scarcely noticeable. The anal fold is quite hairy and bears the anal opening. Numerous hairs occur upon each segment of the entire body.

Pupa.—The pupa (fig. 17) shows the form in some degree of both the larva and the adult. The number of segments is the same as in the larva; the first abdominal segment, however, is not visible upon the under side of the body. The head is of the same general shape as that of the adult, but is bent forward and under, so that the mouth-parts point directly back toward the posterior end of the body. Several bristles are found upon the anterior part of the head. The antennæ are well developed and are coiled on the under side of the elytra, or wing covers, which extend from the mesothorax in a posterior lateral direction, the tips being directly underneath the body and attaining the fourth abdominal segment. The elytra thus lie between the body and the first two pairs of legs. The third pair of legs is between the body and the elytra. The wings are flattened against the under side of the elytra, each one projecting slightly beyond the outer side margin of the elytron, under which it lies. The elytra are attached to the mesothorax and the wings to the metathorax.

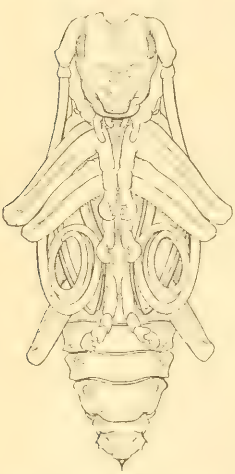

FIG. 17.—The pine sawyer: Pupa. About twice natural size. (Original.)

There is a large fleshy tubercle at each side of the prothorax. The legs are folded underneath the body. The first pair is borne by the prothorax, the second by the mesothorax, and the third by the metathorax. The mesothorax bears a spiracle in the same position as that of the larva, and the first 5 abdominal segments bear spiracles; the rest apparently do not. Upon the dorsal surface all segments of the thorax and abdomen bear bristles. The ventral surface of all abdominal segments, except the last, is smooth. The last abdominal segment, which occupies the extreme posterior end of the body, has a peculiar triangular shape. One of the points of the triangle is prolonged upward into a sharp, chitinized spine. The two lower points of the triangle are armed with several chitinized bristles. The anal segment occurs directly beneath the last abdominal segment, and is inclosed on three sides by the latter. A strongly marked sexual difference is to be found between the anal segment of the male and that of the female. In the male this segment shows merely the anal opening. In the female two globular tubercles are borne side by side on this segment.

SEASONAL HISTORY.

There are four stages in the life of the sawyer, first, the egg (fig. 15); second, the larva (fig. 16); third, the pupa (fig. 17); fourth, the adult (fig. 14).

In southern Mississippi the egg-laying period lasts from about the first of March to the middle of October. In some cases eggs may be laid earlier or later than the dates given, but the main activity in egg-laying will be found to be comprised within this period. The young larvæ hatch from the eggs in about five days after the eggs are deposited.[a]

The length of time from the hatching of the young larva to the time of maturity and change to the pupa appears to vary considerably in different individuals. The comparative periods of time spent in the larval and pupal stages are not known. However, it is probable that while the larval period may last for several months the pupal period is not longer than two or three weeks. The length of time occupied in passing from the egg to the adult stage varies greatly in different individuals. It appears that normally there is one generation a year, with a partial second generation. Thus, on August 12, 1908, the writer found larvæ, pupæ, and emergence holes in the trunk of a tree which had been felled by storm April 24, 1908. The fact that the tree was felled on this date makes it certain that the eggs of the sawyer were deposited subsequently. This gives us a period of less than four months for the development from the egg to the emerged adult, in some individuals. Returning to the same tree October 6, 1908, more emergence holes were found, but there were still plenty of larvæ in the trunk. Also, scattering emergence holes were common at this date in other trees felled by the storm of April 24, 1908, which were also abundantly infested with larvæ. On March 19, 1909, the writer again visited the tree just mentioned, and found a good many larvæ and one pupa still in the log. Thus it is seen what a great variation in the length of time taken for development there may be among different individuals in the same log. The case of the sawyer in the Southern States appears to be somewhat analogous to that of certain species of Lepidoptera, a few adults of which emerge in the fall, while the greater number of the pupæ go through the winter before changing

[a] This statement is based upon observations made during the hottest part of the summer. Possibly eggs laid in the spring or fall might not hatch so quickly, as there would be less heat at those periods.

to the adult. In the case of the sawyer, however, the winter is passed in the larval stage and not the pupal stage. In November, 1908, Mr. R. W. Van Horn found emergence holes of the sawyer in trees felled the previous spring near Virginia Beach, Va., thus showing that the same conditions prevail there.

Among the larvæ which pass the winter in the logs, those which are farthest advanced in development are, of course, the first to go through the changes to the adult, and to emerge in the spring. It is probable that this emergence begins about March 1. At the time the writer was in southern Mississippi, March 18–20, 1909, many adults had already emerged and others were ready to emerge. Females were actively engaged in laying eggs at this time.

Just how long it takes for all the overwintered larvæ, which have not already done so, to go through the changes to the adult stage and emerge is not known, but it is probable that this will be accomplished at least by June 1.

From the last of July, 1908, to the first of February, 1909, the writer had trap trees felled at stated intervals, for the purpose of getting seasonal history notes. The following tabulation shows the net results of these experiments:

Seasonal history records of the pine sawyer from pine trees felled from July, 1908, to February, 1909.

Hopk. U. S. No.	Date of felling.	First eggs noted.	Condition on March 18–19, 1909.
	1908.	1908.	
5873	July 29	Aug. 6	Larvæ and pupæ in wood. A good many adults have emerged.
5874	29	6	Larvæ, pupæ, and young adults in wood. A good many adults have emerged.
5879	Aug. 10	13	Larvæ and pupæ in wood. No emergence holes noted.
5880	10	13	Do.
5885	20	....	Larvæ and pupæ plentiful in wood. No emergence holes noted.
5886	20	....	Larvæ and pupæ common in wood. Three adults have emerged.
5893	31	....	Larvæ and pupæ in wood. Several adults have emerged.
5894	31	....	Larvæ and pupæ in wood very scarce. One young adult (quite small). Two adults have emerged.
5895	Sept. 11	....	Larvæ and pupæ in wood. No emergence holes.
5896	11	....	Larvæ and pupæ rather scarce in wood. A few adults have emerged. A few larvæ between bark and wood, scoring the wood.
5897	28	Oct. 7	Larvæ and pupæ in wood. One larva found between bark and wood, which crawled back into its hole in the wood. One adult has emerged.
5898	28	7	Larvæ, pupæ, and young adults in wood. Several adults have emerged.
5914	Oct. 15	....	Larvæ, some of which have not entered wood, others in wood with exit burrow excavated nearly to surface. No pupæ or emergence holes.
5915	15	....	Larvæ, some between bark and wood, scoring the wood, not having made entrance holes into wood. Others in wood with emergence gallery excavated nearly to surface. No pupæ or emergence holes noted.
5912	Nov. 3	....	A few inconspicuous egg pits evidently made last fall. Two half-grown larvæ, one of which had commenced to mine into the wood. The other had not commenced to do so.
5913	3	....	Two or three egg pits, evidently made last fall, but no larvæ or eggs found.
5910	Dec. 8	....	Many egg pits. Eggs and young larvæ in some cases, in others the conditions seem to have become unfit by reason of the excavations of other insects.
5911	8	....	Many egg pits. Eggs and young larvæ under bark.
	1909.	1909.	
5908	Jan. 7	....	A few egg pits of Monohammus with eggs. One small larva found.
5909	7	....	Scattering egg pits over the log. Eggs and larvæ apparently one or two weeks old.
5906	Feb. 6	Mar. 18	A few egg pits, both in trunk and stump. Eggs under bark, but none found that have hatched. March 20, female digging egg pit.
5907	6	18	A few egg pits with eggs under the bark. One larva found apparently just hatching. March 20, six beetles, three males and three females, observed on this log, the females excavating egg pits, two males fighting and the other male hanging on to a female.

HABITS.

Preparatory to laying the eggs, the female digs with her mandibles quite a conspicuous egg pit in the bark (figs. 18, *a*, and 21, *c*). This pit is more or less funnel shaped, though sometimes it is merely a transverse slit, and reaches as far as the outermost layer of soft, sappy bark. The female, while digging the egg pit, is generally accompanied by the male, who clasps the posterior end of her body with his fore-legs, and frequently fertilizes her while she is digging the pit. In one instance where the operation was noted, the female did not discontinue digging while copulation took place. Many combats take

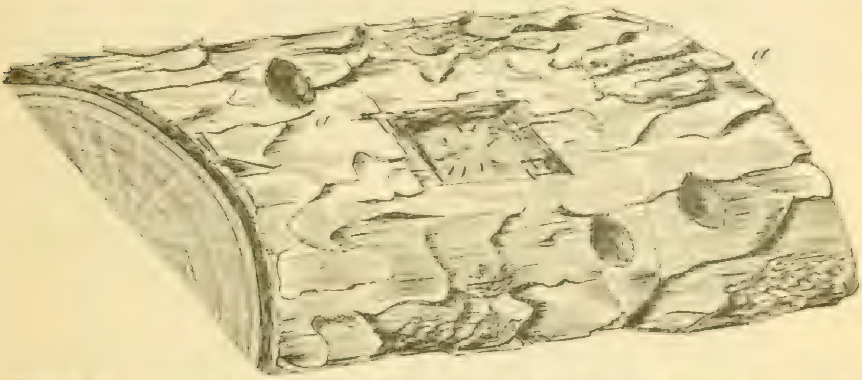

FIG. 18.—The pine sawyer: *a*, Egg pit; *b*, eggs in position in which they were placed by female, the outer bark being removed. About one-half natural size. (Original.)

place between males for the possession of a female during oviposition. The ovipositor is thrust into the egg pit and in between the soft, sappy bark and the first layer of outer hard bark, and the eggs are deposited in a circle around the bottom of the egg pit, the egg (or the end of the egg nearest the pit) being placed from one-eighth to one-quarter of an inch away from the egg pit (see fig. 18, *b*). As many as nine eggs have been found deposited through a single pit opening.

In about five days these eggs hatch, and the small larvæ issuing therefrom begin feeding upon the soft inner bark, and soon work their way through it, but do not enter the wood until they have attained considerable growth. During this period they make irregular galleries through the inner bark just next to the wood, deriving their entire sustenance from the bark and making no marks or cuttings upon the wood. In from eighteen to thirty-two days after hatching the larvæ mine into the sapwood (fig. 19). A few days previous to this they are to be found cutting rather broad, irregular paths upon the surface of the sapwood with their mandibles (fig. 19, *d*). This process is called "scoring." After making the entrance into the wood the larvæ come out again to feed upon the inner bark, evidently retiring into their holes to rest and for protection from their enemies. The chips cut in excavating the hole in the wood, as well as the excrement, are packed between the bark and wood and are not thrown

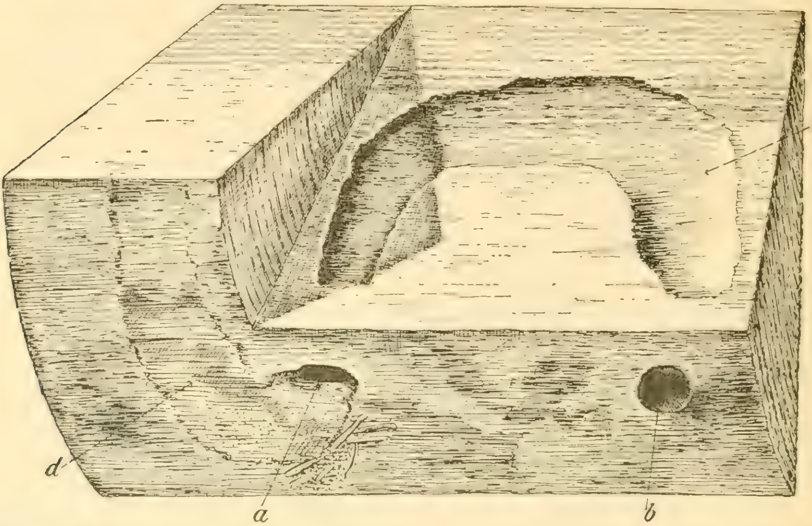

FIG. 19.—The pine sawyer. Gallery: *a*, Entrance hole in wood; *b*, emergence hole; *c*, pupal cell; *d*, surface scored by larva before entering wood. About natural size. (Original.)

out upon the ground, as appears to be the case with some other species. In moving about from the entrance of the hole in the wood to the place where food is obtained, very distinct channels are made through this mass of refuse (fig. 21). This habit appears to continue until the larva is ready to pupate, when, of course, it retires to the pupal chamber (fig. 19, *c*) already constructed, where it remains until the adult stage is reached. Previous to pupation the larva extends the gallery in the sapwood until the heartwood is reached. As a general thing the gallery here turns in a longitudinal direction for 2 or 3 inches, then turns again toward the surface, giving the entire gallery a U-shaped appearance (fig. 19). Sometimes the bottom of the "U" extends a short distance into the heartwood, but as a usual thing it merely reaches it. In the bottom of the "U" is to be found the pupal cell. The gallery is here greatly widened and enlarged in order to accommodate the insect while going through its

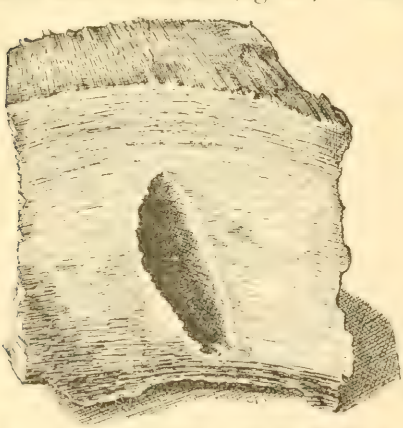

FIG. 20.—The pine sawyer: Cross section of pupal cell. About natural size. (Original.)

transformations (figs. 19, *c*, 20). The unfinished arm of the "U" is usually extended by the larva to within about one-quarter of an inch of the surface of the wood. When the larva pupates, the head of the pupa is turned toward the end of the chamber. When the pupa changes to the adult, the beetle extends the chamber to the surface of the wood and through the bark, if the bark is still upon the tree or

FIG. 21.—The pine sawyer: Section of pine showing, at right, mass of borings and refuse packed under bark (bark removed) by the larvæ and channels made through the mass by the larvæ. *a*, Entrance hole of larva in wood; *b*, scored surface of wood; *c*, egg pit; *d*, emergence hole. About one-half natural size. (Original.)

log, boring a perfectly round exit hole usually about three-eighths of an inch in diameter (figs. 19, 21, 22), thereby escaping to propagate the species in another tree or trees.

NATURAL ENEMIES.

Monohammus titillator is preyed upon by larvæ of the coleopterous family Trogositidæ; by the larva of an elaterid beetle of the genus Alaus, and by a species of Bracon which has been determined as new to science. None of these, however, has been powerful enough, so far, to appreciably thin the ranks of Monohammus. Following is the description, by Mr. H. L. Viereck, of the species of Bracon mentioned above:

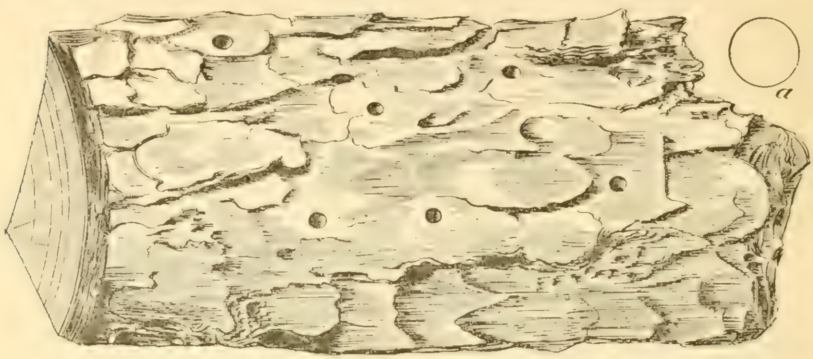

FIG. 22.—The pine sawyer: Emergence holes of young adults in bark. *a*, Natural size of emergence holes. (Original.)

BRACON (MELANOBRACON) WEBBI N. SP.[a]

Compared with *ulmicola* [b] this species differs as follows: Second dorsal abdominal segment without a triangular elevated area but with shallow, almost oblique impressions as diagrammatically represented in figure 23.

FIG. 23.—*Bracon* (*Melanobracon*) *webbi*: Dorsum of second abdominal segment. Greatly enlarged. (Original.)

FIG. 24.—*Bracon* (*Melanobracon*) *webbi*: First four antennal joints. Greatly enlarged. (Original.)

Female: Length, 11mm, exclusive of ovipositor, which is 6mm; antennæ 69-jointed; proportions and relation of first four joints approximately as in figure 24; joints 4 to 55 subequal, becoming wider than long; joints 55 to 69 becoming longer than wide, the apical joint conical. Petiole of first discoidal cell about as long as second and third joints of antenna combined. Second dorsal abdominal segment perfectly smooth.

Type.—No. 12585, U. S. National Museum.

Type locality, Baxterville, Miss., March 19, 1909.

Hopk. U. S. No. 5896*a*; reared by Mr. J. L. Webb, of the Bureau of Entomology.

REMEDIES.

Fire.—During the logging operations upon the storm-felled timber near Baxterville, Miss., in 1908, the felled timber was burned over with the object of destroying the broods of the sawyer. Subsequent examinations of this burned-over area disclosed the fact that a very small percentage of the larvæ had succumbed to the heat. *This method is, therefore, not to be recommended.*

Scoring.—Several experiments were tried to determine the efficiency of "scoring," or removing a strip of bark along the upper surface of a log. In some instances salt was sprinkled along the

[a] By H. L. Viereck, Agent and Expert, Bureau of Entomology.

[b] 1906, Trans. Am. Ent. Soc., pp. 176–177.

scored surface, and in others the strip was covered with brush, these having been recommended locally as remedies. In not a single instance was the scoring, either with or without salt, found to deter the larvæ in the slightest degree. *This method is not recommended.*

Placing logs in water.—Investigation of the method of destroying the larvæ in infested logs by placing the logs in water was made at Lumberton, Miss., where logs from the storm-felled trees were placed in the mill pond. The water killed all the larvæ in the log, both between the bark and wood and in the wood itself. *This method is to be recommended wherever practicable.*

Barking the logs.—Barking the logs is effective up to the time the larvæ enter the wood, and for a short time thereafter—perhaps a week. As stated elsewhere, the first part of the life of the larva is spent between the bark and the wood, during which the larva feeds upon the soft inner bark. It is absolutely impossible for the larva to live for the first month of its existence without this soft inner bark to feed upon. Therefore, if the bark be removed from the log during this period all larvæ between the bark and wood will be destroyed. As stated elsewhere, the larvæ continue to feed upon the inner bark for several days at least, after first entering the wood. The writer determined by experiment that the barking of the log during the first few days after the larvæ have entered the wood was effective in destroying the larvæ, by cutting off their food supply. At this period the larvæ have not gone deeply into the wood, so that there would still be a saving if the barking were done at this time. Where this method is practiced as a remedy, it should be done within forty days after the eggs are laid. If trees are felled between March 1 and October 15, egg laying will probably commence at once after the trees are down.

An important point to be taken into consideration in this connection is whether or not logs and trees barked to destroy the sawyer can be taken to the mill before the sapwood decays from lying on the ground. As the greater part of the injury by the sawyer is confined to the sapwood, there will obviously be little or no saving in barking logs which can not be used before the sapwood is destroyed by decay.

The writer realizes, also, that in some cases barking may not be profitable for other reasons. The local conditions in regard to labor are often far from satisfactory. And it may be quite impossible to assemble enough laborers to bark all the trees felled by a heavy storm in time to save them from injury by the sawyer. It is also true that in cyclone-felled timber the trunks are often so piled up and entangled that it would be necessary to saw them into logs and separate them before they could be barked. However, taking all these points into consideration, the writer feels that in the majority of instances a great saving can be accomplished if the matter is promptly taken in hand, and as many trunks as possible barked before or shortly after the larvæ enter the wood. In each case the holder of storm-felled timber must decide for himself. If the cost of barking the felled trunks is low enough to give a fair profit on the material saved from injury, it is a simple proposition of business economy. In any case the matter should be given careful consideration before all effort to prevent loss from the ravages of the sawyer is abandoned.

SUMMARY OF REMEDIES.

If possible saw all storm-felled trunks into logs and place the logs in water before the larvæ enter the wood, or within forty days after the eggs are laid. If it is impossible to place the logs in water, they should be barked within forty days after the first egg pits are observed in the bark.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 58, Part V.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

INSECT DEPREDATIONS IN NORTH AMERICAN FORESTS

AND PRACTICAL METHODS OF PREVENTION AND CONTROL.

BY

A. D. HOPKINS, Ph. D.,

In Charge of Forest Insect Investigations.

Issued December 4, 1909.

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GOVERNMENT PRINTING OFFICE.

1909.

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[a] Organization of the Bureau on November 1, 1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., August 23, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 58, Part V, of the Bureau of Entomology, manuscript of a paper by Dr. A. D. Hopkins, in charge of forest insect investigations of this Bureau, entitled "Insect Depredations in North American Forests and Practical Methods of Prevention and Control."

The paper is based largely on the observations and experience of the author and of the assistants engaged in forest insect investigations, and contains a list of publications relating to forest insects.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

SOME INSECTS INJURIOUS TO FORESTS.

INSECT DEPREDATIONS IN NORTH AMERICAN FORESTS AND PRACTICAL METHODS OF PREVENTION AND CONTROL.

INTRODUCTION.

It is the purpose of this part of the bulletin to give a summary of facts, conclusions, and estimates relating to the forest-insect problem as applied to North American conditions and to call attention to its importance in the future management of private and public forests. The matter is presented in as brief and concise a form as possible, in order that the information may be readily available to the general reader, as well as to the forester and student, and references are made to publications in which more detailed accounts may be found. The statements and conclusions relating to the insects and their work and to methods for their control are based almost entirely on investigations and observations by the writer and by assistants in the Bureau of Entomology working under his direction, carried on in all of the principal forest areas of the United States. The historical data have been gathered from the publications listed on pages 96–97. The estimates of the amount and value of standing timber killed by insects and of the forest products destroyed and reduced in value through insect injuries to the crude and seasoned products are based on our published results of investigations (pp. 97–100), on unpublished notes, on technical and practical knowledge of the subject, and on the published forest statistics relating to the amount and value of timber, fire losses, etc. (pp. 100–101).

INSECT DEPREDATIONS IN NORTH AMERICAN FORESTS.

CHARACTER AND EXTENT OF DEPREDATIONS.

The records of notable depredations by insects on the timber supply of Europe during the past four hundred years, on that of the

United States during the past century, and especially those that have come under the observation of the writer and assistants engaged in forest insect investigations during the past eighteen years, furnish conclusive evidence that this class of enemies has been, and is now, an important factor in the destruction and waste of forest resources.

Insects Cause the Death of Trees.

It has been conclusively demonstrated that certain species of insects are the direct or primary cause of the death of forest trees of all ages, and that from time to time they multiply to such an alarming extent that their depredations assume the character of a destructive invasion, which results in the death of a large percentage of the best timber over thousands of square miles.

There are many species of barkbeetles which prefer to attack matured and healthy trees, and there are many examples of whole forests of century-old trees having perished from the girdling effect of the mines of the beetles, which are extended in all directions through the inner living bark on the main trunks of the trees. Indeed, we find among these bark-boring beetles the most destructive insect enemies of North American forests. Some notable examples of the depredations of these barkbeetles are given below.

The southern pine beetle.—In 1890–1892 a destructive invasion of the southern pine beetle (*Dendroctonus frontalis* Zimm.) extended from the western border of West Virginia through Maryland and Virginia into the District of Columbia, northward into southern Pennsylvania, and southward into North Carolina. In this area, aggregating over 75,000 square miles, a very large percentage of the mature and small trees of the various species of pine and spruce was killed by this beetle. In many places in West Virginia and Virginia nearly all the pine trees of all sizes on thousands of acres were killed, while shade and ornamental trees within the same area suffered the same as those in the forest. Since 1902 this barkbeetle has been more or less active in the Southern States from Virginia to Texas, and in some localities and during certain years it has killed a large amount of timber. Records of extensive destruction of timber in the Southern States are found dating back to the early part of the nineteenth century (Wilson, 1831). This species may be considered one of the most dangerous insect enemies of southeastern conifers and, therefore, a constant menace to the pine forests of the Southern States. (Hopkins, 1899*b*, 1903*b*, 1909*b*.)

The eastern spruce beetle.—During the period between 1818 and 1900 there were several outbreaks of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in the spruce forests of New York, New England, and southeastern Canada (Peck, 1876, 1878; Hough, 1882; Packard, 1890; Pinchot, 1899, p. 74; Hopkins, 1901*a*, 1909*b*).

This species caused the death of a very large percentage of the mature spruce over an area of thousands of square miles. In the aggregate many billions of feet of the best timber were destroyed. The larger areas of this dead timber furnished fuel for devastating forest fires, with the result that in most cases there was a total loss.

The Engelmann spruce beetle.—Another barkbeetle (*Dendroctonus engelmanni* Hopk.), similar in habits to *piceaperda*, has from time to time during the past fifty years caused widespread devastations in the Rocky Mountains region to forests of Engelmann spruce, in some sections killing from 75 to 90 per cent of the timber of merchantable size. (Hopkins, 1908*a*, p. 161; 1909*b*, pp. 126–132.)

The Black Hills beetle.—One of the most striking examples of the destructive powers of an insect enemy of forest trees is found in the Black Hills National Forest of South Dakota, where during the past ten years a large percentage of the merchantable timber of the entire forest has been killed by the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.). It is estimated that more than a billion feet of timber have been destroyed in this forest as the direct result of the work of this beetle. This destructive enemy of the western pine is distributed throughout the forests of the middle and southern Rocky Mountains region, where, within recent years, it has been found that in areas of greater or less extent from 10 to 80 per cent of the trees have been killed by it. (Hopkins, 1902*a*, 1903*b*, 1905*b*, 1908*a*, and 1909*b*, pp. 90–101.)

The mountain pine beetle and the western pine beetle.—The sugar pine, silver pine, western yellow pine, and lodgepole pine of the region north of Colorado and Utah, westward to the Cascades, and southward through the Sierra Nevadas are attacked by the mountain pine beetle (*Dendroctronus monticolæ* Hopk.) and the western pine beetle (*Dendroctonus brevicomis* Lec.), and, as a direct consequence, billions of feet of the timber have died. In one locality in northeastern Oregon it is estimated that 90 to 95 per cent of the timber in a dense stand of lodgepole pine covering an area of 100,000 acres has been killed within the past three years by the mountain pine beetle. Throughout the sugar-pine districts of Oregon and California, as the result of attacks by this same destructive barkbeetle, a considerable percentage of the largest and best trees is dead. (Webb, 1906; Hopkins, 1908*a*, 1909*b*, pp. 80–90.)

The Douglas fir beetle.—The Douglas fir throughout the region of the Rocky Mountains from southern New Mexico to British Columbia has suffered severely from the ravages of the Douglas fir beetle (*Dendroctonus pseudotsugæ* Hopk.), with the result that a large percentage of dead timber is found, much of which will be a total loss. (Hopkins, 1909*b*, pp. 106–114.)

Three other species of beetles, having destructive habits similar to those above mentioned, depredate on the pines of New Mexico and Arizona, and still another has contributed greatly to the destruction of the larch throughout the northeastern United States and southeastern Canada. (Hopkins, 1909*b*, pp. 49, 53, and 77.)

The hickory barkbeetle.—Within the past ten years the hickory barkbeetle (*Scolytus quadrispinosus* Say) has caused the destruction of an enormous amount of hickory timber throughout the northern tier of States from Wisconsin to Vermont and southward through the eastern Atlantic States and into the Southern States as far as central Georgia. (Hopkins, 1904*b*, pp. 314–317.)

The larch worm.—There are also many examples of widespread depredations chargeable to insects which defoliate the trees, thus contributing to their death. Notable among these are the depredations by the larch worm (*Nematus erichsonii* Hartig), which, during several extensive outbreaks since 1880, has killed from 50 to 100 per cent of the mature larch over vast areas in the northeastern United States and southeastern Canada. It is evident that the amount of merchantable-sized timber that has died as the result of defoliation by this insect will aggregate many billions of feet. (Packard, 1890, pp. 879–890; Pinchot, 1899; Hopkins, 1908*a*.)

Insect Injuries to the Wood of Living Trees.

It has been determined that insects of a certain class attack the wood and bark of living timber and that, while they do not contribute materially to the death of the trees or give much external evidence of their presence, they produce wounds in the bark and wormhole and pinhole defects in the wood which result in a depreciation in commercial value amounting to from 5 to 50 per cent. These defects in the wood are not detected until after the trees have been felled and the logs transported to the mill and converted into lumber. Thus to the actual damage to the lumber is added the expense of logging and manufacture of the defective, low-grade material, much of which must be discarded as worthless culls. (Hopkins, 1894*a*, 1894*b*, 1904*b*, 1905*a*, 1906*b*.)

The oak timber worm.—One of the most destructive of the class of depredators just mentioned is the oak timber worm (*Eupsalis minuta* Dru.). It enters the wood of the trunks of living trees through wounds in the bark and at the base of broken or dead branches and extends its "pinhole" burrows in all directions through the solid heartwood. The losses occasioned by this insect in the hardwood forests of the eastern United States are enormous and usually affect the wood of the finest examples of old trees. (Hopkins, 1894*a*, 1904*b*.)

The chestnut timber worm.—The chestnut throughout its range is damaged in a like manner by the chestnut timber worm (*Lymexylon sericeum* Harr.). Practically every tree of merchantable size is more or less affected, and a large percentage is so seriously damaged that the product is reduced to that of the lowest grade. It is estimated that the reduction in value of the average lumber product at any given time is not far from 30 per cent, thus involving extensive waste and an increased drain on the forest to supply the requirements for clear lumber. This insect also attacks the oaks, and especially the red oak, the older trees of which are often as seriously damaged as are the chestnut. (Hopkins, 1894*a*, 1904*b*.)

Carpenter worms.—The oaks, especially the white oak and the red oak, are seriously damaged by carpenter worms of the genus Prionoxystus. The holes made by these insects through the heartwood of the best part of the trunks are sometimes 1.5 inches in diameter one way by 0.75 inch the other, thus causing serious damage to the wood. These, with other large wood-boring beetle larvæ, sometimes infest the top part of the trunk and the larger branches of oak trees, where their continued work results first in the dead and so-called "staghorn" top and subsequently in broken, decayed, and worthless trunks. (Hopkins, 1894*a*, 1904*b*.)

Ambrosia beetles.—One of the commonest defects in white oak, rock oak, beech, whitewood or yellow poplar, elm, etc., is that known to the lumber trade as "grease spots," "patch worm," and "black holes." This defect is caused by one of the timber beetles or ambrosia beetles, *Corthylus columbianus* Hopk., which makes successive attacks in the living healthy sapwood from the time the trees are 20 or 30 years old until they reach the maximum age. Thus the black-hole and stained-wood defect is scattered all through the wood of the best part of the trunks of the trees. The average reduction in value of otherwise best-grade lumber amounts, in many localities, to from 25 to 75 per cent. The defect is commonly found in oak and elm furniture and in interior hardwood finish in dwellings and other buildings. (Hopkins, 1893*g*, 1894*b*, 1904*b*.)

The locust borer.—The locust, as is well known, suffers to such an extent from the ravages of the locust borer (*Cyllene robiniæ* Forst.) that in many localities the trees are rendered worthless for commercial purposes or they are reduced in value below the point of profitable growth as a forest tree, otherwise this would be one of the most profitable trees in the natural forest or artificial plantation and would contribute greatly to an increased timber supply. (Hopkins, 1906*b*, 1907*a*, 1907*c*.)

Turpentine beetles and turpentine borers.—While the softwood trees, or conifers, suffer far less than the hardwoods from the class of enemies which cause defects in the living timber there are a few notable examples of serious damage. There is a common trouble affecting the various species of pine throughout the country known as basal wounds or basal fire wounds. It has been found that a large percentage of this injury to the pine in the States north and west of the Gulf States and in the Middle and South Atlantic States is caused by the red turpentine beetle (*Dendroctonus valens* Lec.) and in the Southern States by the black turpentine beetle (*Dendroctonus terebrans* Oliv.). These beetles attack the healthy living bark at and toward the base of the trunks of medium to large trees and kill areas varying in size from 1 to 10 square feet. These dead areas are subsequently burned off by surface fires and are then generally referred to as fire-wounds. The further damage to the exposed wood by successive fires, decay, and insects often results in a total loss of the best portion of the tree, or a reduction in value of the lower section of the trunk of from 10 to 50 per cent. (Hopkins, 1904*a*, 1909*b*.) These and similar wounds in the bark of trees, including those caused by lightning and by the uncovering and exposure of the wood in turpentining, offer favorable conditions for the attack of the turpentine borer (*Buprestis apricans* Hbst.), the work of which, together with that of two or three others with similar habits, is very extensive, and causes losses amounting to from 10 to 50 per cent of the value of the wood of the best part of the trees thus affected. (Hopkins 1904*a*.)

The white pine weevil.—The abnormal development of white pine trees as the result of succesive attacks on the terminals of the saplings and young trees by the white pine weevil (*Pissodes strobi* Peck) is an element of loss of considerable importance, especially in mixed stands and in open pure stands of this timber. The value of such trees is reduced from 20 to 50 per cent below those of normal development, and there is an additional loss from the effect of their spreading branches or crowns in the suppression or crowding out of trees which would otherwise occupy the space thus usurped. (Hopkins, 1906*c*, 1907*d*.)

There are many other examples of insects which damage the wood and bark of living trees, but those mentioned should be sufficient to demonstrate the importance of insects in this relation.

Insect Injuries to the Wood of Dying and Dead Trees.

Timber dying from insect attack and other causes, including fire, disease, storms, etc., is attacked by certain wood-boring insects which extend their burrows through the sound sapwood and heartwood, and thus contribute to the rapid deterioration and decay of a commodity which otherwise would be available commercially during periods of from one to twenty years or more after the death of the trees, depending on the species of trees and on the character of the product desired. This loss often amounts to from 25 to 100 per cent during the period in which the dead timber would otherwise be almost as valuable as if living. (Hopkins, 1894*a*, 1901*d*, 1904*a*, 1905*a*; Webb, 1909.)

CONIFEROUS TREES.

Sawyers.—One of the most striking examples of the destruction or deterioration of the wood of dying and dead timber, familiar to all lumbermen, is the injury to fire-killed and storm-felled pine, fir, spruce, etc., caused by boring larvæ known as "sawyers." These borers hatch from eggs deposited by the adult beetles in the bark of the dying trees, and after feeding on the inner bark for a time they enter the solid wood and extend their large burrows deep into the heartwood. Fire-killed white pine is especially liable to this injury, and is often so seriously damaged within three or four months during the warm season as to reduce the value of the timber 30 to 50 per cent. The shortleaf, loblolly, and longleaf pines of the Southern States are damaged to a somewhat less extent, but instances are known in which more than one billion feet of storm-felled timber within limited areas were reduced in value 25 to 35 per cent within three months after the storm. (Webb, 1909.) The fire-killed and insect-killed sugar pine, silver pine, and yellow pine of the western forests are also damaged in a similar manner and the value of the product greatly reduced within a few months after the trees die. The aggregate losses from this secondary source in the coniferous forests of the entire country contribute largely to the annual waste of millions of dollars' worth of forest products which otherwise might be utilized. (Hopkins, 1905*a*, p. 385; Webb, 1909.)

Ambrosia beetles.—Wood-boring insects of another class, known as timber beetles or ambrosia beetles, cause pinhole defects, principally in the sapwood, although some of them extend their burrows into the heartwood. These insects make their attack in the early stage of the declining or dying of the tree, or before the sapwood has materially changed from the normal healthy condition, and often in such numbers as to perforate every square inch of wood. Thus the wood is not only rendered defective on account of the presence of pinholes, but the holes give entrance to a wood-staining fungus which causes a rapid discoloration and produces still further deterioration of the product.

The sapwood of trees dying from the attack of other insects or from fire, storm, or other causes is often reduced in value 50 per cent or more, and in some cases the value of the heartwood is reduced in a like manner from 5 to 10 per cent. (Hopkins, 1894*b*, 1895*c*, 1898*b*, 1904*a*, 1905*a*.)

Pinhole borers in cypress.—An example of the destructive work of insects which attack dying and dead trees is found in the cypress in the Gulf States, where these trees are deadened by the lumbermen and left standing several months, or until the timber is sufficiently dry to be floated. Upon investigation it was found that trees deadened at certain seasons of the year were attacked by the ambrosia beetles or pinhole borers, and that in some cases millions of feet of timber had been reduced 10 to 25 per cent or more in value. (Hopkins, 1907*b*.)

HARDWOOD TREES.

Roundheaded borers, timber worms, and ambrosia beetles.—The principal damage to dying and dead hardwood trees is caused by certain roundheaded wood-borers (Cerambycidæ) with habits similar to the sawyer, by the timber worms mentioned as damaging living timber, and by ambrosia beetles having habits similar to those that attack the sapwood and heartwood of conifers. All of the hardwoods suffer more or less, but the greatest damage is done to the wood of hickory, ash, oak, and chestnut, which are often reduced in value 10 to 25 per cent or more within the period in which it would otherwise remain sound and available for commercial purposes. (Hopkins, 1894*a*, 1904*a*, 1905*a*.)

Insect Injuries to Forest Products.

Damage is caused by various species of insects which are attracted by the varying conditions prevailing at different stages during the process of utilizing the forest resources, from the time the trees are felled until the logs are converted into the crude and finished product and until the latter reaches the final consumer, or even after it is placed in the finished article or structure. As a result, additional drains are made on the timber to meet the demand for the higher grades of lumber and for other supplies to replace those injured or destroyed. From the writer's personal investigations of this subject in different sections of the country it is evident that the damage to forest products of various kinds from this cause is far more extensive than is generally recognized. This loss differs from that resulting from insect damage to standing timber in that it represents more directly a loss of money invested in material and labor. (Hopkins, 1894*a*, 1903*c*, 1904*a*, 1905*a*.)

CRUDE PRODUCTS.

Roundheaded borers, timber worms, and ambrosia beetles.—Round timber with the bark on, such as poles, posts, mine props, sawlogs, etc., is subject to serious damage by the same class of insects as those mentioned under injury to the wood of dying and dead trees. The damage is especially severe when material is handled in such a manner as to offer favorable conditions for attack (Hopkins, 1905*a*), as when the logs are left in the woods on skidways or in mill yards for a month or more after they have been cut from the living trees. Under such conditions there is often a reduction in value of from 5 to 30 per cent or more, due to wormhole and pinhole defects caused by roundheaded and flatheaded wood-borers and timber beetles. Frequently the insects continue the work in the unseasoned and even dry lumber cut from logs which had been previously infested. They also continue to work in mine props after they have been placed in the mine, and in logs and other material used for the construction of cabins, rustic houses, etc., and in round timbers generally.

The products from saplings, such as hickory hoop-poles and like material, are often seriously injured or rendered worthless by roundheaded and flatheaded borers and wood-boring beetles, sometimes resulting in a loss of from 50 to 100 per cent of the merchantable product. (Hopkins, 1905*a*.)

Stave and shingle bolts left in moist, shady places in the woods or in close piles during the summer months are often attacked by ambrosia beetles and timber beetles. The value of the product is often reduced, as a consequence, from 10 to 50 per cent or more. (Hopkins, 1894*a*, 1905*a*.)

Handle and wagon stock in the rough is especially liable to injury by ambrosia beetles and roundheaded borers. Hickory and ash bolts from which the bark is not removed are almost certain to be greatly damaged if the logs and bolts cut from living trees during the winter and spring are held over for a few weeks after the middle of March or first of April. (Hopkins, 1905*a*.)

Pulpwood, and cordwood for fuel and other purposes, cut during the winter and spring and left in the woods for a few weeks or months or in close piles after the beginning of the warm weather, are sometimes riddled with wormholes or converted into sawdust borings, causing a loss of from 10 to 100 per cent. One example reported from near Munising, Mich., represents a loss of $5,000 from injury to spruce and fir pulpwood cut in the winter and kept in piles over summer.

MANUFACTURED UNSEASONED PRODUCTS.

Ambrosia beetles and other wood borers.—Freshly sawed hardwood placed in close piles during warm, damp weather during the period from June to September is often seriously injured by ambrosia beetles. Heavy 2-inch to 3-inch stuff is also liable to attack by the same insects, even in loose piles. An example of this was found in some thousands of feet of mahogany lumber of the highest grade, which had been sawed from imported round logs and piled with lumber sticks between the tiers of plank. Native species of ambrosia beetles, principally *Pterocyclon mali* Fitch, had entered the wood to such an extent as to have reduced the value 50 per cent or more within a few weeks. Oak, poplar, gum, and similar woods often suffer severely from this class of injury, causing losses varying from 5 to 50 per cent. (Hopkins, 1905*a*.)

Lumber and square timbers of both soft and hard woods with the bark left on the edges are frequently damaged by flatheaded and roundheaded wood borers, which hatch from eggs deposited in the bark before or after the lumber is sawed. There are examples of losses from this character of injury amounting to from 20 to 50 per cent or more.

Telegraph and telephone poles, posts, mine props, etc., are frequently injured before they are set in the ground, especially if the bark remains on them during a few weeks after the middle of March.

SEASONED PRODUCTS IN YARDS AND STOREHOUSES.

Powder-post beetles.—Hardwood lumber of all kinds, rough handles, wagon stock, etc., made partially or entirely of sapwood, are often reduced in value from 10 to 90 per cent by a class of insects known as powder-post beetles. The sapwood of hickory, ash, and oak is most liable to attack. The reported losses from this source during the past five or six years indicate that there has been an average reduction in values of from 5 to 10 per cent or more. (Hopkins, 1903*c*, 1905*a*.)

Old hemlock and oak tanbark is often so badly damaged by various insects which infest dead and dry bark that in some tanyards as much as 50 to 75 per cent of the bark that is over three years old is destroyed. In one tannery in West Virginia it is estimated that more than $30,000 worth of hemlock bark was thus destroyed. (Hopkins, 1905*a*.)

FINISHED PRODUCTS.

The greatest loss of finished hardwood products, such as handle, wagon, carriage, and machinery stock, is caused by powder-post beetles. This is especially true of hickory and ash handles and like products in the large and small storehouses of the country, including the vast amount of material held in storage for the army and navy. When material of this kind is once attacked it is usually worthless for the purposes indicated, and therefore must be replaced with new material. In some cases losses have amounted to from 10 to 50 per cent, and it is estimated that the average losses have been as much as 10 per cent on nearly all sapwood material that has been in storage more than one year. (Hopkins, 1903*c*, 1905*a*.)

UTILIZED PRODUCTS.

Powder-post beetles, white ants, and other wood-boring insects.—The finished woodwork in implements, machinery, wagons, furniture, and the inside finish in private and public buildings are often seriously damaged by powder-post beetles, thus requiring increased demands for new material. (Hopkins, 1903*c*, 1905*a*.)

Construction timbers and other woodwork in new and old buildings are often so seriously damaged by powder-post beetles, white ants, and other wood-boring insects that the affected material has to be removed and replaced by new, or the entire structure torn down and rebuilt. (Hopkins, 1905*a*.)

Construction timbers in bridges and like structures, railroad ties, telephone and telegraph poles, mine props, fence posts, etc., are sometimes seriously injured by wood-boring larvæ, termites, black ants, carpenter bees, and powder-post beetles, and sometimes reduced in efficiency from 10 to 100 per cent.

INSECTS IN THEIR RELATION TO THE REDUCTION OF FUTURE SUPPLIES OF TIMBER.

Insects not only reduce future supplies by killing the mature trees and destroying the wood of timber that is inaccessible for utilization, but through injuries inflicted upon trees during the flowering, fruiting, germinating, seedling, and sapling periods of early growth they prevent normal reproduction and development. (Hopkins, 1904*a*, 1906*c*.)

INTERRELATIONS OF FOREST INSECTS AND FOREST FIRES.

Investigations conducted by the writer and assistants in all sections of the country during the past ten years indicate to them quite conclusively that the average percentage of loss of merchantable timber in the forests of the entire country to be charged to insects during a five or ten year period is infinitely greater than most people realize. (Hopkins, 1906*a*, pp. 4–5, 1908*b*, p. 345, 1909*b*, pp. 5, 24; Forbes, 1909, pp. 51–52.)

Losses from forest insects.—The writer estimates (p. 70) that for a ten-year period the average amount of timber in the forests of the entire country killed and reduced in value by insects would represent an average loss of $62,500,000 annually.[a]

It has been estimated (Hopkins, 1905*b*, p. 5; 1908*a*, p. 162) that the Black Hills beetle killed approximately 1,000,000,000 feet b. m. of timber during a period of ten years, which at $2.50 per thousand would amount to an average of $250,000 annually. This is merely one example of very destructive depredations by a single species of barkbeetle in a single national forest.[b] (See also p. 70.)

Prof. Lawrence Bruner, state entomologist of Nebraska, at a meeting of the American Association of Economic Entomologists, held at

[a] *Losses from forest fires.*—It has been estimated that "on the average, since 1870, forest fires have yearly cost $50,000,000 in timber." (Cleveland, T., jr., 1909, p. 3.)

[b] It has been estimated that the losses of timber from forest fires on all of the National Forests of the United States from 1905 to 1908, inclusive, average only $165,062 annually. (Cleveland, T., jr., 1908, p. 541.)

Baltimore, Md., in December, 1908, spoke as follows: "I can agree with Doctor Hopkins that the insects are far more important in destroying our forests than fires." (Bruner, 1909, p. 53.)

Insect-killed timber as fuel for fires.—It has often happened that after insects have killed the timber over extensive areas the standing and fallen dead trees furnished fuel for great forest fires which have not only destroyed or charred the dead timber but killed the living timber and reproduction and swept on into adjacent areas of healthy timber. Indeed, abundant evidence has been found during recent investigations to indicate that some of the vast denuded areas in the Rocky Mountains and other sections of the country are primarily due to widespread devastation by insects, and that subsequent fires destroyed the timber and prevented reproduction. (Hopkins, 1906*a*.)

It is also evident that a considerable percentage of dead timber, and especially that found in coniferous forest regions, which has generally been believed to have been fire-killed is a result of primary attack by insects. This has been demonstrated in many cases by the pitch-marked galleries of the destructive barkbeetles on the surface of the wood of the old dead trees which had escaped subsequent fires.

Fire-killed timber injured by insects.—It is true that a vast amount of timber has been killed outright or has died as the direct result of forest fires, but in almost every case observed insects have contributed to a greater or less extent to the death of recently fire-injured trees which might otherwise have recovered, and especially to the rapid deterioration of the wood of a large percentage of the injured and killed trees. It is evident that in some cases fire-scorched and fire-killed timber has contributed to the multiplication of one or more of the insect enemies destructive to living timber, and thus the injury started by the fire may have resulted in a destructive outbreak of beetles. However, it is evident that this has happened only when the destructive beetle was already present in abnormal numbers in the forest surrounding the fire-swept area. Therefore, *it is believed that injuries by fire are not as a rule an important factor in contributing to subsequent depredations by barkbeetles.* Such fires, however, contribute to the multiplication of the insects which depredate on the bark and wood of dying and dead trees, so that in forested areas where fires are frequent the damage to the wood of such trees is more severe, and fewer injured trees recover on account of the abundance of secondary barkbeetle enemies which do not, as a rule, attack and kill living timber.

Destruction of insects by fire.—There is another important feature in the relation of insects and fire, in which the fire contributes to the destruction of the principal barkbeetle enemies of the living timber. This happens when the fire burns the timber while it is infested, thus effectually destroying the broods of the insects. It is perfectly plain that the dying and dead foliage of the beetle-infested trees and the dead bark on the trunks would contribute to the spreading of crown fires and thus the bark on the entire infested trunks would be sufficiently scorched to kill the insects. Therefore, complete fire control may easily contribute to more extended depredations by insects on the living timber, thus increasing, rather than diminishing, the need for insect control. However, the setting of fires or permitting them to burn for the purpose of combating insects should never be undertaken or permitted.

Durability of insect-killed timber.—Some of the matured larch trees which evidently died as a result of defoliation by the larch worm between 1881 and 1885, and which had escaped subsequent depredations by fire and wood-boring insects, were found by the writer in 1908 to be standing and sound enough to be utilized for railroad ties and many other purposes. Under similar conditions the heartwood of red spruce and white pine in the East, of Engelmann spruce in the Rocky Mountains, and of Douglas fir in the Northwest coast region have been found by the writer to be sound enough for profitable utilization for pulp wood, lumber, fuel, and other purposes from twenty to thirty years after it had been killed by insects or fire. Thus it is shown that timber killed by insects and fire would be available for utilization for many years were it not for injuries through the secondary attacks of wood-boring insects and the destruction of insect-killed timber by forest fires.

INTERRELATION OF FOREST INSECTS AND FOREST FUNGI.

Decay following injury by insects.—It is well known that the burrows in the bark and wood of living and dead trees and in the crude and finished products often contribute to the entrance of bark and wood decaying fungi. Deterioration and decay are thus far more rapid than would otherwise be possible. It is also known that trees injured and dying from primary attack by parasitic fungi are attractive to certain insects which breed in the bark and wood of sickly and dying trees, and that certain other complicated troubles affecting forest trees are the result of an intimate interrelation and interdependence of insects and fungi. There can be no doubt, however, that certain species and groups of both insects and fungi are independently capable of attacking and killing perfectly vigorous and healthy trees.

SUMMARY AND ESTIMATES RELATING TO CHARACTER AND EXTENT OF INSECT DAMAGE.

The killing of trees by insects; the damage by them to the wood of living, dying, and dead timber; the destruction of insect-killed timber by subsequent forest fires; the damage to fire-killed timber by insects; and the damage from decay resulting from insect injuries to the wood, have all been more or less continuous for centuries and are still going on in the forest and woodland areas of this country.

While these depredations are not always evident or important in all forests or localities, yet almost every year, somewhere in the forests of the country, there are widespread depredations.

In every forest and woodland there is an ever present but inconspicuous army of insects which require the bark, wood, foliage, and seeds of the various tree species for their breeding places or food. Thus, the accumulated but inconspicuous injuries wrought during the period required for the growth of a tree to commercial size go far toward reducing the average annual increment below the point of profitable investments.

The accumulated damage to crude, finished, and utilized products reduces the profits of the manufacturer, increases the price of the higher grades to the consumer, and results in an increased drain on the natural resources.

In any attempt to estimate in *dollars* or *feet, board measure*, the extent of losses or waste of timber supplies caused by insects there are many conflicting factors which contribute to the difficulty of arriving at accurate conclusions. The published information concerning the amount in board feet of standing timber in the country is admittedly only an estimate, as are also the published data relating to average stumpage value. The published statistics relating to the amount and value of forest products are of course more accurate, but until more complete data can be furnished by the forest experts on the various complicated phases of forest statistics, any figures given by the forest entomologist relating to the value of timber and commercial products destroyed or reduced in value by insects must be considered on the same basis as the other estimates, and as the best that can be presented on available evidence.

Standing timber killed and damaged by insects.—When we consider the amount of standing merchantable timber killed by insects and the amount of standing timber, living, dying, and dead, which has been reduced in quantity and value through their agency during a ten-year period, we would estimate that such timber represents an equivalent of more than 10 per cent of the quantity and stumpage value of the total stand of merchantable timber in the United States at any given time.[a] A certain percentage of such timber is a total

[a] The estimate of the area and stand of the present forests of the United States, as given in Circular 166 of the Forest Service, page 6, is two trillion five hundred billion feet (2,500,000,000,000) board measure. The average stumpage value has been given as $2.50 per one thousand feet b. m., making a total value of the standing merchantable timber of $6,250,000,000. Ten per cent of this amount would be $625,000,000, as the amount to be charged to insects for a 10-year period, or an average of $62,500,000 annually. As an example, it has been estimated that over 1,000,000,000 feet b. m. of timber was killed by the Black Hills beetle in the Black Hills National Forest within a period of ten years. This, at $2.50 per one thousand feet stumpage, would be an average of $250,000 annually in a single forest of 1,294,440 acres.

loss because of the impossibility of utilization; but in some cases a greater or less percentage can be, and in some cases is, utilized within the period in which it is of sufficient value to yield a profitable return on the cost of logging and manufacture, although its value is greatly reduced.

Reduction in the Nation's wealth.—When we consider the forest resources both in merchantable timber and young growth as an important asset of the Nation's wealth; as representing a given value to the people for direct utilization; as a cover to the soil for protection of the land from erosion; as protection of headwater streams and of game; and as contributing to the æsthetic value of health and pleasure resorts, it would be difficult indeed to estimate the amount or percentage of loss of timber or the reduction in the land values, in each case, chargeable to insects. It is plain, however, that in the aggregate it is considerably greater than when estimated on stumpage values alone.

Reduction in cash revenue.—When we consider the problem from the standpoint of direct utilization we can estimate the annual loss on a basis of mill values; but here again we meet with complications, since much of the damaged material is left standing or is discarded in the woods or at the mill without measurement. Therefore we are left to judge from our observations and knowledge of the general conditions as regards dead and damaged timber found in the forests of the country, and the information from lumbermen in different sections, as to the percentage of loss from defective timber. On this basis we can estimate that the amount of insect-killed and damaged timber left in the woods, plus the reduction in value of that utilized, to be charged to insects is not far from an equivalent of 10 per cent of the value of the annual output of forest products of all kinds, in the rough. The total value of the forest products of the United States in 1907 is given as $1,280,000,000; the losses from insect depredations would therefore represent an annual loss in a cash value of more than $100,000,000. (Hopkins, 1895*c*, 1901*a*.)

Reduction in value of finished and commercial products.—When we consider the aggregate loss to the manufacturers of the finished products, to the trade, and to the consumer from insect injuries to the wood, it is evident that it amounts to many millions of dollars in addition to the estimated loss of crude products, or at least 3 per cent of the mill value.

METHODS OF PREVENTION AND CONTROL.

The results of extensive investigations and of practical applications of the knowledge gained during recent years have demonstrated that some of the most destructive insect enemies of American forests and of the manufactured and utilized products can be controlled, and serious damage prevented, with little or no ultimate cost over that involved in forest management and business methods. (Hopkins, 1904*b*, 1905*a*, 1908*a*, 1909*b*.)

There are, of course, certain insects and certain injuries which, under present conditions and available information, can not be controlled or prevented, but it is very evident that if the information now available through the publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future it would result in the prevention of at least 30 per cent of the estimated annual waste of forest resources that has been caused by insects within recent years, and thus contribute greatly to the conservation of forest resources.

GENERAL PRINCIPLES OF CONTROL.

The ordinary spraying and similar methods employed in dealing with fruit and shade tree insects are, of course, not available for practical application in the case of forest trees. But there are other and less expensive methods of accomplishing the desired results.

In all efforts to control an outbreak or prevent excessive loss from forest insects it should be remembered that as a rule it is useless to attempt the complete extermination of a given insect enemy of a forest tree or forest product. Experience has demonstrated that it is only necessary to reduce and weaken its forces 75 per cent or more. It can not then continue an aggressive attack, but must occupy a defensive position against its own enemies until conditions resulting from avoidable negligence and mismanagement by the owners of the forests and manufacturers of forest products favor its again becoming destructive. Forest insects can thus be easily kept under control by good management.

The desired control or prevention of loss can often be brought about by the adoption or adjustment of those requisite details in forest management and in lumbering and manufacturing operations, storing, transportation, and utilization of the products which at the least expenditure will cause the necessary reduction of the injurious insects and establish unfavorable conditions for their future multiplication or continuance of destructive work.

It is, however, of the utmost importance that any adjustment or modification in management or business methods should be based on expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved and the essential features of the methods for their control. This should be supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care, and utilization of the forest and its resources, and still further supplemented by practical knowledge and experience relating to local conditions and facilities favorable and unfavorable for success in practical applications according to the recommended method or policy of control.

As has been shown, the mature or merchantable timber is the most susceptible to injury or death from the ravages of insects. Therefore, considered from the standpoint of insect control and the prevention of one of the greatest items of loss, it is important that such matured timber should be utilized before it begins to deteriorate, or before it reaches the stage of unprofitable growth.

For the greatest success in dealing with forest insects, it must be recognized that there are certain features in the habits and seasonal history of each species which differ to a greater or less extent from those of all other species, even of the same genus; that there are certain features in the characteristics of the various species of trees which differ from those of all other species; and that as a rule it is the technical knowledge of these peculiar features or characteristics of the trees and their enemies which furnishes the clew to successful methods of control.

There are also many peculiar features in the prevailing conditions in different localities, some of them favorable, others unfavorable, for the practical application according to a given method, so that while certain general advice may apply in a broad sense and be available for utilization by the practical man, whether owner, manager, or forester, without further advice, it is often necessary to diagnose a given case before specific expert advice can be given as to the exact cause and the most effective method or policy to be adopted, just as a physician must diagnose a case of illness or injury before prescribing the required treatment for his patient.

Therefore, in a consideration of the problem as to how far the waste of forest resources caused by insects can be prevented and how far the damaged timber can be utilized, we will attempt to give only general statements based on the results of our observations relating to some of the principal kinds of loss discussed in the first part of this paper, namely, by insects which (1) kill the trees, (2) cause injuries to the wood of living timber, (3) reduce future supplies, and (4) cause injuries to the manufactured products. In addition, we will consider the utilization of natural enemies of injurious insects, the utilization of damaged timber, and the present conditions and opportunities for success in the general control of forest insects.

CONTROL OF BARKBEETLES WHICH KILL TREES.

The barkbeetles which kill trees attack the bark on the trunk and destroy the life of the tree by extending their burrows or galleries in all directions through the inner living bark. The broods of young grubs or larvæ develop within the inner bark, on which they feed.

Those of some species develop to the adult stage within the inner bark and are exposed when the bark is removed, while those of other species transform to the adults in the outer corky bark and the larvæ are not exposed when the bark is removed. Some species have two or more generations in a season or annually, while others have but one, and in a few species it requires two years for a single generation to develop. (Hopkins, 1909*b*.)

The barkbeetles of the genus Dendroctonus represent the most destructive enemies of the principal coniferous tree species of American forests, and at the same time are among the easiest of control. The general requisites for success are embodied in the following rules:

(*a*) Give prompt attention to the first evidence of a destructive outbreak, as indicated by an abnormal percentage of yellow or red topped dying trees, and especially when such trees occur in groups of ten or more or cover large areas; (*b*) secure authentic determination of the particular species of insect responsible for the trouble; and (*c*) take prompt action toward its control according to specific expert advice, published or otherwise, on the best method for the destruction of the necessary 75 per cent or more of the insects in the infested trees.

Some of the methods to be adopted to meet the requirements of various local conditions are as follows:

(1) Utilize the infested timber and burn the slabs during the period in which the broods of the destructive beetles are in the immature stages or before the developed broods emerge from the bark; or

(2) Fell the infested trees and remove the bark from the main trunk and burn the bark if necessary;[a] or

(3) Remove the infested bark from the standing timber and burn the bark when necessary;[a] or

(4) Immerse the unbarked logs in ponds, lakes, or streams, where the bark will remain soaked long enough to kill the insects; or

(5) Remove the unbarked logs or products to a locality where there are no trees liable to attack within a radius of 20 miles or more.

MAINTAINING CONTROL OF BARKBEETLES.

Future trouble of a serious nature from barkbeetles which kill trees can be prevented within a given forest or area of greater or less extent if an insect-control policy is adopted in connection with, or independent of, a fire-control policy by which groups of dying trees will receive similar prompt attention as that required for the prevention or control of forest fires.

In state and national forests.—In all forest reserves in which there is an organized force of rangers and fire wardens or patrols each

[a] If the broods develop to adults in the outer bark, it must be burned; if they develop in the inner bark and are exposed when the bark is removed, burning is not necessary. As a rule the burning of the tops to destroy the insects is not necessary.

officer should be furnished with instructions for the location of beetle-infested trees, and with equipment and directions for taking the necessary action whenever the conditions demand or warrant it.

In private forests.—Private forests should receive the same attention as public forests, but this is often far more difficult on account of intervening forests, where the owners either can not or will not give the matter the required attention. While it may be advisable to have some laws to govern the treatment of timber infested with a dangerous pest, when the owner refuses to take any action such a law should apply only to the more extreme cases or as a last resort on authoritative advice. It is probable that in most cases legislation will not be necessary, and more ultimate good will result without than with strict laws, especially when it can be made clear to the owner that his personal interests demand that he take the proper action and that, when necessary, his neighbors will render assistance, as is done in the case of a forest fire.

Inaccessible areas.—There are yet large inaccessible areas in the East and West where it is not practicable or possible at present to control the depredations by these beetles and which must therefore be left to the same natural adjustment that has been going on in all forests from their beginning. While under such natural control much of the older matured timber will be lost it will usually be replaced by young growth, either of the same species of trees or of a different species, so that under normal conditions the forest will be perpetuated; but under exceptional conditions and combinations of detrimental influences, such as secondary insect enemies, fire, drought, etc., extensive areas may be completely denuded, never to be reforested under natural conditions. Therefore it will evidently not be very long before it will pay to adopt insect-control policies even in the areas that are inaccessible for profitable lumbering.

Examples of Successful Control of Barkbeetles.

We have a sufficient number of examples of successful control of depredations by the destructive barkbeetles to demonstrate the practicability of the advice based on the results of recent entomological investigations.

Control of the eastern spruce beetle.—The control of an alarming outbreak of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in northeastern Maine in 1900 and 1901 was effected by the concentration of regular logging operations into the areas of infested timber and placing the logs in lakes and streams and driving them to the mills on the Androscoggin River. Thus, with little or no additional expense, there was a saving to one firm, according to its estimates, of more than $100,000.

Control of the Black Hills beetle.—An extensive outbreak of the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.) in the vicinity of Colorado Springs, Colo., in 1905–6, which was threatening the living pine timber of the entire section, was brought under control through the efforts of the private owners of forests and those of forest officials in the adjoining National Forests. It was accomplished by cutting and barking about 1,000 beetle-infested and beetle-killed pine trees. The cost of the operations was largely, if not entirely, covered by the utilized felled timber, although there was considerable unnecessary expense involved through the felling and barking of trees from which the beetles had emerged and from the unnecessary burning of the bark and tops.

The successful control of another serious outbreak of the Black Hills beetle, in 1906, on an extensive private estate in southern Colorado, was effected through the efforts of the owners, who had some 500 infested trees felled and barked within the necessary period to destroy the broods. A large percentage, but not all, of the infested timber was thus treated. These operations were so successful that not a single infested and dying tree could be found when the area was inspected in 1908. In this, as in the other case, considerable unnecessary expense was involved in the burning of the bark and tops, but the value of utilizable timber was evidently more than enough to pay all expenses. It is evident that in this case a destructive invasion was prevented.

The most striking example of success relates to a large estate near Idaho Springs, Colo., and in the adjoining Pike National Forest. In May, 1907, it was found that some 63,000 feet of standing timber on the estate was infested by the Black Hills beetle, and the owner was advised by the Bureau of Entomology that unless the ravages were checked at once the beetle would kill the timber not only on this estate but that on the adjoining estates and National Forest, and that therefore radical action should be taken according to the recommendations and detailed instructions given relating to a necessary control policy. No action was taken, however, before the first of the following July, and therefore not in time to prevent the broods of beetles from swarming from the infested trees and extending their ravages. In December, 1907, another examination of the timber was made, and it was found that instead of 65,000 feet of timber in the old infestation there was nearly four times as much timber involved in the new, or over 250,000 feet. The owner was again notified of the serious character of the outbreak, and further suggestion made that if the logs from the infested trees were converted into lumber and the slabs burned before May, 1908, it would result in the protection of the remaining living timber. Immediate steps were then taken by the owners to carry out the original recommendations. An expert in locating infested timber, working under instructions from this Bureau, gave instructions to the manager of the estate in locating and marking the infested trees and in the essential features in the methods of utilization to destroy the necessary number of beetles; he also marked infested timber on an adjoining estate and on the National Forest. Five months later, in May, 1908, this expert reported that the larger clumps of infested trees on the estate had been converted into lumber and the slabs burned, and that the marked trees on the adjoining estate and National Forest had been cut and barked. In November, 1908, another inspection of the forest on the estate and surrounding area was made by the expert, and on December 1 he reported as follows:

> Nothing could be more satisfactory than the results obtained by the cutting of the infested timber on the estate. Your recommendations and instructions submitted to the owner, and carefully followed by the manager of the estate, have clearly demonstrated that insect infestation can be controlled, and at no expense to the owner of the timber involved; in fact a very satisfactory price was realized, resulting in a net profit, I understand, of over \$5 per thousand feet, board measure, on the 240,000 feet cut. This, of course, does not include the profit of the milling operations, but for the logs sold at the mill, after deducting the expenses of cutting and logging. The sawmill was owned and operated by an Idaho Springs firm, and the manufactured article sold in that town. I spent six days on the estate, November 18 to 23. After a very thorough examination of the timber, I found only three infested trees, isolated individuals, and over a mile from where the large clumps of infested trees were cut. With the exception of those three trees, there is no new infestation on the estate. I also examined the adjoining lands, but no new infestation was observed. The infested trees which I marked in December, 1907, had been cut and barked. On the Pike National Forest, contiguous to the first mentioned estate, where you will remember I marked some clumps of infested trees, no new infestation was found, not one tree.

This most gratifying result demonstrated two important things: One, that an extensive outbreak by the most destructive barkbeetle enemy of the pine timber of the central Rocky Mountain forests, involving in this case more than 1,000 infested trees, can be controlled without expense, and even at a profit, whenever the conditions are favorable for the utilization of the infested timber; the other, that the essential details of the recommendations and expert advice, based on the results of scientific research, can be successfully applied by a manager of a private forest or by the rangers of national and state forests. It also indicates quite conclusively that the widespread depredations in the Black Hills National Forest could have been prevented with very little expense to the Government if the matter had received prompt attention in 1901, when the first investigations were made and essentially the same recommendations submitted. But, through the lack of public appreciation of the importance of the problem at the time, and the lack of sufficient authority and funds later, the outbreak was allowed to extend beyond practical control, and in consequence a large percentage of the timber of the entire National Forest has been killed. There were, then, no forcible examples of the practical value of such recommendations based on scientific research, and no other argument was effective in arousing public interest in the threatening character of the outbreak or confidence in scientific advice or methods of control. Now we have several examples demonstrating the practicability of forest-insect control in America which should lead to confidence in the results of scientific research as a basis for success in practical application.

Control of the hickory barkbeetle.—The complete control of the hickory barkbeetle (*Scolytus quadrispinosus* Say), which threatened the total destruction of the hickory trees on Belle Isle Park, at Detroit, Mich., in 1903, was effected by felling and removing the infested trees and converting them into merchantable products, all without cost to the park commission. (Hopkins, 1904*b*.)

CONTROL OF INSECTS WHICH CAUSE DEFECTS IN LIVING TIMBER.

The class of insects which causes defects in the wood of living timber can be controlled to a greater or less extent, depending upon local conditions, and a large percentage of the losses prevented through the adoption of certain requisite details in forest management. Of these the following are especially important:

(1) The utilization of all of the defective and infested timber that will pay expenses for manufacture into merchantable products, such as lumber, cordwood, etc.

(2) The burning of infested timber and waste material not available for use, including dead standing and fallen timber, to remove the breeding places of insects like the oak timber worm and the chestnut timber worm, which go from the dead to the living timber.

(3) The prevention of wounds of any kind in the bark of living trees.

(4) The prevention of future losses by the practice of improved forestry methods which will eliminate favorable conditions for injury and contribute to a perpetual supply of vigorous, healthy timber to be utilized before it passes the stage of profitable increment.

PREVENTION OF INJURY TO DYING AND DEAD TREES.

A large percentage of the injury to the wood of insect, fire, and lightning killed trees and those killed or dying from injuries by storms, disease, etc., can be prevented as follows:

(1) By the prompt utilization of such timber within a few weeks or months after it is dead or found to be past recovery.

(2) By removing the bark from the merchantable portions of the trunks within a few weeks after the trees are dead (the work to be done either before or after the trees are felled).

(3) By felling the trees and placing the unbarked logs in water.

(4) By the adoption of a system of forest management which will provide for the prompt utilization of all trees which die from any cause.

PREVENTION OF LOSS FROM INSECT INJURIES TO NATURAL AND ARTIFICIAL REPRODUCTION.

The successful control of the insects which destroy or prevent the normal development of natural reproduction is a far more difficult problem than that presented by other classes of insect injuries, but in this as in the others a great deal can be accomplished toward preventing the reduction of future supplies.

Much can be accomplished in nurseries and small plantations by the adoption of the ordinary methods of controlling farm and orchard insects, but in the natural forests reliance must be placed largely on systems of forest management which will bring about unfavorable conditions for the work of the more important enemies. (Hopkins, 1906*c*.)

Utilization of Immune and Resistant Varieties and Races of Trees.

Certain individuals representing varietal or racial forms of trees of a given species are sometimes found to be either immune or decidedly more resistant to the insects which are destructive or seriously injurious to the life or wood of other individuals or varieties of the same species. This fact suggests the importance of recognizing the well-known principle of improvement by selection. Thus, selecting seed or cuttings from such immune and resistant trees for artificial propagation, or taking great pains to leave such trees in commercial or selection cuttings for natural reproduction, will undoubtedly be an important step toward providing against damage and loss in the future. (Hopkins, 1906*b*, 1907*a*, 1907*c*, 1907*d*.)

PREVENTION OF INSECT INJURIES TO FOREST PRODUCTS.

The problem of artificial control and prevention of insect injuries to forest products offers less difficulties perhaps than that relating to many other branches of the general subject of forest-insect control. In most cases the principle of prevention is the only one to be considered, since the damage is done soon after the insects enter the wood, and therefore it can not be repaired by destroying the enemy.

Crude Products.

The proper degree of moisture found in the bark and wood of newly felled trees, saw logs, telegraph poles, posts, and like material, cut in the fall and winter and left on the ground or in close piles during a few weeks or months in the spring and summer, or during the period when the particular species of injurious insects are flying, are some of the conditions most favorable to attack. The period of danger varies with the kind of timber and the time of the year it is felled. Those felled in late fall and winter will generally remain attractive to ambrosia beetles and adults of round and flat headed borers during March, April, and May. Those felled during the period between April and September may be attacked in a few days after they are felled, but the period of danger from a given species of insect may not extend over more than a few weeks. Thus certain kinds of trees felled during certain seasons are never attacked, while if they are felled at other times and seasons the conditions for attack may be most favorable when the insects are active, and then the wood will be thickly infested and ruined. The presence of bark is absolutely necessary for successful infestation by most of the wood-boring grubs, because the eggs and young stages must occupy the inner and outer portions before the latter can enter the wood. Some ambrosia beetles and timber worms will, however, attack barked logs, especially those in close piles or otherwise shaded or protected from rapid drying. A large percentage of the injury to this class of products can be prevented, as follows:

(1) Provide for as little delay as possible between the felling of the tree and its manufacture into rough products. This is especially necessary with trees felled from April to September in the region north of the Gulf States and from March to November in the latter, while the late fall and winter cuttings should all be worked up by March or April.

(2) Do not leave the round timbers in the woods or on the skidways during the danger period, or, if this is unavoidable, take every precaution to facilitate the rapid drying of the inner bark by keeping the logs off the ground, in the sun, or in loose piles, or else, if possible, the opposite extreme should be adopted and the logs kept in water.

(3) Remove the bark within a few days after the trees are felled, from poles, posts, and other material which will not be injured by checking or season cracks.

(4) Take advantage of the proper months or seasons in which to fell or girdle different kinds of trees to avoid danger.

Damage to products cut from saplings and left with the bark on can be prevented by transporting the material from the woods soon after it is cut, so that it will not be left in piles or bundles in or near the forest during the season of insect activity. Damage may also be prevented by care not to leave the material stored in one place for several months.

Pinhole damage to stave and shingle bolts cut during a warm season can be prevented by removing the bark from the timber as soon as it is felled and by converting the bolts into the smallest practicable dimensions and piling them in such a manner as to facilitate rapid drying.

Damage to unseasoned handle and wagon stock in the rough can be prevented by taking special precautions to provide against the same favorable conditions for attack as mentioned in connection with round timbers. This is especially necessary with hickory and ash if cut during the winter and spring.

Damage to pulpwood and cordwood can be prevented to a great extent by placing the sticks of wood in triangular or crib piles immediately after they are cut from the trees, especially if the timber is cut during the danger period or must be held for a few months during the warm season. Peeling or splitting the wood, or both, before it is piled will also provide against damage from insects.

Manufactured Products.

UNSEASONED PRODUCTS.

Freshly sawed hardwood lumber placed in close piles during warm, damp weather in the period from July to September, inclusive, presents the most favorable conditions for injury by ambrosia beetles. In all cases it is the moist condition and retarded drying of the lumber which induces attack. Therefore any method which will provide for the rapid drying of the lumber before or after piling will tend to prevent loss. It is important, also, that heavy lumber should, as far as possible, be cut only in the winter and piled so that it will be well dried out before the middle of March.

The damage to lumber and square timber when the bark is left on the edges or sides can be prevented by removing the bark before or immediately after the lumber is sawed, or by sawing and piling the material during the winter, or if sawed at other times it should be piled so that rapid drying will be facilitated.

SEASONED PRODUCTS.

Unfinished seasoned products.—Injury by powder-post beetles to dry hardwood lumber and other material in stacks or storehouses can be prevented as follows:

(1) Have a general inspection of the material in the yards and storehouses at least once a year, preferably during November or February, for the purpose of (*a*) sorting out and destroying or otherwise disposing of any material that shows the slightest evidence of injury, as indicated by the presence of fine powdery boring dust, and (*b*) sorting out and destroying all old and useless sapwood material of any kind that will offer favorable breeding places for the insects.

(2) Prevent the introduction into the lumber yards or storehouses of any infested material, remembering that the insect may be thus distributed to or from all parts of the world.

(3) Adopt a system of classification of all dry or seasoned hardwood stock which will provide for (*a*) the separation of the pure heartwood material from the pure and part sapwood material; (*b*) classification of all kinds of wood most liable to attack, such as hickory, ash, oak; (*c*) the successive utilization or sale of the older material (remembering that material one year old or over is far more liable to injury); (*d*) providing against the accumulation of refuse material in which the insects could breed; and (*e*) treating the best material with linseed oil or kerosene to prevent attack.

Finished seasoned products.—Damage to finished handles, oars, spokes, rims, hubs, wheels, and other unpainted wagon, carriage, machinery, and implement stock in factories, wholesale and retail storehouses, and army and navy stores can be prevented by the adoption of the same general rules as those given under rough products. In addition, damage can be controlled and prevented in the following manner:

Sort out and (*a*) destroy all articles showing the slightest evidence of powder-post injury, or (*b*) treat with kerosene oil such infested and slightly injured articles as may be tested for required strength and found to be of sufficient value for retention, placing the same in quarantine for a sufficient time to determine whether the treatment is successful.

Damage by powder-post insects to many kinds of articles can be prevented and at the same time the material otherwise benefited by treating the sapwood with linseed oil or kerosene, either by immersing it in the oil or by applying the oil with a brush, the application to be made as soon as possible after the articles are finished from recently seasoned, uninjured stock.

Past and Present Conditions of Powder-Post Injury.

Up to 1906 there were a great many reports of extensive losses of valuable material from the ravages of powder-post beetles which were seriously affecting all industries involved in the manufacture, sale, and utilization of the classes of hardwood products affected by them. In response to these reports and accompanying appeals to the Department of Agriculture for information on causes and remedies, the problem was thoroughly investigated and specific advice and instructions relating to practical methods of control and prevention have been widely disseminated, both through publications of the Department and special correspondence.

Reports of present conditions from our principal correspondents, together with the less frequent requests for advice, indicate that the disseminated information has been extensively utilized and that it has been worth many millions of dollars toward eliminating the losses and reducing the drain on the limited supply of the kinds of timber required to replenish the damaged and destroyed material.

The army and navy stores of handles, tent poles, wheelbarrows, oars, and many other hardwood articles have suffered severely from powder-post damage, involving an enormous loss, but the carrying out of the information already supplied has evidently contributed greatly toward the elimination of this source of loss to the Government.

Tan Bark.

Damage to hemlock and oak tan bark by the class of insects which in some cases has been so destructive to these products in the past can be easily prevented without cost, as follows:

(1) Utilize the bark within three years from the time it is taken from the trees.

(2) Prevent the accumulation in the yards and store-sheds of old bark and waste material in which the insects can breed.

These simple methods have been extensively adopted since their recommendation in correspondence and publications between about 1891 and 1901, and afford one of the most striking examples of the value of expert information on the peculiar habits of insects and of how millions of dollars can be saved without cost through a simple adjustment in methods of utilization.

Utilized Products.

Damage and loss from insect injuries to timber and other woodwork in structures of various kinds, to telephone and telegraph poles, posts, railroad ties, mine props, etc., can be prevented to a large extent through the adoption of the proper methods of management or of treating the material with preservatives before and after it is utilized.

TIMBERS AND WOODWORK IN STRUCTURES.

Injuries to timbers and woodwork in dwellings, outbuildings, bridges, etc., by powder-post insects can be prevented as follows:

(1) Use nothing but heartwood for the concealed parts most liable to damage.

(2) If it is necessary to use all or part sapwood material, attack can be prevented by treating the sap portions with kerosene, coal tar, creosote, or linseed oil. Facilities for future treatment can be provided wherever the rough or finished woodwork is exposed, as in outbuildings, bridges, etc., if care is taken to expose the sapwood portions.

(3) If the untreated timbers and woodwork in old buildings show evidence of attack, the affected portions should be given a liberal application of kerosene.

Damage by white ants, or termites, can often be prevented in the following ways:

(1) By the use of nothing but sound wood for underpinning and foundation timbers and the removal of decaying timbers from old structures.

(2) By preventing moist conditions of the wood in any part of the structure and especially that in foundation timbers.

(3) By the treatment of timbers necessarily exposed to moist conditions with creosote, zinc chlorid, corrosive sublimate, etc.

(4) If the timbers become infested, further progress of insect damage can be prevented by removing the badly damaged parts and soaking the remainder with kerosene, fumigating with bisulphid of carbon, and by removing any adjacent decaying or other wood in which the insects have been breeding or may breed, such as logs, stumps, etc.

Log cabins and rustic work.—Damage by bark and wood boring insects to the unbarked logs and poles used in rustic cabins, summer houses, fences, etc., can be largely prevented by cutting the material in October and November and utilizing it at once, or by piling it off the ground or under cover in such a manner as to offer the best facilities for the rapid and thorough drying of the inner bark before the middle of March or the 1st of April following. If these necessary precautions are not taken, and there is evidence that insects are at work in the bark and wood, the damage can be checked by injecting bisulphid of carbon through natural or artificial openings in the affected bark, and immediately stopping these and other openings with putty or a similar substance.

Poles, posts, piles, ties, mine props, and similar products.—Insect damage to poles, posts, and similar products can be prevented to a greater or less extent by the preservative treatments which have been tested and recommended by the Forest Service for the prevention of decay. These should be applied before the material is utilized for the purposes intended, or, if it be attacked after it has been utilized, further damage can be checked to a certain extent by the use of the same substances.

It is often of prime importance to prevent injury from wood-boring insects, for the reason that such injuries contribute to more rapid decay. Therefore anything that will prevent insect injury, either before or after the utilization of such products, will contribute to the prevention of premature deterioration and decay.

UTILIZATION OF NATURAL ENEMIES AND FACTORS IN THE CONTROL OF INJURIOUS INSECTS.

Were it not for the natural checks and natural factors of control of some of the more destructive insect enemies of forest trees and forest products, artificial control would in many cases be impossible, and the depredations would evidently be far more continuous and complete. These natural factors in the control of the depredating insects consist of parasitic and predatory insects, diseases of insects, birds, adverse climatic conditions, etc. While one or more of these beneficial factors exert a continuous and powerful influence toward the prevention of a more extensive waste of forest resources, it has been repeatedly demonstrated that they can not be depended on to prevent widespread devastations or to otherwise work for the best interests of the private or public owner by protecting the best trees and the best tree species. The insects and birds which prey upon the depredating insects also have factors to contend against, consisting of insects, birds, diseases, and climatic conditions. Therefore under normal conditions the tendency is toward the preservation of a balance between the warring factors, but frequently the enemies of the trees get the ascendancy and take on the character of an invasion, which may continue for two or three or even ten years before the balance is again adjusted through the influence of the natural enemies or diminished food supply. Thus a vast amount of timber or of a given forest product may be destroyed before the factors of natural control can prevail.

It is evident that the most effective utilization of the factors of natural control will be through the alliance with them of the owner of the forest in the artificial reduction of the enemies of the trees rather than by efforts to make the natural enemies of the injurious insects his allies through artificial introduction or dissemination. The former is accomplished by the adoption of methods of combating the invaders which will reduce and weaken their forces below their power of prosecuting aggressive movements and attacks, or, as previously stated, to reduce their numbers to the point where they must occupy a defensive position against their natural enemies and be dependent for their supplies of food and breeding places upon that furnished through avoidable mismanagement of the forests and manufacturing operations. Thus the owner of the forest can contribute greatly toward the preservation of a balance which will be to his material benefit. On the other hand, he may in the future, as in the past, contribute greatly to the multiplication of the depredating insects and to greatly increased losses caused by them, through neglect or a disregard of available information on the fundamental principles of insect control in the management of forests and manufacturing enterprises.

Beneficial Insects.

The beneficial insects comprise those which are internal or external parasites of the immature or mature stages of the injurious insects, and predators which feed on the young or adults of insects either before or after they make their attack on the trees or products. These two beneficial factors are doubtless far more effective in the long run than any other agencies of natural control. Yet they, in combination with all other factors, can not be always relied upon to render continued and efficient control. They can, however, be relied upon to respond to artificial assistance in reducing the numbers of the depredators.

Beneficial Diseases of Insects.

It is very evident that the parasitic fungi and bacteria which sometimes cause epidemics among injurious insects often exert a powerful influence toward the control of extensive outbreaks or invasions of insect enemies of forests. Indeed, it appears that the greatest service rendered by this class of natural enemies is in the frequent sudden appearance of an epidemic which kills off a destructive species of insect after the latter has increased to such numbers and extended its depredations over such vast areas as to be far beyond the control of man or his insect and bird allies. Numerous examples of this kind of natural control are found in the sudden ending of widespread depredations by various species of caterpillars and sawfly larvæ which defoliate deciduous and coniferous trees. As a rule, however, the beneficial effects of the diseases of insects prevail only after the injurious insects have increased to excessive numbers. Therefore this factor of insect control can not be depended upon to hold the insects in check or prevent outbreaks. The fact, however, that it operates on a class of insect enemies of the forest (defoliators) which at present can not be controlled by any known artificial methods renders the services of the diseases all the more valuable.

It is believed that with further knowledge of nature's method of propagating, perpetuating, and disseminating the diseases which cause epidemics among insects, they may be utilized more or less successfully through artificial propagation and dissemination to prevent threatened invasions of defoliating insects.

Beneficial Birds.

It is very evident that certain kinds of birds, such as woodpeckers, render valuable service toward the natural control of destructive bark and wood boring insects. They appear to render the greatest service, however, where but few trees are being killed or injured, because their concentrated work on such trees may contribute toward the prevention of an abnormal increase of the insects. They also render some service as allies of the other beneficial factors which assist in artificial control. It is evident, however, that where many hundreds or thousands of trees are being killed the comparatively limited number of birds in any forest under the most favorable conditions could have little or no beneficial effect. Therefore, while the birds should be classed among the valuable friends of the forest, and should be protected, it is plain that they can not, even with the utmost protection, always be relied upon to protect the forest against destructive ravages of insects.

We must remember, in this connection, that there are complicated interrelations between birds, injurious insects, and beneficial insects which do not necessarily always operate to the benefit of the forest. In fact, it may sometimes be quite the reverse. Therefore, in order to derive the greatest benefit from the conflict between the birds, the insect enemies of the trees, and the insect friends of the trees, we must utilize our knowledge of the factors which are contributing toward the preservation of a balance, so that whenever the enemies of the forest threaten to get beyond natural control we may enter the field through artificial means and endeavor to force them back to their normal defensive position.

Beneficial Climatic Conditions.

The benefits to be derived from climatic conditions which are detrimental or destructive to insect enemies of the forest, while sometimes very great, are necessarily unreliable, and thus can not be depended upon to assist in artificial control. In fact, the very condition which may contribute to the destruction of one depredator may favor the multiplication of another.

UTILIZATION OF WASTE CAUSED BY INSECTS.

When we come to consider the vast amount of standing timber in the forests of the country which has been injured or killed by insects, and will go to waste if it is not utilized within a limited period, we realize that there are great possibilities in its utilization as a means of preventing the reduction of future supplies of living healthy timber. It is all the more important that the insect-infested timber should be utilized, because in so doing we can contribute more perhaps than in any other way to the reduction of the insects to or below their normal numbers, and thus provide against serious injury in the future, as well as to the maintenance of control.

PRESENT CONDITIONS AND OPPORTUNITIES.

Unfortunately, the examples of management, or rather mismanagement, which are contributing to an extension or increase of waste are far in excess of those which under proper management are contributing to the reverse. This is due in a large part to the conditions that have prevailed in American forests in the past that have rendered it impracticable to adopt improved policies of forest management, but at present it is largely due to a lack of appreciation of the importance of the subject, and of the opportunities to prevent such losses, when it is not only practicable but possible to do so, and when it will, at the same time, yield large returns on the necessary additional expense. This is especially true in thousands of farmers' woodlots and private holdings in the States east of the Mississippi River, in which from 25 to 90 per cent of all of the serious injury of the past can be prevented in the future with little or no additional expense over that required for ordinary good forest management.

Forest Entomology as Applied to American Forests.

It is only within the past eleven years that any attempt has been made toward a systematic investigation of the insect enemies of the forest trees and forest products of the entire country. The state of knowledge of the subject previous to that time can be judged by the fact that a number of the most destructive enemies of forest trees are found to be new to science, and that nothing whatever was known of the habits and seasonal history of a large number of the more important known species which are common enemies of forest trees and forest products, while scarcely anything was known in regard to practical methods of controlling the principal enemies of the forest and its products, or of preventing losses from their ravages as applied to conditions in this country.

PRESENT KNOWLEDGE.

Within the past ten years forest-insect investigations have been conducted by the Bureau of Entomology of the Department of Agriculture in all of the principal forest regions of the United States, and have led to the following results:

Results of investigations.—Satisfactory progress has been made toward the attainment of some of the fundamental objects of the investigations, one of which has been the laying of a substantial foundation for forest entomology in this country on which future progress can be made along the lines of acquiring, disseminating, and applying information of immediate practical value in the protection of our forest resources.

Acquired and new information.—The principal insect enemies of the forests and forest products of North America have become known, and the general character and extent of their depredations have been ascertained.

The more important facts in the life history, habits, and practical methods of control relating to some of the more destructive insects have been determined.

A mass of original data has been collected relating to forest insects in general, including not only those which are destructive or injurious, but also those which are beneficial or neutral in their relation to the forest, as represented by a collection of more than a million specimens of insects and their work.

As a direct result of the investigations of forest insects during the past six years, at a cost of less than $53,000, there has been accumulated a reserve fund of information now available through publications, correspondence, and field demonstrations which, if properly utilized for practical application, would evidently prevent from 10 to 30 per cent of the annual losses at a very small cost.

Disseminated information.—In addition to information disseminated in all sections of the country through correspondence, lectures, demonstrations, exhibitions, etc., the published information, based on results of investigations conducted by the West Virginia Agricultural Experiment Station and by the Bureau of Entomology of the U. S. Department of Agriculture during the past eighteen years, is represented by over 1,300 pages, 99 plates, and 340 figures. (See list of publications.)

NEEDS.

The work that has been done is only a beginning in the vast field of forest entomology. There is need of more systematic work (or so-called pure science) on the different stages of the thousands of species of injurious and beneficial insects involved. *This is absolutely necessary in order to have the further scientific basis of facts on which to build the structure of complex details necessary to success in practical application in its broadest sense.*

There is need of further detailed study of habits and seasonal history of the species of injurious and beneficial insects, as well as of the local and other conditions favorable and unfavorable for their multiplication and work.

Further information is desirable on the principal factors of natural control of injurious insects, in order that it may be better utilized to facilitate artificial control.

There is special need of more general information and public interest in the subject of losses from insect depredations on standing timber and timber products, and a better realization of the possibility and practicability of preventing losses.

Looking to this end, there is need of further demonstration and educational work along the lines which will bring the matter to the attention of the man in the woods, sawmill, factory, or trade who is in direct touch with the local conditions and business methods.

There is a special need of more experts in forest entomology, and there will be an increasing demand for such experts in the future, to organize and take charge of insect-control policies in state forests, in public parks, in the more extensive private or commercial forests, and in extensive manufacturing enterprises, and to give instructions to students in forestry schools and forestry departments in state and other institutions of learning.

The need of trained and experienced experts in forest entomology for all of this class of work can not be too strongly urged. There is perhaps no branch of economic or applied science which requires more technical knowledge and practical experience as a basis for proper investigations and authentic instructions and advice than forest entomology, and there is perhaps no other feature in the science and practice of forestry in which advice and application based on insufficient knowledge is so dangerous.

There is quite a general recognition of the importance of guarding against contagious diseases, of the necessity of consulting a physician in cases of serious illness, and of relying on authorized pharmacists to fill the prescription, and then administering the prescribed treatment according to directions, but it is a notable fact that there are comparatively few persons who, even when deeply interested in preserving the health of the forest, have heretofore recognized the importance of guarding against insect epidemics or of consulting an expert forest entomologist in case of a threatened or existing outbreak. It has often happened that when such advice has been sought and received, the treatment was not administered according to the recommendations but changed to suit the ideas of some one entirely ignorant of the facts and principles upon which it was based. This has often resulted not only in failure to accomplish the desired end, but has contributed to an aggravation of the trouble and increased loss. The determination of the cause of specific troubles affecting the individuals of a given species of forest tree or an injury to a given type of product is just as complicated and requires the same elements of experience, training, and skill as that required for the determination of the cause of a given disease or the character of a given injury affecting man. It is just as important to know the cause or character of injury in the former as it is in the latter, in order to prescribe the specific treatment which will yield the desired results.

Therefore, in order to make the best progress toward preventing future waste of our forest resources from depredations by insects, every one interested in the subject, and especially those in authority in the public and private institutions of investigation and learning, should see to it that the instructions to students and the information given out to the public is not only the best available but that it is limited to the range of expert knowledge of the subject possessed by the instructor or investigator.

Elementary and Technical Knowledge of Forest Entomology for the Forester.

While it may be desirable that every professional forester should have an expert knowledge of forest entomology, it is rarely possible, even under exceptionally favorable conditions, for him to acquire more than the necessary elementary knowledge, and even this has not been possible under the conditions which have necessarily prevailed in the forest schools, and in the practice of forestry, in this country. Little or no time has been available for acquiring the necessary information from subsequent study and practical experience. Therefore this feature in the education of the American forester has been practically neglected.

PRESENT REQUIREMENTS OF INSTRUCTION.

As long as expert forest entomologists and authentic text-books based on American insects and conditions are not available for giving a complete course in technical and applied forest entomology the requirements of such a course should be limited to instruction in elementary entomology, and in elementary principles of applied forest entomology, which will give the necessary foundation for intelligent observations and utilization of available information as required in future practice.

CONCLUSION.

There is conclusive evidence that insects have been in the past, and are now, important factors in the waste and reduction of timber supplies, and will continue to be such in the future (pp. 57–58).

They attack perfectly healthy trees of all ages and kill them (p. 58).

They have at times killed a large percentage of the best timber over thousands of square miles of heavily forested lands (pp. 58–60).

They reduce the value of living timber and that of crude and finished products (pp. 60–66).

The accumulated evidence through many years of investigation and observation in the principal forest areas of the entire country by the writer and the field assistants in forest insect investigations furnishes the basis for the following summarized statements and estimates:

A large percentage of pine and spruce timber was killed by the southern pine beetle in 1890–1892 over an area of 75,000 square miles in West Virginia, Maryland, Pennsylvania, Virginia, and North Carolina (p. 58).

Billions of feet of matured spruce have been killed by the eastern spruce beetle during the past half century in the northeastern United States and southeastern Canada (p. 58).

A large percentage of the matured Engelmann spruce of the Rocky Mountains region has been killed by the Engelmann spruce beetle within the past fifty years (p. 59).

A large percentage of the pine timber of merchantable size in the Black Hills National Forest and other national and private forests of the central Rocky Mountains region has been killed during the past ten years by the Black Hills beetle (p. 59).

A large percentage of the best matured pine timber of the region north and west of Colorado and Utah has been killed within the past twenty years by the mountain pine beetle and the western pine beetle (p. 59).

A large percentage of the matured Douglas fir, or red fir, of the Rocky Mountains region has been killed by the Douglas fir beetle (p. 59).

The supply of hickory timber in the forests and woodlots of the States east of the Mississippi River has been greatly reduced by the ravages of the hickory barkbeetle (p. 60).

Practically all of the matured eastern larch has been killed over vast areas in the northeastern United States and southeastern Canada by the larch worm and eastern larch beetle (p. 60).

The wood of living timber has been rendered defective by wood-boring insects to such an extent as to reduce the value of a vast amount of standing timber from 50 to 75 per cent (p. 60).

Rapid deterioration of the wood of dying and dead trees has been caused by wood-boring insects, often amounting to from 25 to 100 per cent during the period in which it would otherwise be available for utilization (p. 62).

Crude manufactured and finished forest products have been damaged by insects to such an extent as to cause an estimated average annual loss of 10 per cent of its mill value (pp. 64–67).

Insects are the cause of greatly reducing our forest resources by killing the inaccessible timber; by reducing the quantity through injuries to the wood of living and dying timber; by preventing normal reproduction and development of future supplies, and through destroying forest products.

GENERAL ESTIMATES OF AMOUNT OF DAMAGE CAUSED BY FOREST INSECTS.

The results of extensive observations during the past ten years in the principal forested areas of all sections of the country, and during an additional eight years in West Virginia, indicate to the writer that the amount of standing timber killed by insects, together with the standing living, dying, and dead timber reduced in quality and value by them in the forests of the country, to be found at any given time, has been not far from 10 per cent of the total stand of merchantable-sized timber (pp. 70–71).

Considering the forest in its broadest sense as a source of national wealth of a given value for all purposes, including direct utilization, protection of land from erosion, protection of headwater streams, protection of game, and as contributing to the real and æsthetic value of health and pleasure resorts, it is evident to the writer that the total damage caused by insects has been equivalent to an average additional 5 per cent of the value of the merchantable-sized timber of the entire country (p. 71).

Considering the problem of insect damage to standing timber and crude products on the basis of direct utilization of the forest resources, it is evident that the reduction in value below that of healthy timber or sound products at the time of utilization, including losses from handling defective material, has amounted to an equivalent of at least 10 per cent of the average annual mill value of the aggregate output of forest products of all kinds. This of course, includes the killed and damaged merchantable-sized timber considered under the estimate relating to standing timber, given above. Since the killed and damaged standing timber is involved in any given annual output, this estimate on a basis of utilization represents more nearly a direct reduction in cash values (p. 71).

The writer estimates that the annual loss caused by insects injurious to finished and utilized products, including the consequent increased drain on the forest resources to replace that prematurely destroyed by insects, is equivalent to at least 3 per cent of the original or mill value.

HOW LOSSES CAN BE PREVENTED.

The results of extensive investigations and of practical applications during recent years have demonstrated that some of the most destructive insect enemies of American forests and of manufactured and utilized products can be controlled and serious damage prevented with little or no ultimate cost over that involved in good forest management and business methods.

It is evident that if the information now available through publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future it will result in the prevention of an equivalent of at least 30 per cent of the estimated annual waste of forest resources that has been caused by insects within recent years and thus contribute greatly to the conservation of the forest resources. This can be accomplished as follows:

(1) By the adoption or adjustment of certain requisite details in forest management, in lumbering and manufacturing operations, and in storing, transporting, and utilizing the products which, at the least expense, will bring about the necessary reduction of the injurious insect and unfavorable conditions for their future multiplication or destructive work.

(2) By the adoption of policies of control, based upon expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved, and methods for their control, supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care, and utilization of the forest and its resources and still further supplemented by practical knowledge and experience relating to local conditions and facilities favorable and unfavorable for successful application according to a given method or policy of control.

(3) By reliance on technical advice furnished by recognized experts in forest entomology and forestry as a basis for success in practical application by the owner or forester.

(4) By utilization of so-called matured timber, and especially dense or pure stands of such timber, thus removing one of the favorable conditions for rapid deterioration through attacks by wood-boring insects or death through the attack of destructive bark-boring or defoliating insects.

(5) By the utilization of a knowledge of the principles of natural control as a means of contributing to the efficiency of artificial control.

(6) By prompt recognition of the first evidences of the work or destructive outbreaks of the principal insect depredators, by authentic identification of the species involved, and by prompt action in adopting the proper method or methods of control for the prevention of losses.

It should be remembered that as a rule it is useless to attempt the extermination of an insect enemy of the forest or its products. It is only necessary to reduce and weaken its forces at least 75 per cent, so that it can not continue an aggressive invasion, but must occupy a defensive position against its own enemies and become dependent upon favorable conditions resulting from avoidable negligence and mismanagement by the owners of the forests and the manufacturers of forest products.

While beneficial insects, beneficial birds, and beneficial diseases exert a continuous and powerful influence toward the prevention of a more extensive waste of forest resources, it has been repeatedly demonstrated that they can not be depended upon always to prevent widespread devastations or otherwise to work for the best interests of the private or public owner by protecting the best trees and the best tree species.

The best way to utilize the factors of natural control is to become their allies and assist in the reduction of the enemy, rather than to try to make them our allies through artificial introduction or dissemination.

A large percentage of the waste caused by insects can be prevented by the utilization of infested material, and at the same time, without additional expense, this will contribute greatly to the control of insects which cause such waste and also prevent injuries and depredations in the future.

Under past conditions the poor management or neglect of the average forest has contributed to the increase of depredations by insects.

Under present conditions of better management of local forests and of the more progressive manufacturing enterprises much is being accomplished toward the reduction of losses. In the average forest, and in the average business enterprise dealing with forest products, present conditions are little better than in the past. This is largely due to a lack of appreciation of the importance of the subject and failure to realize the opportunity and practicability of preventing a large percentage of the loss.

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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 58.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

CONTENTS AND INDEX.

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1910.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 58.

L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO FORESTS.

I. THE LOCUST BORER.

By A. D. HOPKINS, *In Charge of Forest Insect Investigations.*

II. THE WESTERN PINE-DESTROYING BARKBEETLE.

By J. L. WEBB, *Special Field Agent, Forest Insect Investigations.*

III. ADDITIONAL DATA ON THE LOCUST BORER.

By A. D. HOPKINS, *In Charge of Forest Insect Investigations.*

IV. THE SOUTHERN PINE SAWYER.

By J. L. WEBB, M. S., *Agent and Expert.*

V. INSECT DEPREDATIONS IN NORTH AMERICAN FORESTS AND PRACTICAL METHODS OF PREVENTION AND CONTROL.

By A. D. HOPKINS, PH. D., *In Charge of Forest Insect Investigations.*

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1910.

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F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

Forest Insect Investigations.

A. D. Hopkins, *in charge.*

H. E. Burke, J. L. Webb, Josef Brunner, S. A. Rohwer, T. E. Snyder, W. N. Dovener,[a] W. D. Edmonston, *agents and experts.*
W. B. Turner, *special agent.*
Mary E. Faunce, *preparator.*
William Middleton, Mary C. Johnson, *student assistants.*

[a] Transferred to another branch of the Bureau.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., August 5, 1910.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 58, five papers dealing with insects injurious to forests and forest products. These papers were issued separately during the years 1906 to 1909.

Part I, "The Locust Borer," by A. D. Hopkins, comprises a summary of information from published accounts, supplemented by data secured by recent investigations, and deals more particularly with practical methods for controlling this, our most important enemy of the black locust. It is designed to be of service to owners of plantations and forests, as well as to investigators, in the prevention of injuries to this useful tree.

Part II, "The Western Pine-destroying Barkbeetle," by J. L. Webb, has special reference to the results of investigations by Mr. Webb in central Idaho in 1905, but relates also to the results of other investigations and to available information on the insect and methods of controlling it.

Part III, "Additional Data on the Locust Borer," by A. D. Hopkins, comprises a partial revision of Part I and gives additional information based on the results of investigations carried on since that part was issued.

Part IV, "The Southern Pine Sawyer," by J. L. Webb, gives the results of special investigations by Mr. Webb and relates to a subject of much economic importance to the timber interests of the Southern States, and especially of sections in which the pine timber is damaged by storms. The results of these investigations and the information contained in this paper make it possible to avoid a large percentage of the losses from damage by the sawyer, which have heretofore seemed inevitable.

Part V, "Insect Depredations in North American Forests and Practical Methods of Prevention and Control," by A. D. Hopkins, gives a summary of facts, conclusions, and estimates relating to the forest-insect problem as applied to North American conditions and calls attention to its importance in the future management of private, state, and national forests. The matter is presented in as brief and concise a form as possible, in order that the information may be readily available to the general reader, as well as to the forester and student, and references are made to publications in which more detailed accounts may be found. The statements and conclusions relating to the insects and their work and to methods for their control are based almost entirely on investigations and observations by Doctor Hopkins and by assistants in the Bureau of Entomology working under his direction, carried on in all of the principal forest areas of the United States.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. W. M. Hays,
Acting Secretary of Agriculture.

CONTENTS.[a]

[a] The five papers constituting this bulletin were issued in separate form on June 13 and August 18, 1906; March 5, 1907; and November 10 and December 4, 1909, respectively.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

ERRATA.

Page 57, line 10, for *private and public* read *private, state, and national*.
Page 59, line 19 from bottom, for *Dendroctronus* read *Dendroctonus*.
Page 61, line 13 from bottom, for *robinæ* read *robiniæ*.

INDEX.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ENTOMOLOGY—BULLETIN No. 59.

L. O. HOWARD, Entomologist and Chief of Bureau.

PROLIFERATION

AS A FACTOR IN THE NATURAL CONTROL

OF THE

MEXICAN COTTON BOLL WEEVIL.

BY

W. E. HINDS, Ph. D.,
In Charge of Cotton Boll Weevil Laboratory.

ISSUED AUGUST 27, 1906.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1906.

BUREAU OF ENTOMOLOGY.

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W. D. HUNTER, *in charge of cotton boll weevil investigations.*
F. M. WEBSTER, *in charge of cereal and forage-plant insect investigations.*
A. L. QUAINTANCE, *in charge of deciduous-fruit insect investigations.*
FRANK BENTON, *in charge of apicultural investigations.*
D. M. ROGERS, *in charge of gypsy and brown-tail moth work.*
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PROLIFERATION FROM WEEVIL FEEDING-PUNCTURES.

Fig. 1.—Right half of square filled with granular-appearing proliferation, enlarged four diameters. Fig. 2.—Interior of square, proliferation from feeding puncture, dried and brown, enlarged two diameters. Fig. 3.—Section through feeding puncture from which proliferation spread to tip of square, enlarged four diameters. Fig. 4.—Proliferation starting from feeding punctures in bolls, enlarged two diameters. (Original.)

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ENTOMOLOGY—BULLETIN No. 59.

L. O. HOWARD, Entomologist and Chief of Bureau.

PROLIFERATION

AS A FACTOR IN THE NATURAL CONTROL

OF THE

MEXICAN COTTON BOLL WEEVIL.

BY

W. E. HINDS, Ph. D.,

In Charge of Cotton Boll Weevil Laboratory.

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1906.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 10, 1906.

Sir: I have the honor to transmit herewith a manuscript prepared by Dr. W. E. Hinds, special field agent of this Bureau, engaged in work on the boll weevil. This manuscript is a study of the proliferation in the squares and bolls of cotton by means of which a certain percentage of weevil larvæ are killed. It does not deal at length with the botanical aspects of the question, but is rather a practical statement of the effect of this formation of loose tissue cells upon the boll weevil, based upon a large number of observations made by agents of the Bureau of Entomology. The botanical side of this phenomenon has been fully considered by Mr. O. F. Cook, of the Bureau of Plant Industry, and this paper is therefore supplemental to papers published by Mr. Cook on this subject. The preface is written by Mr. Hunter, and the conclusions in the paper have been revised by him. In addition to the general interest in the subject, the information given will be undoubtedly of distinct advantage to those engaged in cotton-breeding work, and I therefore recommend that it be issued as Bulletin No. 59 of this Bureau.

Respectfully,

C. L. Marlatt,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE

Aside from the habit of determinate growth, perhaps the most important tendency of the cotton plant that has the effect of avoiding damage by the boll weevil is that of proliferation in the squares and bolls, which was first observed by Dr. W. E. Hinds in 1902 at Victoria, Tex. The present paper places on record a large number of observations and experiments relating to this phenomenon, which have been carried on for several years by the boll-weevil investigation in Texas. The studies upon which the paper is based were planned primarily to determine the ways by which proliferation actually affects the weevil. Other features of proliferation have been dealt with fully by Mr. O. F. Cook, whose publications are referred to more specifically in the text. In addition to the general interest of the information given, much of it will undoubtedly be of special advantage to those who are engaged in cotton-breeding work.

As will be seen in the following pages, it has been ascertained that the rate of mortality among weevils in squares of American upland varieties of cotton is higher by about 13.5 per cent as a result of proliferation. This in itself is of no little significance, but it is to be noted that the greatest importance of proliferation is in connection with some of the foreign varieties of cotton, which seem to have this property developed to a much greater extent than the American upland varieties. Consequently, the discoveries of Mr. O. F. Cook, relating to the Kekchi cotton of Guatemala and the possibility of utilizing this cotton in the United States, are of great interest.

An important difficulty which will be encountered in the work of breeding cottons which proliferate to a great extent, will be the capability for adaptation on the part of the boll weevil. That this insect has considerable capability for adaptation is shown in the great variation in the size of the adults, the result of conditions of food supply in the immature stages to which it has adapted itself, as well as in many other ways. As a matter of fact, the capacity of the weevil for adaptation is probably fully as great as is the natural adaptive capacity of the cotton plant. Nevertheless, the interference of man may throw the advantage greatly in favor of the plant.

The work upon which this publication is based was performed under the general direction of the writer by Dr. W. E. Hinds. He was assisted in various ways by practically all the agents of the boll-weevil investigations, but more particularly by Messrs. A. C. Morgan, W. W. Yothers, W. Dwight Pierce, A. W. Morrill, and F. C. Pratt.

W. D. Hunter,

In Charge of Cotton Boll Weevil Investigations.

CONTENTS.

ILLUSTRATIONS.

PLATES.

PROLIFERATION AS A FACTOR IN THE NATURAL CONTROL OF THE MEXICAN COTTON BOLL WEEVIL.

INTRODUCTION.

EARLIEST OBSERVATIONS.

Soon after the beginning of the laboratory work upon the cotton boll weevil at Victoria, Tex., in 1902, it was noticed that the attack of the weevil was frequently followed by a very decided change in the structure of the tissues near the point of attack in both buds and bolls. The significance of this change was not at that time fully appreciated, and the observations made upon the weevil did not include records as to the occurrence and effect of this phenomenon. For this reason the early observations made before the autumn of 1903 have furnished comparatively little material which could be used in making tabular statements, such as have been made from more recent studies of the effect of proliferation upon the development of the boll weevil.

When and by whom proliferation was first observed in cotton is not known to the writer, but no publication relating to this phenomenon prior to that made in Bulletin No. 45 of the Bureau of Entomology, pages 96 and 97, has been found. The earliest notes upon the occurrence of proliferation and its effect upon the weevil were made by the writer in September, 1902. Since that time there has been gradually accumulating in the notes of the agents of the Bureau of Entomology who have been studying the boll weevil, a large amount of data bearing upon this subject.

In the plans made for the work of 1904, at the beginning of the season, definite provision was made for observations upon this phenomenon in a number of varieties of cotton and for testing the influence of fertilizers in stimulating a greater manifestation of proliferation in the plants treated. Since that time the observations upon proliferation and its effect upon weevil development and injury have been carried on continuously.

SCOPE OF PRESENT DISCUSSION.

The present paper does not pretend to be a study of proliferation in the botanical aspects of the question, but rather a practical statement of the large number of observations made by agents of the Bureau of Entomology primarily regarding the effect of this formation of loose tissue cells upon the boll weevil. It is consequently of an entomological and not a botanical character. The botanical significance of the phenomenon has been very fully considered by Mr. O. F. Cook, of the Bureau of Plant Industry, to whose publications among those listed below[a] the reader is referred for a discussion of that part of the subject.

DEFINITIONS.

In order that the statements here made may be readily understood by one who is not familiar with terms used in botany or entomology a few general definitions may be in order. In Bulletin No. 45 of the Bureau of Entomology, concerning the cotton boll weevil, the term "gelatinization" was used instead of proliferation, as it was believed that its significance would be better understood by the average reader, though it was realized that, strictly speaking, the term used expressed an incorrect idea concerning the nature of the change to which it referred. The term "proliferation" is in general use both in botany and zoology, to denote a growth by the multiplication of elementary parts. In the present case we may define proliferation as being the development of numerous elementary cells from parts of the bud or boll which are themselves normally the ultimate product of combinations of much more highly specialized cells. The resulting product is thus composed of comparatively large, thin-walled cells, which are placed so loosely together that the resulting formation is of a soft texture, and has a granular appearance (Pl I, fig. 1) which may be plainly seen with the unaided eye. The soft, pulpy nature of this growth led to the choice of the term "gelatinization" as being most appropriate to signify in a general way its appearance and texture. It appears that this formation may originate from various causes in almost any part of the bud or boll (Pl. I, figs. 2–4). Whatever may have been the inciting cause, the character of the formation appears very much the same in any case. Undoubtedly, however, certain tissues proliferate more readily than do others. In squares, the outer layer of the column upon which the stamens are borne appears to be especially susceptible to stimuli which produce this reaction. In bolls, the cells immediately adjoining the thin, hard layer lining the hulls or carpels are most frequently the

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[a] Bibliography of Proliferation:

1904. Hunter, W. D., and Hinds, W. E.—The Mexican Cotton Boll Weevil. Bul. No. 45, Bureau of Entomology, U. S. Dept. Agric., pp. 96–97.

1904. Cook, O. F.—Evolution of Weevil Resistance in Cotton. Science, Vol. XX, pp. 666–670.

1905. Hunter, W. D., and Hinds, W. E.—Bul. No. 51, Bureau of Entomology, U. S. Dept. Agric., pp. 133–134.

1905. Cook, O. F.—Cotton Culture in Guatemala. Yearbook U. S. Dept. Agric., f. 1904, pp. 475–488.

1906. Cook, O. F.—Weevil Resisting Adaptations of the Cotton Plant. Bul. No. 88, Bureau of Plant Industry, U. S. Dept. Agric.

point at which proliferation begins. In most cases the proliferation appears to begin very near to the point of injury, but from that point it may spread through an entire lock, or to all the inner parts of an injured bud.

METHOD OF STUDY.

As the significance of these observations came to be more fully appreciated it was believed that they contained at least a suggestion as to some very promising lines of work in the problem of controlling the weevil. Accordingly, it has been necessary to study carefully the nature of the phenomenon, conditions of climate, soil, fertilizer, and variety of cotton which affected the occurrence of proliferation. Observations have, therefore, been made upon quite a large number of varieties, and in locations ranging from Victoria to Dallas, Tex., upon various types of soil, and in connection with various experiments with fertilizers and different conditions of cultivation. From a comparison of the results thus obtained it was hoped that some factors might be found which could be used practically in increasing proliferation, and thus rendering it more effective as a factor in controlling the weevil. In many cases the results of the work have been quite different from those anticipated, but enough has been learned to justify the assertion that at present proliferation is a more important factor in retarding the multiplication of the weevil than are the parasites which have thus far been found.

Large numbers of squares and bolls have been carefully examined in obtaining these records. In the examination of bolls, the lock has been made the unit rather than the boll. As a general rule, a larva confines its injury almost, if not entirely, to the lock within which the egg was originally placed. Quite frequently two or more larvæ occur within a lock, but even in such cases the injury does not often extend through the septum or partition which separates the locks.

In making a comparison of varieties considerable care is required in subdividing the classes of observations in order to render the influential conditions sufficiently uniform to make the observations fairly comparable and wherever possible to reduce the fundamental causes or stimuli producing variations in the proliferation to one essential factor. While the phenomenon in bolls is of a similar nature to that in squares, conditions in these two cases are so different that the results are not strictly comparable, and therefore separate tables have been made for squares and bolls. The effects of feeding and egg punctures also call for separate classification. This treatment of the subject necessarily multiplies the number of tables, but we hope that it will render the results more easily intelligible. The personal equation of the observer has been equalized by combining the records made by a number of investigators.

PROLIFERATION FROM FEEDING PUNCTURES IN SQUARES.

As the square precedes the boll in the natural process of development and the feeding puncture precedes oviposition in the attack of the weevil, we shall consider first the observations regarding proliferation resulting from feeding punctures made in squares. These observations include nearly 25 varieties of cotton. They are grouped by years and localities in order to bring as closely together as is possible those records which may be considered as most strictly comparable. The totals and averages for so many seasons and localities should constitute a very fair average statement of the true condition.

TABLE I.—*Proliferation resulting from feeding punctures in squares—comparison of varieties.*

Date.	Locality.	Variety.	Total number of punctured squares examined.	Squares with proliferation.		Squares with no proliferation.	
				Number.	Per cent of total.	Number.	Per cent of total.
1902.							
Sept. 17	Victoria, Tex	Several varieties	16	4	25.0	12	75.0
1903.							
July 8 to Oct. 28	do	King	470	286	60.1	184	39.9
Aug. 10 to Oct. 19	do	Parker	83	49	59.0	34	41.0
Oct. 25	do	Mascot	102	38	37.3	64	62.7
Do	do	Dickson	101	67	66.3	34	33.7
Oct. 24	do	Mit Afifi	79	59	74.3	20	25.7
Oct. 22	do	Ashmouni	74	35	47.3	39	52.7
Do	do	Jannovitch	82	62	75.6	20	24.4
Aug. 8 to Oct. 28	do	Native	78	42	53.8	36	46.2
1905.							
Nov. 9	Dallas, Tex	Egyptian	53	8	15.1	45	84.9
Do	do	Pachon	10	3	30.0	7	70.0
Do	do	Kekchi	21	6	29.6	15	71.4
Sept. 24	San Antonio, Tex	Shine	70	15	21.4	55	78.6
Do	Calvert, Tex	King	33	14	42.4	19	57.6
Do	do	Shine	47	23	48.9	24	51.1
Do	do	Rowden	45	28	62.2	17	37.8
Do	do	Nicholson	69	32	46.4	37	53.6
Do	do	Triumph	25	11	44.0	14	56.0
Do	do	Tools	39	22	56.4	17	43.6
Do	do	Hawkins	36	18	50.0	18	50.0
Do	do	Russell	18	7	38.9	11	61.1
Do	do	Allen	30	15	50.0	15	50.0
Do	do	Bohemian	27	15	55.6	12	44.4
Do	do	Truitt	34	15	44.1	19	55.9
Do	do	Hetty	31	4	12.9	27	87.1
Do	do	Native	34	16	47.0	18	53.0
Do	do	Territory	163	71	43.6	92	56.4
Totals and averages			1,870	965	[a] 51.6	905	[a] 48.4

[a] Weighted average.

The general average for all the various seasons and localities shows that in squares approximately one-half of all feeding punctures stimulate proliferation. The highest percentage shown is 75.6 per cent in "Jannovitch" (an Egyptian variety), at Victoria, Tex., on October 22, 1903, while the lowest percentage found was 12.9

per cent for "Hetty," at Calvert, Tex., September 24, 1905. These figures show a wide range. Five series of observations show proliferation in less than 30 per cent of the squares fed upon; three series show between 30 and 40 per cent; eight series between 40 and 50 per cent; six show between 50 and 60 per cent; three between 60 and 70 per cent. It appears, therefore, that the range, while wide, is well balanced, the large majority of observations showing between 40 and 60 per cent.

PROLIFERATION FROM FEEDING PUNCTURES IN BOLLS.

Turning now to an examination of proliferation following feeding punctures made in bolls, records are presented of the observations made during 1905 only. These observations include 18 varieties and 3 localities.

TABLE II.—*Proliferation resulting from feeding punctures in bolls.*

Date of examination.	Variety.	Locality.	Total bolls examined.	Total locks in lot.	Locks with feeding punctures only. With proliferation. Number.	With proliferation. Per cent of total.	Without proliferation. Number.	Without proliferation. Per cent of total.	Per cent of punctured locks in which proliferation followed.
1905.									
Sept. 25.	King	Calvert, Tex.	80	340	123	36.2	32	9.4	79.4
Do	Shine	do	91	398	159	40.0	22	5.5	87.9
Do	Rowden	do	63	274	94	34.3	56	20.5	62.7
Do	Nicholson	do	83	374	195	52.2	39	10.4	83.3
Do	Triumph	do	57	247	146	59.1	69	27.5	68.0
Do	Tools	do	109	462	239	51.7	56	12.1	81.0
Do	Hawkins	do	110	462	302	65.4	124	26.8	70.9
Do	Russell	do	98	419	254	67.8	29	6.9	89.7
Do	Allen	do	83	371	180	48.5	37	10.0	83.0
Do	Bohemian	do	90	399	173	43.4	8	2.0	95.6
Do	Truitt	do	94	419	187	44.6	21	5.0	90.0
Do	Hetty	do	97	419	248	59.2	20	4.8	92.5
Do	Native	do	94	407	122	30.0	22	5.5	84.7
Do	Territory	do	655	2,830	1,251	44.0	284	10.0	81.5
Sept. 27.	Shine	San Antonio, Tex.	156	656	164	25.0	65	10.0	71.6
Nov. 11.	Mit Afifi	Dallas, Tex.	79	244	64	26.2	14	5.7	82.0
Do	Pachon	do	2	7	5	71.4	0	0.0	100.0
Do	Korean	do	1	3	2	66.7	0	0.0	100.0
Totals and averages			2,042	8,731	3,908	[a] 44.8	898	[a] 10.3	[a] 81.3

[a] Weighted average.

The bolls examined all showed distinct external signs of weevil injury. Among them, however, fully one-fourth of the total number of locks were found to have no noticeable internal injury, and probably a majority of these locks would have matured had the bolls been allowed to remain upon the plants. As the bolls examined were selected especially for weevil injury, it appears that their condition would probably be worse than the average in fields where the weevil has done its worst damage. The figures are of interest, therefore, as indicating that even under the most severe conditions of weevil injury sufficient seed would still be produced to replant the field. While practically one-half of the squares attacked showed proliferation, a far greater proportion of the locks attacked by the weevil showed a similar formation.

From these records it appears that 55 per cent of the nearly 9,000 locks examined received feeding punctures only. Among the locks thus injured, an average of slightly over 81 per cent showed distinct evidence of proliferation. A comparison with Table I indicates that in bolls proliferation occurs from feeding punctures in a higher percentage of cases than it does in squares. The records upon Pachon and Korean cottons were included in the table because of the special interest attached to these varieties, but the data regarding them are too meager to be reliable in drawing definite conclusions regarding proliferation in them, and they should be excepted in making a comparison of varieties. It is to be regretted that the two varieties mentioned produced so little fruit at Dallas, Tex., that more extensive data regarding them could not be obtained, and the fruiting occurred so late in the season that no bolls could mature. The range in the percentage of cases in which proliferation results from feeding punctures in bolls is not so great as it appears to have been in squares. This fact may possibly be due to more uniform climatic and cultural conditions, as nearly all the records for bolls were made from material collected in one locality at the same time.

These records appear to the writer to show a remarkable uniformity, and to indicate that among the 15 varieties mentioned in the table which are most clearly comparable there is little difference in the natural tendency to proliferate in response to feeding injuries made by the weevil in bolls.

INFLUENCE OF DIFFERENT LOCALITIES AND SEASONS.

OBSERVATIONS ON SQUARES.

This series of observations was made to determine, if possible, what influence different localities and seasons might have upon proliferation in the same variety of cotton. While similar data have been secured for a number of varieties, the exhibit following is restricted to the two varieties on which the largest number of observations was made, as the conclusions which may be drawn therefrom are consequently most reliable. In the case of King cotton, different seasons as well as localities are represented, while with Shine, different localities are represented at approximately the same time. In compiling this table, both feeding and egg punctures have been included. It has seemed desirable also to present the figures showing the effect which the proliferation has had upon the weevil stages found.

TABLE III.—*Proliferation in King and Shine squares—different seasons and localities.*

Variety and locality.	Date.	Number of squares examined.	Squares with proliferation.					Squares without proliferation.					Per cent of all dead stages found with proliferation.	Increase in rate of mortality due to proliferation.
			Number.	Per cent of total.	Weevil stages alive.	Weevil stages dead.	Per cent of stages found dead.	Number.	Per cent of total.	Weevil stages alive.	Weevil stages dead.	Per cent of stages found dead.		
KING.														
Victoria, Tex.	1904. July to October.	822	437	53.1	87	14	13.8	385	46.9	165	0	0.0	100.0	13.8
Calvert, Tex.	1905. August and September.	218	124	56.2	64	24	27.3	94	43.8	61	2	3.2	92.3	24.1
Totals and averages		1,040	561	a54.0	151	38	a20.0	479	a46.0	226	2	a0.9	a95.0	a19.1
SHINE.														
Calvert, Tex.	1905. August	229	122	53.3	59	28	32.2	107	46.7	52	5	8.8	84.8	23.4
San Antonio, Tex.	September	443	212	47.9	152	51	25.1	231	52.1	178	18	9.7	73.9	15.4
Totals and averages		672	334	a49.7	211	79	a27.2	338	a50.3	230	23	a9.1	a77.5	a18.1
General totals and averages		1,712	895	a52.3	362	117	a24.4	817	a47.7	456	25	a5.2	a82.4	a19.2

a Weighted average.

Two rather striking contrasts are shown by a study of the figures in this table. First, in the 1,040 King squares examined there were found 417 weevil stages, while in 672 Shine squares examined there were found 543 stages. Stated in a way to make the contrast most evident, in King there was found an average of one weevil stage for each 2.5 squares; in Shine an average of one weevil stage for each 1.24 squares. That is, in Shine there were almost exactly twice as many weevil stages found, in proportion to the number of squares examined, as in King. This is a factor, however, which would naturally vary widely with the degree of infestation found in the field and it is a well-established fact that weevils were much more numerous and injurious at San Antonio in 1905 than they were at Calvert, Tex. The second striking contrast is to be found in the percentage of mortality. In King squares without proliferation only 0.9 per cent of the weevil stages found were dead, while in Shine squares without proliferation ten times as large a proportion, or 9.1 per cent, of the stages found were dead. Doubtless much of this difference may have been due to seasonal rather than to varietal differences, since it appears that in King squares at Calvert in 1905 the percentage of mortality was much greater than at Victoria in 1904.

In other respects there is a most striking uniformity in the results shown. The percentage of squares showing proliferation varies only between 49.7 per cent for Shine and 54 per cent for King. The average increase in mortality apparently due to the proliferation varies only between 18.1 per cent for Shine and 19.1 per cent for King. It appears that the "normal mortality," due to other causes than proliferation, varies much more widely in different localities and seasons than does the increase in mortality attributable to the presence of proliferation.

OBSERVATIONS ON BOLLS.

Before drawing any general conclusion from Table III the similar records of examinations of bolls should be considered. The same varieties and localities are used as in Table III, the only change being the inclusion of the examination of King bolls made at Victoria, Tex., in 1903.

TABLE IV.—*Comparison of proliferation in King and Shine bolls in different seasons and localities.*

Variety and locality.	Date.	Total bolls examined.	Total locks examined.	Locks with proliferation.				
				Number.	Per cent of total.	Weevil stages alive.	Weevil stages dead.	Per cent of stages found dead.
KING.								
Victoria, Tex	1903. Oct. 14	620	2,666	1,398	52.4	53	50	48.5
Victoria, Tex	1904. Sept. 5	200	865	417	48.2	13	2	13.3
Do	Oct. 1	198	843	468	55.5	14	4	22.2
Calvert, Tex	1905. Sept. 25	80	340	176	51.7	30	8	21.0
SHINE.								
Calvert, Tex	Sept. 25	91	398	234	58.8	37	21	36.2
San Antonio, Tex	Sept. 27	156	656	422	64.3	189	69	26.7
Totals and averages		1,345	5,768	3,115	[a] 54.0	336	154	[a] 31.4

Variety and locality.	Date.	Locks without proliferation.					Percent of all dead stages in locks with proliferation.	Locks with feeding punctures only.		
		Number.	Per cent of total.	Weevil stages alive.	Weevil stages dead.	Per cent of stages found dead.		With proliferation.	Without proliferation.	Percent with proliferation.
KING.										
Victoria, Tex	1903. Oct. 14	1,268	47.6	34	11	24.4	82.0	....	....	....
Do	1904. Sept. 5	448	51.8	0	0	0.0	100.0	14	5	73.7
Do	Oct. 1	375	44.5	8	1	11.1	80.0	56	27	67.5
Calvert, Tex	1905. Sept. 25	164	48.3	7	1	12.5	53.3	123	32	79.4
SHINE.										
Calvert, Tex	Sept. 25	164	41.2	7	0	0.0	75.0	159	22	88.0
San Antonio, Tex	Sept. 27	234	35.7	8	1	11.1	98.6	164	65	71.6
Totals and averages		2,653	[a] 46.0	64	14	[a] 18.0	[a] 91.7	516	151	[a] 77.4

[a] Weighted average.

In the case of bolls the conclusions indicated are quite similar to those which have been stated for squares. The percentage of locks showing proliferation in consequence of weevil injury is remarkably uniform, varying through a range of only 16 per cent in three years in three localities and with two varieties. Furthermore, the percentage is almost identical with that shown for squares.

By far the highest percentage of mortality among weevils in bolls was that found in Victoria in 1903, when an average of 40.5 per cent of all immature stages was found dead in King bolls. The weather during a six-weeks period preceding the examination was exceptionally cool and dry, but a heavy rain falling shortly before the examination was made may have been a factor in markedly increasing the mortality. The percentage of dead stages in locks in the presence of proliferation for all the bolls examined averaged 7 per cent higher than it did in squares. The percentage of dead stages in locks where no proliferation occurred was also higher in bolls than in squares by nearly 15 per cent, so that the increase in mortality apparently due to proliferation was only about 13.4 per cent in bolls, whereas it was 19.2 per cent in squares. It would appear that in bolls the normal mortality, which has no relation to proliferation, is not as clearly influenced by varying climatic conditions as it appears to be in the squares.

EFFECTS OF CLIMATIC CONDITIONS.

In connection with Tables III and IV, some statement should be made regarding the climatic conditions prevailing in each locality during the periods in which the observations recorded were being made. The statements following are based largely upon the published Weather Bureau records. We shall begin with the records for Victoria in 1903, considering first the data for about six weeks preceding the examination of bolls made on October 14, 1903, as we may safely assume that a large majority of these bolls had been attacked within that time. While preceding conditions, especially those regarding rainfall, may have had some influence upon plant growth during this period, we believe they may safely be disregarded, assuming that the conditions immediately prevailing would be most significant in their influence upon the growth of the plant, the development of the weevil stages in buds and bolls, and the formation of proliferation.

The mean average temperature at Victoria during September, 1903, was 77.2° F., which was 3.7° below the normal. During the first thirteen days of October the mean temperature averaged 75.8°, which was about normal. Precipitation during September was very slight, amounting to only 0.54 inch, which was nearly 3 inches below the normal. During the first thirteen days of October the rainfall amounted to 1.75 inches, which was 0.42 inch above the normal.

At Victoria in 1904, from July 1 to October 10, the mean temperature averaged 80.6° F., which was 1.17° below the normal. During the same period the total rainfall amounted to 8.50 inches, which was only 0.57 inch below the normal. In a general way this season might be described as slightly cooler than usual, with the humidity and rainfall practically normal.

No records are available for Calvert, Tex., but the reports from Hearne, which is only 8 miles from Calvert, will serve to indicate the temperature and rainfall of the latter place with sufficient accuracy. During the months of July and August, 1905, the mean temperature averaged 82.85° F., which was 2.8° above the normal. No rain fell during September, and during August the rain amounted to only 0.63 of an inch. For these two months, therefore, the rainfall was 4.33 inches below the normal. The season may be characterized in general as exceptionally hot and dry. At San Antonio the mean temperature during these two months averaged 82.5° F., which was 1.6° above the normal. During this period the rainfall amounted to 2.31 inches, which was 3.35 inches below the normal. Here again the season was exceptionally hot and dry.

Considering these climatic conditions in relation to the figures given in Table III, the following conclusions would seem to be indicated: (1) The percentage of squares which proliferate from attack by the weevil is not greatly affected by varying conditions of temperature and moisture; (2) the increase in mortality due to proliferation is not greatly affected by the varying climatic conditions as shown for these localities; (3) the normal mortality of the weevil which may not be attributed to proliferation is decidedly greater during especially hot dry weather than it is under cooler and more moist conditions.

As for bolls, the range in formation of proliferation in locks from 48.2 to 64.3 per cent is not unexpectedly great. The most remarkable fact is that the maximum percentage for locks and the minimum percentage for squares occur at the same time, in the same locality, and with the same variety. It is plain, therefore, that climatic conditions can not be held responsible for these contradictory results. The records concerning percentages of mortality are also too inconsistent to point to any constant effect of the climatic conditions upon this particular point. The records for "normal mortality" also fail to show any consistent increase or decrease which may be attributed to exceptional conditions of heat or drought. The reason why the records for bolls fail to show as consistent conclusions as are indicated for squares may probably be found in the comparative difference in the length of the growing season for each and in the essential difference in the nature of the two sets of organs. Obviously the square would be subject to climatic changes occurring within only a short period of time as compared with the boll, which would therefore exhibit a more composite result of any influential conditions affecting it.

It is probably true that the increased mortality in squares occurring during hot dry weather is more directly attributable to the absolute maximum temperature experienced than it is to the slightly higher mean average temperature prevailing. The observations which have been here recorded refer only to conditions found in squares which have been attacked by the weevil, but before they have fallen to the ground. After squares have fallen the influence of hot dry weather in largely raising the percentage of mortality wherever the squares become directly exposed to the sun is unquestionably a still more important factor in destroying the immature stages of the weevil.

EFFECT ON PROLIFERATION OF FERTILIZING THE SOIL.

In accordance with indications shown by some of the examinations of bolls made in 1903, it was expected that fertilization of cotton might produce a considerable increase in the percentage of cases in which proliferation followed injury by the weevil. A test of this point required a comparison of a considerable number of varieties under similar cultural and soil conditions with check plats unfertilized for each variety. Tests of this nature were instituted at the beginning of the season of 1904. Favorable conditions for such observations were also furnished by the field experiment at Calvert, Tex., during the season of 1905. Fourteen varieties were there grown upon Brazos bottom lands. Each fertilized plat received an application of 400 pounds of acid phosphate per acre. Conditions in all plats were similar with the exception of fertilization.

TABLE V.—*Comparison of proliferation on fertilized and unfertilized plats of 14 varieties of cotton on uniform soil and receiving otherwise similar treatment.*

Variety.	Part of plant.	Plat on which grown.	Total number of squares examined.	Total number of locks examined.	Squares or locks with proliferation.					Squares or locks without proliferation.					Per cent of total dead stages found with proliferation.	Apparent increase in rate of mortality as a result of proliferation.
					Number.	Per cent of total.	Weevil stages alive.	Weevil stages dead.	Per cent of stages dead.	Number.	Per cent of total.	Weevil stages alive.	Weevil stages dead.	Per cent of stages dead.		
King	Squares	Fertilized	119	....	67	56.3	39	16	27.3	52	43.7	36	1	2.7	88.2	24.6
		Unfertilized	99	....	57	57.6	25	8	24.2	42	42.4	25	1	3.8	88.9	20.4
	Bolls	Fertilized	....	167	98	58.7	10	2	16.7	69	41.3	1	1	50.0	66.7	(33.3)
		Unfertilized	....	173	98	45.1	20	6	23.1	95	54.9	6	0	14.3	85.9	8.8
Shine	Squares	Fertilized	122	....	70	57.4	30	17	36.2	52	42.6	27	4	12.9	81.0	23.3
		Unfertilized	107	....	52	48.6	26	11	29.7	55	51.4	25	1	3.8	91.7	25.9
	Bolls	Fertilized	....	200	85	42.5	4	20	83.3	115	57.5	6	0	0.0	100.0	83.3
		Unfertilized	....	198	149	75.3	33	1	3.0	49	24.7	1	0	0.0	100.0	3.0
Rowden	Squares	Fertilized	99	....	55	55.6	45	3	6.3	44	44.4	35	1	2.8	75.0	3.5
		Unfertilized	108	....	50	46.3	38	27	41.5	58	53.7	40	1	2.4	96.5	39.1
	Bolls	Fertilized	....	134	83	62.0	10	4	28.6	51	38.0	0	0	0.0	100.0	28.6
		Unfertilized	....	140	87	62.1	5	23	82.1	53	37.9	5	3	37.5	88.5	44.6
Nicholson	Squares	Fertilized	104	....	47	45.2	38	4	9.5	57	54.8	45	6	11.8	40.0	(2.3)
		Unfertilized	101	....	65	64.4	48	8	14.3	36	35.6	27	0	0.0	100.0	14.3
	Bolls	Fertilized	....	155	99	63.9	38	13	25.5	56	30.1	1	0	0.0	100.0	25.5
		Unfertilized	....	219	173	79.0	14	2	12.5	46	21.0	0	0	0.0	100.0	12.5
Triumph	Squares	Fertilized	96	....	54	56.2	24	9	27.3	42	43.8	28	2	6.7	81.8	....
		Unfertilized	98	....	61	62.2	22	5	18.5	37	37.8	21	2	8.7	71.4	....
	Bolls	Fertilized	....	90	61	65.6	5	0	0.0	29	34.4	0	0	0.0	....	....
		Unfertilized	....	157	96	61.2	13	0	0.0	61	38.8	0	0	0.0	....	....
Tools	Squares	Fertilized	109	....	54	49.5	33	9	21.4	55	50.5	26	6	18.8	60.0	2.6
		Unfertilized	113	....	51	45.1	31	4	11.4	62	54.9	30	2	6.2	66.7	5.2
	Bolls	Fertilized	....	252	166	65.8	8	2	20.0	86	34.2	1	0	0.0	100.0	20.0
		Unfertilized	....	210	159	75.7	17	1	5.6	51	24.3	1	0	0.0	100.0	5.6
Hawkins	Squares	Fertilized	108	....	59	54.6	40	10	20.0	49	45.4	30	2	6.2	83.3	13.8
		Unfertilized	106	....	55	51.9	31	14	31.1	50	48.1	32	4	11.1	77.8	20.0
	Bolls	Fertilized	....	253	177	70.0	11	2	15.4	76	30.0	1	0	0.0	100.0	15.4
		Unfertilized	....	209	146	70.0	8	0	0.0	63	30.0	1	0	0.0	....	....
Russell	Squares	Fertilized	118	....	59	50.0	40	13	24.5	59	50.0	40	3	7.0	81.2	17.5
		Unfertilized	128	....	57	44.5	37	8	19.9	71	55.5	51	3	5.6	72.7	14.3
	Bolls	Fertilized	....	211	170	80.6	14	2	12.5	41	19.4	1	0	0.0	100.0	12.5
		Unfertilized	....	208	138	66.3	21	4	16.0	70	33.7	5	0	0.0	100.0	16.0
Allen	Squares	Fertilized	120	....	72	60.0	47	19	30.2	48	40.0	42	2	4.5	90.5	25.7
		Unfertilized	121	....	71	58.7	50	20	28.6	50	41.3	39	0	0.0	100.0	28.6
	Bolls	Fertilized	....	192	147	76.5	12	2	14.3	45	23.5	1	1	50.0	33.3	(25.7)
		Unfertilized	....	179	116	64.8	27	0	0.0	63	35.2	7	0	0.0	....	....

Bohemian	Squares	Fertilized	114		63	55.3	32	14	34.3	51	44.7	35	2	5.7	87.5	28.4
		Unfertilized	133		66	42.1	55	9	14.1	67	57.9	40	7	14.9	56.2	[illegible]
	Bolls	Fertilized		194	147	75.8	42	3	6.7	47	24.2	1	0	0.0	100.0	6.7
		Unfertilized		205	153	74.6	22	1	4.3	52	25.4	4	0	0.0	100.0	4.3
Truitt	Squares	Fertilized	116		56	48.3	42	16	27.6	60	51.7	33	1	3.0	94.1	24.6
		Unfertilized	105		55	52.4	34	9	20.9	50	47.6	40	0	0.0	100.0	20.9
	Bolls	Fertilized		195	120	61.5	47	2	4.0	75	38.5	7	0	0.0	100.0	4.0
		Unfertilized		224	162	72.3	27	2	7.0	62	27.7	2	0	0.0	100.0	7.0
Hetty	Squares	Fertilized	140		69	49.3	36	28	43.7	71	50.7	55	20	36.4	58.4	7.3
		Unfertilized	116		33	28.5	25	9	26.5	83	71.5	56	13	18.8	40.9	7.7
	Bolls	Fertilized		208	164	78.8	40	1	2.4	44	21.2	2	0	0.0	100.0	2.4
		Unfertilized		211	174	82.5	17	6	26.1	37	17.5	0	0	0.0	100.0	26.1
Native	Squares	Fertilized	116		62	53.4	40	12	23.1	54	46.6	35	2	5.7	85.7	17.4
		Unfertilized	118		56	47.5	34	15	30.6	62	52.5	40	0	0.0	100.0	30.6
	Bolls	Fertilized		200	93	46.5	29	4	12.1	107	53.5	0	0	0.0	100.0	12.1
		Unfertilized		207	120	58.0	36	3	7.7	87	42.0	4	0	0.0	100.0	7.7
Territory	Squares	Fertilized	123		75	61.0	58	12	17.0	48	39.0	25	1	3.8	92.3	13.2
		Unfertilized	118		63	53.4	52	11	17.5	55	46.6	28	1	3.4	91.7	14.1
	Bolls	Fertilized		243	175	72.0	22	8	26.7	68	28.0	0	0	0.0	100.0	26.7
		Unfertilized		194	143	73.7	19	3	13.6	51	26.3	2	0	0.0	100.0	13.5
Totals and averages for squares			3,175		1,654	a 52.1	1,052	350	a 25.6	1,520	a 47.9	962	88	a 8.4	a 89.0	a 16.6
Totals and averages for bolls				5,428	3,679	a 67.8	571	117	a 17.0	1,749	a 32.2	60	5	a 7.7	a 95.1	a 9.[illegible]

a Weighted average.

At the end of Table V are given totals and average percentages for squares and for bolls, but the differentiation of the results for fertilized and unfertilized plats is more clearly shown in Table VI, which is practically a summary of Table V. In each case the totals show the amount of data upon which the conclusions rest.

TABLE VI.—*Summary of data appearing in Table V, showing effect of fertilization upon formation of proliferation, and the mortality of weevils in squares and bolls.*

Part of plant.	Plat on which grown.	Number of squares and locks examined.	Per cent of total squares and locks showing proliferation.	Weevil stages alive.		Weevil stages dead.		Per cent of total stages dead.		Average increase in mortality with proliferation.	Average percentage of mortality.
				With proliferation.	Without proliferation.	With proliferation.	Without proliferation.	With proliferation.	Without proliferation.		
Squares	Fertilized	1,604	50.5	544	466	182	53	25.0	10.2	14.8	18.9
Do	Unfertilized	1,571	49.5	508	494	159	35	23.8	6.6	17.2	16.2
Bolls	Fertilized	2,694	66.2	302	22	65	2	17.7	8.3	9.4	17.1
Do	Unfertilized	2,734	69.5	286	38	52	3	15.4	7.3	8.1	14.5
Totals and averages		8,603	[a]61.9	1,640	1,010	458	93	[a]21.4	[a]8.4	......	......

[a] Weighted average.

An examination of Table VI shows that proliferation follows weevil attack in approximately two-thirds of the cases in bolls and in approximately one-half of the cases in squares. As between squares on fertilized and unfertilized plats, there is found a difference of only 1 per cent, which is in favor of the fertilized plats. In the figures for bolls there is shown a difference of 3.3 per cent in favor of the unfertilized plats. Even if both these differences were on the same side of the account, they are too small to justify the conclusion that fertilization with acid phosphate, as used in these experiments, appreciably affected the percentage of instances in which proliferation followed weevil attack.

From a comparison of the mortality percentages it appears that, although among the squares from fertilized plats there is a slightly larger percentage of squares showing proliferation following weevil attack, there is, on the contrary, a smaller difference in the average mortality which may be attributed to the presence of proliferation than is found among the squares from unfertilized plats. With squares on the unfertilized plats having a slightly smaller percentage showing proliferation there is a somewhat higher average mortality apparently due to the presence of proliferation. In a similar comparison with bolls, among those grown on fertilized ground showing proliferation in 66.2 per cent of the injured locks, there was an average increase of 9.4 in the percentage of mortality, while in bolls grown on unfertilized ground showing proliferation in 69.5 per cent of injured locks the average excess of mortality apparently due to proliferation is only 8.1 per cent.

The second significant feature of Table VI is that showing the effect of fertilization upon the mortality of the weevil without regard to the presence or absence of proliferation. A comparison of the percentages of mortality shown in the last column of the table shows us that in the case of squares there is a difference of 2.7 per cent and in the case of bolls of 2.6 per cent in favor of the fertilized plats. These differences are so nearly alike in both squares and bolls as to indicate that fertilization, as practiced in this case, would increase the general average mortality by a small percentage, but that this increase was not due to any increase in the proportion of cases showing proliferation.

One general fact should be stated in regard to field conditions in connection with these observations. As has been stated, the experiment was located in the Brazos bottom. The application of fertilizer produced little apparent difference in the size of plants, and the difference between varieties was by no means as marked as is usually the case. It is possible that upon soil naturally less fertile greater differences might have been produced both as regarding varietal characters and the effect of the application of fertilizer. From the data at hand, however, we would not venture to predict that such differences would result in any greater increase in the mortality of the weevil than has been found in the observations here reported.

PROLIFERATION FOLLOWING OVIPOSITION IN SQUARES.

The next series of observations to be presented will deal with a comparison of varieties in regard to the formation of proliferation following egg punctures in squares. The comparison includes observations made during three seasons and includes about 25 varieties. The table shows also the increase in mortality due, apparently, to proliferation. It is impossible to obtain a close comparison of varieties in this examination, as the conditions of soil, cultivation, and season were so diverse, and the influence of these varying conditions can not as yet be even closely estimated. In the following tabulation are included records where there were less than 100 observations in the series. It is noticeable that the greatest differences in the percentage of squares examined which showed proliferation occurs in cases where examination was made of only a small number of squares and late in the season. It is evident that the data in these cases are insufficient as a basis for reliable conclusions regarding those particular varieties, but the figures may be included in the totals of examinations made without materially disturbing the general averages.

TABLE VII.—*Comparison of varieties for proliferation from egg punctures in squares.*

Date.	Locality.	Variety of cotton.	Total number of squares examined.	Squares with proliferation.				Squares without proliferation.				Average per cent mortality.	Per cent of total dead stages in squares with proliferation.	Per cent of mortality apparently due to proliferation.
				Number found.	Per cent of total examined.	Number weevil stages found.	Per cent of weevil stages dead.	Number found.	Per cent of total examined.	Number weevil stages found.	Per cent of weevil stages dead.			
1902.														
Sept. 17	Calvert and Victoria, Tex.	Several varieties	105	44	41.9	59	30 5	61	58.1	113	19.5	23.3	45.0	11.0
1904.														
July 25, Aug. 28	Victoria, Tex	King	1,307	688	52.6	162	11.0	619	47.4	268	0.0	4.6	100.0	11.0
July 28, Sept. 19	...do	Parker	377	200	53.1	56	9.0	177	46.9	82	2.4	5.0	71.4	6.6
July 28, Aug. 8	...do	Sunflower	174	59	33.9	18	0.0	115	66.1	89	0.0	0.0	0.0	0.0
July 28, Sept. 25	...do	Dickson	171	101	59.1	19	0.0	70	40.9	21	0.0	0.0	0.0	0.0
July 28, Sept. 25	...do	Mascot	169	70	41.4	13	7.7	99	58.6	22	4.5	5.7	50.0	3.2
July 8, Sept. 24	...do	Mit Afifi	159	89	56.0	37	19.0	70	44.0	50	0.0	8.0	100.0	8.0
July 8, Sept. 22	...do	Ashmouni	123	50	40.7	18	16.7	73	59.3	34	0.0	5.8	100.0	5.8
July 8, Sept. 22	...do	Jannovitch	141	82	62.4	22	9.0	59	37.6	39	0.0	3.3	100.0	3.3
July 8, Sept. 28	...do	Native	333	141	42.3	71	5.6	192	57.7	102	1.0	2.9	80.0	4.6
1905.														
Aug. 24	Calvert, Tex	King	105	57	54.3	31	12.9	48	45.7	32	6.3	9.5	66.7	6.6
Do	...do	Shine	105	55	52.9	40	25.0	50	47.1	23	17.4	22.2	71.4	7.6
Aug. 25	...do	Triumph	87	43	49.4	24	50.0	44	50.6	22	9.1	30.4	85.7	40.9
Do	...do	Tools	114	40	35.1	30	16.7	74	64.9	38	21.1	19.1	46.2	4.4
Aug. 28	...do	Hawkins	106	49	46.2	47	31.9	57	53.8	43	11.6	22.2	75.0	20.3
Do	...do	Russell	126	43	34.1	42	23.8	83	65.9	61	8.2	14.6	66.7	15.6
Do	...do	Allen	117	59	50.4	59	42.4	58	49.6	50	4.0	24.8	92.5	38.4
Do	...do	Bohemian	128	53	41.4	48	22.8	75	58.6	52	17.3	20.0	55.0	5.5
Do	...do	Truitt	102	41	40.2	38	36.8	61	59.8	42	4.8	18.7	93.3	32.0
Do	...do	Hetty	131	52	40.0	52	34.6	79	60.0	53	11.3	22.9	75.0	23.3
Aug. 29	...do	Native	120	56	46.7	53	28.3	64	53.3	36	5.5	19.1	88.2	22.8
Do	...do	Territory	815	334	41.0	314	26.7	481	59.0	250	5.6	17.4	85.7	21.1
Sept. 11	...do	King	113	67	59.3	57	35.1	46	40.7	31	0.0	22.7	100.0	35.1
Do	...do	Shine	124	67	54.0	45	40.0	57	46.0	34	3.0	24.1	94.7	37.0
Do	...do	Rowden	207	105	50.7	113	26.5	102	49.3	77	2.6	16.8	93.7	23.9

Do	......do	Nicholson	205	112	54.6	98	12.2	93	45.4	78	7.7	10.2	66.7	4.5
Do	......do	Triumph	107	72	67.3	83	20.0	35	32.7	26	5.5	21.8	92.3	23.5
Do	......do	Tools	108	65	60.2	47	17.0	43	39.8	26	0.0	11.0	100.0	17.0
Do	......do	Hawkins	108	66	61.1	48	18.7	42	38.9	25	4.0	13.7	90.9	14.7
Do	......do	Russell	122	73	60.0	66	16.7	49	40.0	36	2.8	11.8	91.7	13.9
Do	......do	Allen	124	84	67.7	77	18.2	40	32.3	33	0.0	14.5	100.0	18.2
Do	......do	Bohemian	119	76	63.9	62	19.4	43	36.1	30	0.0	13.0	100.0	19.4
Do	......do	Pratt	119	70	58.8	63	17.5	49	41.2	35	0.0	11.4	100.0	17.5
Do	......do	Hetty	125	50	40.0	46	41.3	75	60.0	48	8.3	24.5	82.6	33.0
Do	......do	Native	114	62	54.4	48	25.0	52	45.6	39	0.0	13.8	100.0	25.0
Do	......do	Territory	753	494	65.6	449	19.6	259	34.4	172	1.0	15.7	98.8	18.6
Sept. 27	San Antonio, Tex	Shine	443	212	47.9	203	24.6	231	52.1	196	9.2	17.5	74.0	15.4
Nov. 9	Dallas, Tex	Egyptian	65	18	27.7	10	40.0	47	62.3	27	4.0	13.5	80.0	36.0
Nov. 11	......do	Pachon	25	5	20.0	2	0.0	20	80.0	13	0.0	0.0	0.0	0.0
Do	......do	Kekchi	50	16	32.0	10	40.0	34	68.0	19	5.3	17.2	80.0	34.7
Do	......do	Korean	4	1	25.0	1	0.0	3	75.0	3	0.0	0.0	0.0	0.0
Totals and averages			8,150	4,121	a 50.6	2,801	a 22.3	4,029	a 49.4	2,488	a 5.0	a 14.2	a 83.5	a 17.3

a Weighted average.

Studying Table VII with a view to making a comparison of the varieties in regard to their tendency to proliferate in response to egg punctures and larval injuries, it appears that, in cases where one hundred or more observations were made, the highest percentage showing proliferation was 67.7 per cent, found in Allen at Calvert, Tex., on September 11, 1905. A previous examination of this variety shows, however, only 50.4 per cent, which is almost exactly the average percentage found for all varieties. The average of all observations on Allen shows 59.3 per cent having proliferation. The lowest percentage, from observations which are closely comparable, was 33.9 per cent, found in Sunflower at Victoria, Tex., in 1904. Unfortunately there are no other observations upon Sunflower by which this result may be checked to see whether it may be considered as a somewhat constant tendency in that variety. This being true, it would not be safe to conclude that Sunflower shows the least tendency to proliferate among the varieties examined. It should be noted that the average of the three Egyptian varieties grown at Victoria in 1904 is 52.3 per cent, which is slightly above the general average for all varieties examined. Considering all examinations for each of the four varieties having more than 500 observations each, we find for King 53.2 per cent, for Territory 52.8 per cent, for Shine 49.7 per cent, and for Native 45.7 per cent. Because of the larger number of observations made the average percentages shown for these four varieties are undoubtedly the most reliable of all those given in the table. It appears to the writer from the small variation of 7.5 per cent that the tendency of different varieties to proliferate in response to weevil injury by oviposition or by larval feeding is a remarkably uniform character. Much more extensive examinations would be required to determine the positive status of so many varieties in respect to this tendency to proliferate.

SUMMARY OF RECORDS FOR FOUR VARIETIES.

Examining more closely the portion of Table VII relating to mortality, we find that the percentage of mortality in squares with proliferation ranges from 0 to 50 per cent. The latter figure is found in Triumph at Calvert, August 25, 1905. A general average for the 4,121 squares examined is 22.3 per cent. For the four varieties—Territory, King, Shine, and Native—a closer comparison can be made by presenting the figures in tabular form.

TABLE VIII.—*Comparison of four varieties, each having over 500 observations in Table VII, showing average percentages of mortality and influence of proliferation thereon.*

Variety.	Number of squares examined.	Squares with proliferation. Number of squares with proliferation.	Number of weevil stages found.	Per cent of stages found dead.	Squares without proliferation. Number of squares without proliferation.	Number weevil stages found.	Per cent of stages found dead.	Average number of stages per 100 squares.	Average increase in rate of mortality due to proliferation.
Territory	1,568	828	763	22.4	740	422	3.7	76	18.7
King	1,525	812	250	16.7	713	331	.6	38	16.1
Shine	672	334	288	27.1	338	253	9.1	81	18.0
Native	567	259	172	17.5	308	177	1.7	62	15.8

In squares having proliferation the range in mortality varies between 16.7 per cent for King and 27.1 per cent for Shine. In squares without proliferation this range is between 0.6 per cent for King and 9.1 per cent for Shine. The most striking point in this comparison is shown in the last column of the table giving the average increase in mortality due to proliferation in each variety. In spite of the variations of 8.5 and 10.4 in the preceding percentage columns there is shown in the last column a variation of only 2.9 per cent. The unfavorable influence of proliferation appears, therefore, to be very nearly constant in different varieties, instead of varying widely, as early indications had led us to anticipate that it might do.

In respect to the rapidity of maturity these four varieties may be fairly considered as ranging from the very earliest to the late varieties. Rapid maturing or, in other words, "short season" cotton does not seem to increase especially either the formation of proliferation or the percentage of mortality occurring in the squares.

INCREASE OF MORTALITY ACCOMPANYING MORE SEVERE ATTACK.

While only injured squares were selected for these examinations there was a difference in the severity of the weevil attack in different fields. It was evident during the growing season that the field in which most of the data for Shine was obtained was being more severely injured than any other in which observations were made. The figures show some very interesting results of this condition, if, indeed, they do not indicate the explanation for the increased severity of the attack. The four varieties may be arranged in the order of the increasing proportion of weevil stages to number of squares examined. The figures for the number of weevil stages found and for the stages dead in squares without proliferation are reduced to the common basis of 1,000 squares for convenience in comparing.

Increased mortality in squares without proliferation accompanying increased severity in weevil attack.

Variety.	Number of squares.	Number of weevil stages found.	Number of stages dead.	Per cent of mortality.
King	1,000	380	6	1.6
Native	1,000	620	17	2.7
Territory	1,000	760	37	4.9
Shine	1,000	810	91	11.2

The comparison given above shows very clearly the great increase in mortality accompanying increased severity in the weevil attack. The data here given furnish a very interesting confirmation of the conclusions stated in Bulletin No. 51 of the Bureau of Entomology (p. 119). The statement most directly confirmed is here repeated.

By this time the number of weevils has become so great that the supply of squares is insufficient to meet their need for both feeding and oviposition. Selection of squares so that these two portions of their attack may be kept separate can no longer be exercised. Female weevils are forced to deposit their eggs in squares which have either received other eggs or been largely fed upon, and a much larger proportion of squares at this time shows that feeding punctures are made in squares having eggs or larvæ. By these two factors the mortality among young larvæ especially is greatly increased.

An examination of the figures given shows that in Territory cotton were found twice as many weevil stages as in King, and among these there were 6 times as many dead. In Shine cotton having more than twice as many weevil stages as the King, 15 times as many stages were dead.

INCREASED MORTALITY IN SQUARES AND BOLLS DUE TO PROLIFERATION.

Next in order will be a special study of the increased mortality in squares and bolls which may be attributed directly to the formation of proliferation. The figures for squares and bolls together include more than 20,000 observations. In many cases the records are taken from data which have been used in preceding tables.

TABLE IX.—*Summary of observations showing increased mortality in squares and bolls caused by proliferation.*

Year of observations.	Number of localities covered.	Number of varieties included.	Squares examined.			Per cent of mortality in squares.		Increase in mortality due to proliferation.	Number of bolls examined.	Locks examined.			Per cent of mortality in locks.		Increase in mortality due to proliferation.
			Total number.	Number with proliferation.	Per cent with proliferation.	With proliferation.	Without proliferation.			Total number.	Number with proliferation.	Per cent with proliferation.	With proliferation.	Without proliferation.	
1902	4	4	105	44	41.9	30.5	19.5	11.0	......	......	......	......	......	......	......
1903	1	1	......	......	......	......	......	......	246	1,033	434	42.0	15.0	5.0	10.0
1903	1	1	......	......	......	......	......	......	452	1,898	995	52.4	28.4	12.8	15.6
1904	1	9	2,954	1,480	50.0	9.6	.6	9.0	......	......	......	......	......	......	......
1904	2	2	......	......	......	......	......	......	398	1,708	885	51.8	18.2	11.1	7.1
1905	1	14	4,504	2,365	52.5	19.6	5.5	14.1	......	......	......	......	......	......	......
1905	1	6	771	372	48.2	28.6	.3	28.3	......	......	......	......	......	......	......
1905	1	1	443	212	47.9	25.1	9.7	15.4	......	......	......	......	......	......	......
1905	1	4	144	40	27.8	34.8	3.2	31.6	......	......	......	......	......	......	......
1905	1	14	......	......	......	......	......	......	1,802	7,821	5,069	64.8	16.7	8.5	8.2
1905	1	1	......	......	......	......	......	......	82	254	158	62.2	14.6	0.0	14.6
Totals and averages			8,921	4,513	[a]50.6	[a]17.2	[a]3.7	[a]13.5	2,980	12,714	7,541	[a]59.3	[a]15.5	[a]9.2	[a]6.3

[a] Weighted average.

SUMMARY OF RESULTS OF OBSERVATIONS.

FORMATION OF PROLIFERATION.

In the portion of Table IX relating to squares it should be noticed especially that proliferation follows weevil punctures in approximately one-half of the squares attacked, either for feeding or for oviposition. The constancy of this proportion may be most clearly shown by bringing together the general averages relating to this point found in preceding tables.

Average percentage of squares in which proliferation follows weevil punctures as shown in several preceding tables.

	Per cent.
Table I. Feeding punctures in squares—proliferation formed	51.6
Table III. Comparison King and Shine squares—proliferation formed	52.3
Table V. Squares from fertilized and unfertilized plats—proliferation formed	52.1
Table VI. Squares from fertilized plats—proliferation formed	50.5
Table VI. Squares from unfertilized plats—proliferation formed	49.5
Table VII. Egg punctures in squares—proliferation formed	50.5
Table IX. Increased mortality from proliferation—proliferation formed	50.6

The general average of all these results shows that proliferation follows weevil attack in 51 per cent of all cases.

In the portion of the table relating to bolls it appears that proliferation follows weevil attack in a somewhat higher proportion of cases than it does in squares. A list of the figures for bolls is here given similar to that shown for squares.

Average percentage of locks in which proliferation follows weevil punctures in bolls as shown in several preceding tables.

Table II. Feeding punctures in bolls. Proliferation formed in 44.8 per cent of total locks and in 81.3 per cent of locks actually fed upon.

Table IV. King and Shine bolls. Proliferation formed in 54 per cent of total locks and in 77.4 per cent of locks actually fed upon.

Table V. Fertilized and unfertilized bolls. Proliferation formed in 67.8 per cent of total locks.

These figures indicate that proliferation is stimulated by weevil punctures in somewhat more than 55 per cent of all locks in bolls attacked. The figures in regard to feeding punctures only, show that proliferation results in nearly 80 per cent of the locks thus attacked. It should be noted here that in many cases the proliferation may have been stimulated by secondary causes, such as the entrance of fungi or by decay starting in the open feeding punctures.

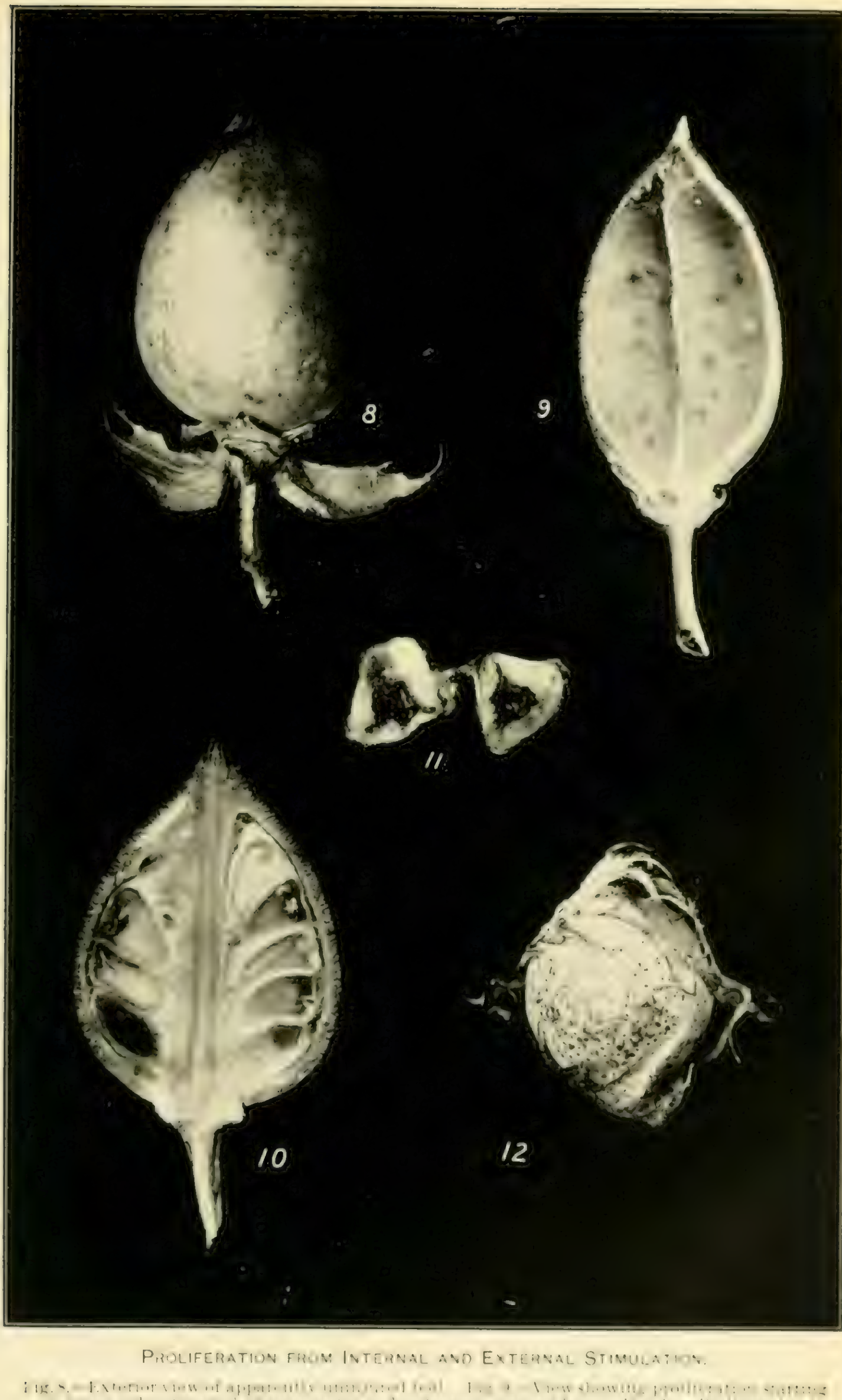
INCREASED MORTALITY OF WEEVIL STAGES DUE TO PROLIFERATION.

As would naturally be expected, a study of the increase of mortality attributable to proliferation will show a somewhat greater variation in the figures for various series of observations than has been found in the percentages of instances in which proliferation occurs. Thus for squares there is found a range of from 9 to 31.6 per cent, the general average being only about 13.5 per cent. For bolls the range is not as great as for squares, being only from 7.1 per cent to 15.6 per cent, while the general average increase in mortality in bolls was found to be only about 6.3 per cent. This increase is scarcely one-half as great as was the increase found in squares.

In neither squares nor bolls is the percentage of mortality sufficiently high to appreciably delay the time of maximum infestation by the weevil, since, if hibernated weevils survived in their usual numbers, the number of weevils developing would be abundantly able to totally infest a field by the time the weevils of the third generation had deposited a majority of their eggs. However, the fact that proliferation does evidently increase the mortality in both squares and bolls must be regarded as a very encouraging sign. It indicates clearly one of the most promising lines of investigation in the future development of cotton varieties which, by possessing this quality in a still greater degree and in combination with other desirable characters, may prove most desirable for culture in the weevil-infested area. So far as our present knowledge is concerned, we may say that the mortality of the weevil is more greatly increased by only two other natural factors known—(1) by the effect of long-continued dry weather when the sun has direct access to the fallen squares upon the ground, and (2) by the work of a widely distributed species of native ant, *Solenopsis geminata* Fab.

OTHER INSECTS THAN BOLL WEEVIL CAUSING PROLIFERATION

Fig. 5.—Bollworm inciting proliferation in boll (after Quaintance), slightly enlarged. Fig. 6.—Feeding punctures of young bollworm in square, proliferation protruding on right side, enlarged two diameters. Fig. 7.—Square borer inciting proliferation, slightly enlarged. Figs. 6 and 7 original



PROLIFERATION FROM INTERNAL AND EXTERNAL STIMULATION.

Fig. 8.—Exterior view of apparently uninjured boll. Fig. 9.—View showing proliferation starting on inner side of carpel shown in fig. 8 due to punctures of bugs. Fig. 10.—Proliferation in seeds due to punctures of *Pentatoma ligata*. Fig. 11.—Section of seed proliferating from Pentatoma puncture. Fig. 12.—Boll attacked by anthracnose, which incited proliferation. Figs. 8-11 slightly enlarged; fig. 12 natural size. (Original.)

STIMULATION TO PROLIFERATION BY CAUSES OTHER THAN WEEVIL ATTACK.

PROLIFERATION STIMULATED BY OTHER INSECTS.

Since beginning this study of proliferation it has been noticed frequently that it occurs commonly in localities where the weevil is not found and from many other inciting causes. Some of the most abundant proliferations have been found in bolls and squares following the attack of young bollworms (*Heliothis obsoleta* Fab.). (See Pl. II, figs. 5, 6.) In many cases small columns of purely proliferous material have been found projected from the punctures made by the pressure produced within the square or boll. Similar cases resulting from the attacks of young square-borers—*Uranotes melinus* Hbn. (Pl. II, fig. 7) or other Thecla larvæ—are to be found in a probably larger proportion of the cases of attack than is generally true with weevils. Many species of bugs commonly produce proliferation of internal tissues in bolls, though no mark of their puncture can be seen in an external examination of the boll (Pl. III, figs. 8, 9). In this way a Mexican bug (*Pentatoma ligata* Say) does great damage by inciting proliferation in the seeds (Pl. III, figs. 10, 11) and preventing the opening of the boll. In a series of examinations covering 4,000 punctures made by this bug 34 per cent of the punctures were found to show distinct proliferation. A number of species of native bugs have been found to incite proliferation in a similar manner. *Leptoglossus phyllopus* L. and *Nezara hilaris* Say have been studied especially, and proliferation has been found in a large percentage of punctures made by these species. In the fields the injury of several species is likely to be so similar in nature and effect as to make it impossible to separate the work of the various species concerned. Thus *Euschistus servus* Say, *Nezara hilaris* Say, and *Thyanta custator* Fab. commonly occur together. In an examination of bolls attacked by these three species proliferation was found in 52 per cent of the total number of locks examined. Other species of Leptoglossus, especially *L. oppositus* Say and *L. zonatus* Dall., have frequently been taken upon cotton, and undoubtedly they incite proliferation exactly as *L. phyllopus* is known to do. *Largus succinctus* L. also feeds upon cotton bolls and in all probability incites proliferation, although specific instances have not been observed.

PROLIFERATION STIMULATED BY ATTACKS OF FUNGI.

In examining large series of bolls it was found that a small percentage showed distinct and characteristic proliferation on the inner side of carpels, which were severely attacked externally by a fungous disease of cotton known as anthracnose. No other cause for the proliferation could be seen, and the number of observations leaves little doubt that the anthracnose (Pl. III, fig. 12) was the cause of the proliferation. In an examination of 1,800 bolls 71 locks showed proliferation from anthracnose. Undoubtedly various species of fungi find favorable places for attack in the cavities formed by open feeding punctures, and these also appeared to incite proliferation in many cases, though it is possible that their attack accompanied rather than caused the proliferation. In still other cases decay seemed to be the inciting agent, but whether by chemical stimulus or in some other way is not known.

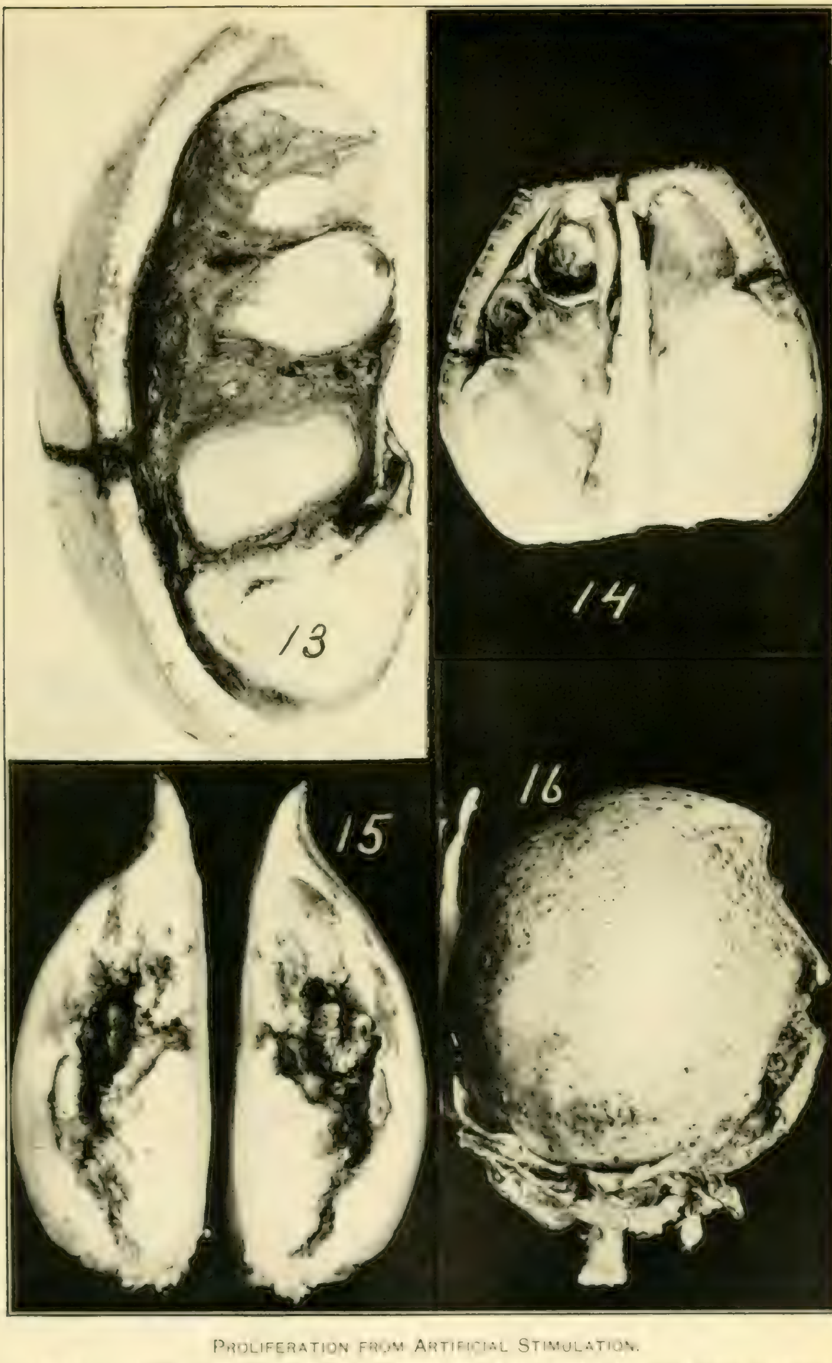
ARTIFICIAL STIMULATION TO PROLIFERATION.

In order to determine positively whether the formation of proliferation was connected specifically with weevil attack, a series of experiments was undertaken to see if it could be produced by artificial stimulation without the intervention of any insect. The experiments, as originally planned, were much more extensive than is shown by the figures which follow, but unfortunately a considerable portion of the records was destroyed in the field through the vandalism of some unknown person. The records secured are sufficient, however, to indicate reliable conclusions to be drawn from the work.

METHOD OF TREATMENT.

Punctures of two sizes were made in these tests, the smaller by a No. 12 needle, which is the smallest size that is commonly used. This needle is not as thick as the proboscis of a weevil, and it made a small puncture. The hypodermic syringe needle used would make a larger puncture than that ordinarily made by the weevil for ovipositing, but not as large as is often made in feeding. The needles were sterilized in a flame before starting a series of experiments, but not between the punctures made in the series.

The "sealing" referred to in Table X, column 1, was accomplished by using a solution of shellac in alcohol. This was not supposed to resemble in nature the mucous secretion used by the weevil in sealing her egg punctures, but was simply expected to close the punctures approximately as tightly as does the weevil. However, the shellac solution accomplished this object only partially, as in many cases it soon peeled away from the surface of the bud or boll. Only a single puncture was made in each square treated, but in more than one-third of these squares a weevil puncture was present also. The effects of a few chemical solutions when injected into buds or bolls were tested also in these experiments (Pl. IV, figs. 13, 14).



PROLIFERATION FROM ARTIFICIAL STIMULATION.

Fig. 13.—Proliferation in seeds following artificial stimulation with injection of water; enlarged three diameters. Fig. 14.—Proliferation in carpel and seed following artificial treatment with acetic acid. Fig. 15.—Proliferation from carpel and septum enveloping larva in boll. Fig. 16.—Lock of boll burst open by pressure of proliferation formed within. Figs. 14-16 slightly enlarged. (Original.)

RESULTS WITH SQUARES.

As in previous tables the records for squares and bolls are kept separate.

TABLE X.—*Results of experiments at Hidalgo, Tex., in producing proliferation in squares by artificial stimulation.*

Treatment of squares.	Number of squares treated.	Total punctures made artificially.	Total weevil punctures present.	Days from treatment to collection.	Weevil stages found.		Effects of artificial punctures.		Per cent artificial punctures showing proliferation.
					With proliferation.	Without proliferation.	Proliferation present.	Proliferation absent.	
Puncture made with No. 12 sterilized needle; unsealed	5	5	1	12.8	1	0	5	0	100.0
Puncture made with No. 12 sterilized needle; sealed with shellac	5	5	1	13.4	1	0	0	5	0.0
Puncture made with hypodermic syringe needle, sterilized; unsealed	4	4	2	14.0	2	0	0	4	0.0
Puncture made with hypodermic syringe needle, sterilized; sealed with shellac	7	7	2	12.7	2	0	2	5	28.6
Puncture made with hypodermic syringe needle; one-half drop of 2 per cent solution of formic acid injected; unsealed	3	3	0	14.0	0	0	0	3	0.0
Puncture made with hypodermic syringe needle; one-half drop of 2 per cent solution of formic acid injected; sealed with shellac	10	10	5	13.4	4	0	5	5	50.0
Puncture made with hypodermic syringe needle; one-half drop of 2 per cent solution of caustic potash injected; unsealed	4	4	2	12.5	1	0	2	2	50.0
Puncture made with hypodermic syringe needle; one-half drop of 2 per cent solution of caustic potash injected; sealed with shellac	5	5	3	10.2	3	1	3	2	60.0
Totals and averages	43	43	16	13.0	14	1	17	26	[a] 40.0

[a] Weighted average.

It must be remembered that in all cases these artificial punctures, though sealed, resemble feeding punctures of the weevil much more closely than they do egg punctures. It is impossible to imitate artificially the natural conditions following oviposition, the hatching of the egg, and the gradually increasing irritation accompanying the growth of the larva. Really the effect of a needle puncture upon the tissues penetrated is very different from the feeding punctures of the weevil. The needle simply crushes the cells, pushing them aside from its path, and leaving the cavity it makes more or less completely filled with sap and crushed cells. In the weevil puncture the work is far more neatly done than it can be in any bungling imitation. The sharply toothed mandibles at the tip of the weevil's snout cut away the tissues smoothly without crushing or injuring adjoining cells, and the material, being eaten, is entirely removed from the cavity, leaving it dry and clean with the adjoining tissues comparatively uninjured. The difference is really about as great as in a case of the accidental amputation of a limb under a railway train as compared with the work of a skilled surgeon. The healing following these two operations might also be likened to the proliferation following artificial and weevil-made punctures. As the probability would be greatly in favor of mortification following from the untreated railway accident, so would decay be more likely to follow a needle puncture in a boll than would the proper healing of the wound by proliferation. The injection of chemical solutions by the hypodermic syringe would, in all probability, hinder rather than assist proliferation.

Unfavorable as conditions for these tests seem, it appears that proliferation was formed in a perceptible degree in 40 per cent of all cases in which artificial punctures were made. The proportion in cases where punctures were left open is slightly greater than where punctures were sealed, being 43.7 per cent in the former case, and 37 per cent in the latter case. In all these cases the proliferation was entirely distinct from that caused by larvæ when such were present. In many instances the proliferation was abundant and very plainly characteristic, in other cases there was only a slight formation with more or less of decay. The fact that the experiments were undertaken at very near the close of the growing season would account for the formation of less proliferation than might have resulted from similar experiments earlier in the season.

RESULTS WITH BOLLS.

More extensive experiments were made with bolls than with squares in testing artificial stimulation to proliferation. Part of the experiments were performed at Dallas and part at Hidalgo, Tex. The same methods were used as with squares. The number of punctures per boll averaged about six. In the experiments at Hidalgo it was difficult to find bolls which were wholly free from weevil attack. The full data from the experiments are given in the following table:

TABLE XI.—*Results of experiments in artificial stimulation to proliferation in bolls.*

Locality and variety.	Treatment of bolls.	Number of bolls treated.	Total punctures made artificially.	Total weevil punctures present.	When treated.	Days from treatment to collection.	Average size of boll, diameter.	Weevil stages found. With proliferation.	Weevil stages found. Without proliferation.	Effects of artificial punctures. No proliferation.	Proliferation present. In carpel.	Proliferation present. In lock.	Proliferation present. In septum.	Per cent of artificial punctures showing proliferation.
Dallas, Tex.:					1905.		*Inch.*							
Mit Afifi	Puncture made with No. 5 sterilized needle; unsealed	3	9	0	Oct. 14	19.0	1	0	0	4	9	5	0	55.6
Red cotton	do	4	19	0	do	10.0	1	0	0	4	15	7	0	79.0
King	do	3	15	3	do	31.0	1	0	1	0	15	5	0	100.0
Mit Afifi	Puncture made with hypodermic-syringe needle; water injected; unsealed	5	24	2	do	8.6	[illegible]	0	0	15	1	7	0	31.8
King	do	5	40	0	do	11.2	1	0	0	32	0	8	0	20.0
Mit Afifi	Puncture made with hypodermic-syringe needle; 2 per cent solution formic acid injected; unsealed.	2	9	0	do	4.0	[illegible]	0	0	3	0	6	0	66.7
Red cotton	do	4	30	0	do	9.5	[illegible]	0	0	6	4	24	1	80.0
Fair variety	do	4	30	1	do	13.0	1	1	0	13	17	0	0	56.7
Red cotton	Puncture made with hypodermic-syringe needle; 2 per cent solution of acetic acid injected; unsealed.	2	14	1	do	17.0	1	0	0	6	8	8	1	61.4
Egyptian	do	2	12	0	do	14.0	[illegible]	0	0	6	6	6	0	50.0
Texas wool	do	2	16	0	do	21.0	1	0	0	15	1	6	0	6.2
King	do	4	32	0	do	9.0	1 1/4	0	0	16	16	0	0	50.0
Do	Puncture made with No. 12 sterilized needle, one-fourth inch deep; unsealed	10	182	4	Oct. 20	8.5	1	1	0	132	45	5	0	27.5
Do	Puncture made with sterilized hypodermic-syringe needle; unsealed	9	172	1	Oct. 21	13.7	1 1/4	1	0	169	3	0	0	2.0
Egyptian	Puncture made with No. 12 sterilized needle; sealed with shellac	9	38	0	Nov. 16	9.6	[illegible]	0	0	21	17	0	3	47.4
Helotes, Tex.:														
Native seed	Puncture made with No. 12 sterilized needle; unsealed	19	120	27	Nov. 23	14.0	......	8	0	78	42	34	4	35.0
Do	Puncture made with No. 12 sterilized needle; sealed with shellac	23	60	24	do	13.4	......	14	0	30	30	20	0	50.0
Do	Puncture made with sterilized hypodermic-syringe needle; unsealed	22	113	27	do	13.0	......	12	0	66	47	41	2	41.6
Do	Puncture made with sterilized hypodermic-syringe needle; sealed with shellac	23	66	17	do	13.3	......	12	0	25	41	17	0	62.1
Do	Puncture made with sterilized hypodermic-syringe needle; one-half drop of 2 per cent formic acid solution injected; unsealed.	8	26	10	do	13.6	......	5	0	13	11	13	3	50.0
Do	Puncture made with sterilized hypodermic-syringe needle; one-half drop of 2 per cent formic acid solution injected; sealed with shellac.	10	31	19	do	13.7	......	7	0	18	8	13	1	42.0
Do	Puncture made with sterilized hypodermic-syringe needle; one-half drop of 2 per cent caustic potash solution injected; unsealed.	5	16	8	do	13.6	......	2	0	7	5	8	1	56.2
Do	Puncture made with sterilized hypodermic-syringe needle; one-half drop of 2 per cent caustic potash solution injected; sealed with shellac.	10	29	11	do	13.4	......	1	0	18	11	11	1	40.7
Totals and averages		188	1,103	158	......	13.0	0.9	64	1	697	352	238	17	[a]39.8

[a] Weighted average.

It should be stated that the attempt to seal punctures by applying a solution of agar-agar was not successful, as upon drying it would peel away from the boll, leaving the puncture practically open. The sealing with a solution of shellac resulted successfully in most cases.

Among the 1,103 artificial punctures made proliferation resulted in 36.8 per cent. While this percentage is hardly half that found in Table II for feeding punctures of the weevil, it seems fully as large as should be expected from the unfavorable conditions prevailing in these tests. Among the 604 unsealed punctures at Dallas proliferation resulted in 30 per cent. Among the 223 instances of proliferation recorded from these unsealed punctures 62.8 per cent were from the inner side of the carpel, 36.3 per cent were in the seeds, and 1 per cent in the septa separating the locks. A comparison with the results from the 38 sealed punctures at Dallas shows in the latter case proliferation formed in 44.7 per cent of the punctures. Among the 20 instances of proliferation resulting, 85 per cent occurred in the carpel and 15 per cent in the septa.

COMPARISON OF RESULTS FROM SIMPLE NEEDLE PUNCTURES WITH EFFECTS OF CHEMICAL INJECTIONS.

Comparing next the results from simple needle punctures with those from chemical injections for the Dallas experiments, it is found that from the needle punctures proliferation resulted in 24.1 per cent of the total cases, while from the chemical injections it resulted in 45.9 per cent of cases. It should be stated, however, that decay was much more common in the cases of chemical treatment, and in many locks it was impossible to tell whether the decay had closely followed or whether it had caused the proliferation.

An examination of the records for Hidalgo shows that proliferation resulted from 44.6 per cent of all simple needle punctures and from 45.1 per cent of those receiving chemical injections.

COMPARISON OF RESULTS FROM SEALED AND UNSEALED PUNCTURES.

In a comparison of results from 164 sealed and 630 unsealed simple needle punctures it is found that proliferation resulted in 53.7 per cent of the sealed punctures and in 28.1 per cent of those unsealed. In the chemically treated punctures proliferation resulted in 47 per cent of the 249 unsealed and in only 40 per cent of the 60 sealed. As these percentages in chemically treated punctures stand in inverse proportion to those in simple needle punctures, it does not appear that a well-founded conclusion can be drawn as to the influence which the sealing of punctures may have upon the subsequent formation of proliferation.

CONCLUSIONS.

Several important and obvious conclusions may be drawn from the results of the artificial stimulation of proliferation. Proliferation in buds and bolls does not depend essentially for its stimulation upon insect injury of any particular kind. It becomes unnecessary to assume that any irritating secretion is deposited by the weevil with the egg. It has been shown conclusively that proliferation may occur entirely apart from weevil presence. Proliferation may result from a large number of causes, of which the following are noted in this bulletin: Weevil feeding punctures, weevil egg punctures, injury by the larva during its feeding period, bollworm punctures, square-borer punctures, feeding punctures of various bugs, fungous attacks in insect punctures, anthracnose, and artificial punctures of the bud or boll.

MANNER IN WHICH PROLIFERATION CAUSES DEATH OF WEEVIL STAGES.

REARING LARVÆ ON PURELY PROLIFEROUS FOOD.

In order to determine whether proliferation caused the death of larvæ by starving or poisoning them, numerous experiments have been performed. Unhatched eggs and larvæ just hatched have been placed in the midst of masses of purely proliferous formation; and these have been kept in a tight, moist chamber and transferred to fresh masses of proliferation as frequently as necessary to preserve proper conditions for the larvæ. In spite of these frequent transferences and the somewhat unnatural conditions necessary, it was found that but a very small proportion of the larvæ died. In some cases the growth was completed in masses of proliferation which were completely decayed. This condition was allowed to exist in order to test the effect of what seemed the most unfavorable food conditions it was possible to produce so far as quality was concerned. In one series of experiments 8 very young larvæ were placed in fresh proliferous masses. Of these, 1 died on the first day, but all others reached full growth and pupated normally in from nine to twelve days, having fed on nothing but proliferous material.

In another series 8 larvæ just hatched were started in locks in which dead full-grown larvæ had been found entirely enveloped by the proliferation. Surely if proliferation were poisonous, this test should prove it, since in each case a larva had been previously killed in the lock given each young larva for food.

One larva was accidentally killed in examining the material on the fourth day. One larva completed its growth and pupated in the lock in which it was originally placed. Two died and the remaining 4 also pupated after being transferred to fresh locks from which dead larvæ were previously taken. Under these most unpromising conditions, therefore, 5 of the 7 larvæ tested reached the pupal stage. This experiment was performed between November 17 and December 12, 1905. The larval stage averaged about thirty days in duration. It does not follow from the length of this stage that the food conditions were even unfavorable, since at that season in bolls the length of the larval stage would undoubtedly exceed thirty days under normal field conditions. These experiments alone would be sufficient to prove that the mortality caused by proliferation is not due to insufficient nutrition or to poisonous qualities in the food material of the larvæ affected. Furthermore, the examination of thousands of squares and bolls has shown that in a very great number of cases weevils reach maturity in the field on no other food than proliferous cells.

MECHANICAL CRUSHING THE REAL METHOD.

The real cause of death in the presence of abundant proliferation will become apparent to any one who will take the pains to examine carefully a few thousand bolls which have been injured by weevil attack. In one series of observations, covering 1,800 bolls, 1,016 weevil stages were found. During this examination a partial record was kept of those cases in which the cause of death was unmistakably shown, with the following result:

Three adults just alive, but badly deformed by pressure.
Two pupæ just alive, but badly deformed by pressure.
Two pupæ unmistakably crushed to death.
Twelve larvæ unmistakably crushed to death.

These 19 cases formed nearly 2 per cent of all the stages found. The record was not kept by all those engaged in the examination of this series of bolls and only the most unmistakable cases were recorded at all. It is certain, therefore, that this 2 per cent is but a small part of the true proportion of weevils which were killed in this way by the proliferation. Considering these facts in connection with the conclusions as to the food quality of proliferous cells, it seems safe to conclude that the great majority of deaths due to proliferation may be caused by the mechanical effect of the formation in first enveloping the larva so closely as to prevent its movement (Pl. IV, fig. 15), and then the continued formation producing sufficient internal pressure (Pl. IV, fig. 16) slowly but surely to crush to death the foe whose attack has called forth this effort at self-defense on the part of the plant. Such an explanation alone fully accords with the facts as we know them. These observations present to us in a very vivid way an illustration of the intensity of the struggle, continually going on between plant and insect life. It is a life and death struggle, and it is not always the insect that wins.

ORIGINATION AND EFFECTS OF PROLIFERATION IN BOLLS.

Fig. 17.—Proliferation beginning under carpel lining. Fig. 18.—Proliferation pressing into pupal cell. Fig. 19.—Adult weevil deformed by pressure of proliferation. Fig. 20.—Proliferous mass spreading over inner side of carpel. Figs. 17, 18, 20 slightly enlarged; fig. 19 enlarged four diameters. (Original.)

LOCKS COMPLETELY FILLED BY PROLIFERATION

Fig. 21.—a, Point of original egg puncture and first proliferation; b, larva crushed by proliferation crowding upon it from all directions. Enlarged four diameters. (Original.)

EXPLANATION OF MECHANICAL ACTION.

A brief explanation of some additional points regarding the formation of proliferation may serve to show more clearly how it becomes possible for the plant to literally crush its irritating foe. The explanation will be given for bolls rather than for squares, though the real effect of proliferation is the same in squares as in bolls.

Proliferation usually begins in the layer of cells adjoining the thin, tough lining within each section of the boll. By far the greater part of this formation projects through the rupture made by the weevil in the tough lining and forms a rather hemispherical mass protruding from the inner side of the carpel (Pl. V, fig. 17) and pressing into the lock. The formation sometimes, though not always, begins before the hatching of the egg, which may be moved quite a distance, in some cases, by the pressure of the mass behind it. In other cases the egg becomes enveloped and the larva hatches into the proliferous mass. In such cases it may be destroyed early in life, though it will often make its way into the lock, eating its way as it goes. As it feeds the larva is continually injuring and irritating tissues capable of proliferation, which thus becomes started all around the larva and gradually pushes in upon it from all directions (Pl. V, fig. 18). It may happen in this way that the space which the larva has eaten out as it grew becomes filled by the masses of cells pushing in upon it and the larva can not possibly eat away the forming mass rapidly enough to preserve room for itself to move (Pl. V, fig. 20). Though it may be nearly or quite full grown, it can not escape from its narrowing prison and soon becomes so closely enveloped as to be unable to move in any direction. It is then an easy victim for the relentless pressure of forming cells and is literally crushed to death in its prison (Pl. VI, fig. 21).

Very frequently, indeed, instances are to be found in which the plant gets a tardy vengeance on the pupa or the newly transformed adult (Pl. V, fig. 19). Whether death results within a short time or the victim is allowed to emerge with only some deformity to tell of its narrow escape within the boll, depends largely upon the continuance of the proliferation. Deformed pupae and adults are by no means uncommon and in nearly all cases they are undoubtedly the partial victims of this form of plant defense. Many of these specimens have been so deformed by pressure upon the pupa that the adult can not feed. These would be unable to make their escape from the boll did it not happen sometimes that the maturing of the boll breaks open the prison cell of these victims and turns them out only to perish slowly by starvation.

PROLIFERATION IN PLANTS OTHER THAN COTTON.

The most definite and abundant observations of proliferation in plants other than cotton have been made in two species of peppers in connection with the work of the pepper weevil (*Anthonomus æneotinctus* Champ.). Proliferation was very distinct in 93.5 per cent of the pods of sweet pepper which had been attacked by the pepper weevil. It was also found to have formed in three-fourths of the feeding punctures. In pods of the chili peppers proliferation was found in about 38 per cent of those examined and in about 34 per cent of the cases of simple feeding punctures. Among the 300 pepper pods examined no trace of mortality resulting from the proliferation was seen.

Among other plants no special observations seem to have been made to determine the presence or absence of proliferation, but it may be allowable to state here that a similar formation, which has every appearance of being homologous with proliferation in cotton, has been observed by Mr. F. C. Pratt in the pods of garden peas, by Mr. C. R. Jones in the pods of cowpeas, by Mr. A. C. Morgan in the buds of *Callirrhoe involucrata*, and by Mr. J. C. Crawford in the seed pods of mesquite. It would appear probable that when special investigation shall be made of the occurrence of proliferation in other plants than cotton it will be found a not uncommon phenomenon in very widely separated species of plants.[a] Naturally, it may not be expected to occur in response to the great majority of insect injuries, since it depends upon a number of coincident favorable conditions, and the presence or absence of some other and entirely unrelated factor may prevent or obscure its formation even where some of the essential favorable conditions are present.

CONCLUSIONS AS TO NATURE AND SIGNIFICANCE OF PROLIFERATION.

In all cases, whatever the stimulant, one factor is uniformly essential. There must be a cell injury which is not sufficiently severe to overcome immediately the vital force of the injured organ or tissue. Proliferation is simply the manifestation of a natural inherent tendency of plant cells to respond to an encountered irritation by multiplying or forming new cells. It is evidently a method of self-defense, and in the case of cotton the irritation appears to be in nearly

[a] The possible general occurrence of proliferation as the result of insect attack is shown by the following quotation relating to *Anthonomus quadrigibbus* Say on apple, by Prof. C. S. Crandall:

> Many of the egg-cavities cut into were found to be more or less completely filled by intruding cell masses. These cell masses were quite firm in texture. Sometimes they invaded the cavity from the bottom, but often grew as wart-like excrescences from small areas on the sides of the cavities. In several instances dead larvæ were found pressed close to the cavity wall by these intruding cell masses. (Bul. 198, Ill. Exp. Sta., page 528.)

all cases strictly mechanical. The function of proliferation in most cases is undoubtedly to repair an injury.

From the numerous observations dealt with in detail in the preceding pages a number of conclusions seem to be warranted. The phenomena considered are very complicated, and consequently only a few generalizations are made.

(1) In a large number of varieties of American upland cotton proliferation has been found to occur in 51 per cent of the cases of weevil attack upon squares and in 55 per cent of the cases of similar attack upon bolls.

(2) Eliminating a certain percentage of mortality, which was found in cases where no proliferation occurred, the increased rate of mortality in all weevil stages apparently caused by proliferation was, in squares 13.5 per cent and in bolls 6.3 per cent.

(3) Ordinary variations in climatic conditions seem to have comparatively little effect upon the proportion of injuries proliferating, although hot, dry weather plainly increased the mortality occurring without regard to the presence of proliferation.

(4) Contrary to a previous tentative conclusion, based upon a much smaller number of observations,[a] the upland American varieties seem to be somewhat on a parity so far as the tendency toward proliferation is concerned.

(5) The application of different fertilizers to cotton has thus far failed to show any tendency toward increasing the proliferation.

(6) Proliferous tissue is not toxic to weevils. Death results in most cases in a mechanical way from simple pressure.

(7) Proliferation is caused by the attacks of a number of different insects, and is easily produced artificially by needle punctures. Its stimulation appears to be from mechanical irritation, and, consequently, a secretion on the part of the insect does not seem to be essential.

(8) Proliferation occurs commonly in plants other than cotton as the result of insect attack or from mechanical injury. It has been noticed in the seed pods of several species of Leguminosæ and in different species of Capsicum.

PRACTICAL APPLICATION OF CONCLUSIONS FROM THIS STUDY.

The fundamental purpose underlying all this study of proliferation, its causes and its effects, is to learn, if possible, facts which may be made of practical use in the effort to grow a profitable crop of cotton in the area infested by the boll weevil, either by so controlling the multiplication of the weevil as to reduce its injury to a sufferable quantity, or by raising the crop so as to avoid the serious injury which the pest has shown itself capable of producing under the system

[a] Bul. No. 51, Bureau of Entomology, U. S. Dept. of Agric., p. 134.

of culture which has been customarily employed. Many factors must be considered in any hopeful solution of this most serious problem. With insect pests ounces of prevention are worth many pounds of cure. The most promising solution of the weevil problem is undoubtedly found in a combination of the factors restricting weevil development with those favoring crop improvement. The facts learned from this study of proliferation may be utilized in the class of factors restricting weevil development.

It appears that there is a small variation between different varieties of cotton in regard to the proportion of cases in which weevil punctures stimulate proliferation. It is evident that the presence of proliferation increases somewhat the percentage of mortality among the larvæ and pupæ in proliferating buds and bolls. The plain conclusion is that the varieties which proliferate most freely will by that characteristic tend to restrain the rapid multiplication of the weevil. It is probable that varieties may be developed by repeated selections which will be more effective than any now known in restraining weevil development in this way; still, this factor alone will probably never be of more than secondary importance in reducing the number of weevils, as other considerations will inevitably be more important in determining the most desirable variety to plant. Although the observations thus far made have failed to show any conclusive effect of fertilization of the soil upon proliferation, further investigations should be made upon this point. Much work would still be necessary to determine any constant relationship between the formation of proliferation and climatic conditions. Probably little practical use could be made of a knowledge of such climatic relationships if ascertained, as the influential factors would always remain beyond the control of the cotton planter.

The tendency to proliferate is by no means a recently acquired characteristic of cotton; therefore it should not be supposed that it is any more susceptible to such variation as will render it a still greater obstacle to weevil development than are many other characteristics which may be emphasized with equal or even greater advantage in the selection of new strains of cotton for growth in the weevil-infested area. Such selections require much time, and we may, therefore, feel somewhat encouraged to know that in the long fight yet to come we may expect this natural factor to accomplish no less than we have found it now doing toward the repression of the weevil. Of course complete reliance can never be placed in natural factors for a solution of the weevil problem. Doubtless the capacity of the weevil for adaptation to any new conditions which its food plant may present is just as great as is any adaptive capacity of the plant. Nevertheless, the interference of man is likely to throw the advantage greatly in favor of the plant. Natural factors having a controlling influence on the weevil will do their work no less effectively if the intelligent assistance of the planter be given in the planting, culture, and subsequent care of the crop. Repeated and widely varied experience has proven that the intelligent planter can, as a rule, so assist natural factors, by adopting certain changes in his methods of cultivation, as to produce a profitable crop in the face of conditions which would otherwise have insured its failure.

INDEX.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—BULLETIN No. 60.

L. O. HOWARD, Entomologist and Chief of Bureau

PROCEEDINGS

OF THE

EIGHTEENTH ANNUAL MEETING

OF THE

ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

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1906.

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PROCEEDINGS

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ISSUED SEPTEMBER 22, 1906.

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1906.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., May 8, 1906.

Sir: I have the honor to transmit herewith the manuscripts of the proceedings of the eighteenth annual meeting of the Association of Economic Entomologists, which was held at New Orleans, La., January 1 to 4, 1906. As the papers presented at the meetings of this association are of very considerable economic importance and as the reports of the secretaries of these meetings have hitherto been published by the Department of Agriculture as bulletins, I recommend the publication of the present report as Bulletin No. 60 of this Bureau.

Respectfully,

C. L. Marlatt,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS

[a] Withdrawn for publication elsewhere.

ILLUSTRATIONS.

PLATES.

TEXT FIGURES.

THE EIGHTEENTH ANNUAL MEETING OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

MORNING SESSION, MONDAY, JANUARY 1, 1906.

The Association met in Gibson Hall of the Tulane University, New Orleans, La., on January 1 to 4, 1906. The following members were in attendance at the several sessions:

C. F. Adams, Fayetteville, Ark.; W. E. Britton, New Haven, Conn.; A. F. Burgess, Columbus, Ohio; R. S. Clifton, Washington, D. C.; A. F. Conradi, College Station, Tex.; Mel. T. Cook, Santiago de las Vegas, Cuba; E. C. Cotton, Columbus, Ohio; J. C. Crawford, Dallas, Tex.; C. W. Flynn, Baton Rouge, La.; S. A. Forbes, Urbana, Ill.; J. B. Garrett, Baton Rouge, La.; E. S. Hardy, Shreveport, La.; W. E. Hinds, Washington, D. C.; L. O. Howard, Washington, D. C.; W. D. Hunter, Washington, D. C.; C. R. Jones, Dallas, Tex.; R. S. Mackintosh, Auburn, Ala.; C. L. Marlatt, Washington, D. C.; W. O. Martin, Shreveport, La.; H. A. Morgan, Knoxville, Tenn.; A. W. Morrill, Washington, D. C.; Wilmon Newell, Shreveport, La.; J. F. Nicholson, Stillwater, Okla.; Herbert Osborn, Columbus, Ohio; A. L. Quaintance, Washington, D. C.; C. E. Sanborn, College Station, Tex.; E. Dwight Sanderson, Durham, N. H.; E. A. Schwarz, Washington, D. C.; R. I. Smith, Atlanta, Ga.; H. E. Summers, Ames, Iowa; T. B. Symons, College Park, Md.; F. L. Washburn, St. Anthony Park, Minn.; F. M. Webster, Washington, D. C.

In the absence of the president and the first vice-president the meeting was called to order at 10 a. m. by the second vice-president, Mr. F. L. Washburn. The secretary read the annual address of the president, as follows:

THE SCOPE AND STATUS OF ECONOMIC ENTOMOLOGY.

By H. Garman, *Lexington, Ky.*

Science in all its aspects, when applied to human affairs, has of late been accorded much more consideration and its devotees more respect than formerly. Economic entomology with the rest has received its share of recognition as a branch of science worthy of the close attention of sensible men. Yet it was not so long ago when we heard much of the pure science of entomology as contrasted with its applied science, as if the two were completely independent of each other; and somehow it was imagined that entomology not applied was a more exalted field of study than entomology made to serve our own wants; the man engaged simply in the study of the science itself, though utterly incapable in practical matters, was a greater scientist than one who sought to render his studies of service to his kind.

It was a foolish notion, to be sure, this making of an arbitrary distinction between the science when utilized and when not, and, excepting in the case of certain belated laboratory and museum workers, no such idea is seriously entertained to-day. Indeed, it seems now that the tendency is to exalt applied entomology to the detriment of the pursuit of its science. Certainly the economic entomologist has had opportunities in the shape of financial support and influential backing that have never been enlisted in the service of the purely scientific side of the subject. Economic entomologists have all good reason to feel proud of this, since it is largely a result of the practical viewpoint and enterprise of the votaries of applied entomology.

It has been the practical sense developed by dealing with affairs that has enabled them to enlist the attention of the public and educate it to the importance of entomology as applied to agriculture and other human concerns. The pure science worker would never have done this, and it thus has happened that the entomologist, who was at one time looked upon by his fellow-worker with something in the nature of disdain, has taken first place in the estimation of the general public and commands attention when the recluse laboratory worker gets little consideration. And this is as it should be. The economic entomologist can claim all entomology as his. Not a fact is there of insect structure or life history or habit that may not at some time prove to be of first importance from the practical point of view. The history of this science is full of illustrations showing how insects and facts concerning them, regarded at first—like the economic entomologist—as of no great consequence, have proven, when their relations with other facts were known, to have a far greater importance than have those with which attention was mainly occupied. The family Coccidæ, at one time almost wholly ignored in this country by entomologists of all sorts, has, from the accidental introduction of one of its species into California from abroad, and more recently into the fruit-growing States of the East, become of late one of the most conspicuous groups of all insects and one of those most often mentioned and discussed among people not entomologists. The species just mentioned may be said to have wrought a greater change in the attitude of the general public toward entomology and entomologists than all of the other known species of scale insects together. The family Culicidæ, also very generally ignored by entomologists until recently, and serving largely as a subject for jokes by other people, has, from the discovery of the relations of certain of its species with the diseases malaria and yellow fever, become one of the most important and interesting of all groups of insects. The discovery of these relations has made necessary careful systematic work on the species of mosquitoes—a study of the life history and habits of each, a knowledge of their structure, a knowledge of the life histories of the parasites for which some of them serve as intermediate hosts, and a knowledge of the precise relations which these parasites sustain to mosquitoes. Because of this discovery the entomologist is compelled to acquire knowledge—systematic, ecological, and morphological—and to delve to some extent into the life history and structure of organisms very remotely related to insects.

Again, a study of the structure of an insect has more than once furnished a clue to means of checking its injuries when everything else failed. A single fact concerning a life history has likewise sometimes placed it within our power to avoid mischief from which we had hitherto been unable to protect ourselves. To meet the requirements of his subject, the economic entomologist must, in a word, be an all-round naturalist. He must know species well. He must know anatomy, minute and microscopic. He must know insect life histories as they are known to no one else. He must know remedies for insect injuries and be able to apply them successfully. He must be a skillful microscopist, and should know the literature of entomology. If he has acquired this knowledge and skill, he is surely as broad, as a man and an entomologist, as he whose work is confined solely to the "pure science" of the subject; and it may be easily maintained that economic entomology as here understood is a much broader field and requires as much talent of the same and different sorts for its successful pursuit as that employed by him who studies simply insect taxonomy, insect embryology, or insect morphology, valuable though the results of such studies may be.

All science is "pure," whether it is applied or not. It may be suspected that some of the disfavor bestowed upon economic entomology in the early days of its history in this country arose from the fact that economic entomologists were often more of the practical order than of the scientific; were, in other words, somewhat deficient in scientific knowledge, though this was not true of Riley, Fitch, or Harris, three great pioneer economic entomologists who have had no superiors in any country. Yet it must be said of these men that they were primarily scientists, whose chief interest lay in working out life histories. Remedies for insect injuries as employed by farmers and fruit growers were studied by them, and what appeared to be the best were recommended in their writings, but these remedies were not experimented with in the thoroughgoing manner that has of late become the fashion. This is not to their discredit. They were able men, who felt impelled to do the work most worth doing in their day. The problems to be solved now are different, and the opportunities to solve them in a satisfactory manner are better than they were when these men wrote.

GROUPS OF ANIMALS STUDIED BY THE ECONOMIC ENTOMOLOGIST.

It has been my custom in pointing out to pupils the extent of the class Insecta and its relations with other groups of animals to remind them that our legitimate field covers the three classes of Arthropods—namely, Arachnida, Myriapoda, and Insecta, and that occasionally a venturesome entomologist pushes on into the fourth group when some member of it, such as the pill bug, becomes troublesome and requires attention from a practical standpoint. Considering the number of species of true insects alone to be studied—and any one of them may demand attention—the economic entomologist occupies a greater territory than do all his fellow-workers in mammalogy, ornithology, ichthyology, herpetology, malacology, etc., put together.

Compared with other groups of animals, the Insecta at once stands out as the most conspicuous, both in point of numbers and of species. Mammals, birds, reptiles, and fishes, composing the vertebrate subkingdom, include but few, relatively. Mollusks are not especially numerous. The same is to be said of the true worms, of the starfishes, and the sea urchins. Of the corals, sponges, and microscopic Protozoa, also, it may be said that their numbers are small as compared with those of insects, though the Protozoans, especially those of salt water, exist in amazing numbers of individuals. Insects, numbering, it is believed, about 1,000,000 species, surpass all these other groups, and constitute approximately four-fifths of the whole animal kingdom. Here is a great field for the entomological taxonomist, and it is this wealth of material that has kept entomology somewhat behind botany and some other branches of biological study. To describe properly the adults alone of all these species of insects would require 2,000 octavo volumes each of 500 pages. To describe the life history of any insect should require at least two octavo pages, which would add 4,000 volumes more, and perhaps another thousand would give adequately the facts relating to the habits and distribution of each species. Good accounts of the morphology and physiology of typical examples, even of family groups, would add many more volumes. Then we must include as part of the domain of the entomologist the classes Myriapoda and Arachnida, comprising, say, 10,000 species. A library of not less than 7,000 volumes would thus be required to give merely the important facts concerning existing insects, not including discussions of remedies for insect injuries.

ALL INSECTS OF ECONOMIC IMPORTANCE.

It may be said of the 1,000,000 insect species estimated as now existing that they are every one in greater or less measure of interest from the economic view-point. If carnivorous, they feed upon one another, or else upon animals of other groups, and all are so knit together that it is impossible to estimate the far-reaching effects that might follow any change in the numbers of the most obscure species. So, too, in their relations to vegetation, while many attack plants of no apparent value to us, it is impossible to say when such plants and their insect dependents with them may become important. But suppose one-half of the existing species of myriapods, arachnids, and true insects were of recognized economic importance, an account of them, together with an adequate discussion of remedies, would require 3,500 or 4,000 volumes of text.

I am sometimes asked to recommend a volume containing accounts of all the insects. If the 25,000 and more known species from North America were described and the life history of each recorded it would fill not less than 150 volumes; and I have been compelled to refer my friends to such imperfect single volumes as we have, explaining, in apology, that our entomological literature is scattered at present in numerous serials and in volumes relating to special groups of insects, and that no single volume contains more than a small fraction of acquired entomological lore.

And here I may be allowed to say a few words with reference to our special literature. It contains much useful material, some of it representing as good work as is done by any class of naturalists. In six of the best known American publications—the Canadian Entomologist, Entomological News, Psyche, Transactions of the American Entomological Society, Journal of the New York Entomological Society, and Proceedings of the Entomological Society of Washington—over 1,500 pages of matter, largely relating to life histories and descriptions of species, have already been published this year (1905). About as many more pages have been published by our fellow-workers of the British Islands, and the entomologists of France, The Netherlands, Scandinavia, Germany, Russia, and other European countries have contributed numerous others. Even little Japan now publishes at least one creditable entomological journal. Including all nationalities, it seems safe to estimate the number of pages on species and life histories at 8,500. Probably one-half of this published matter is of immediate value as economic entomology, and perhaps 4,000 pages more should be added to this as the output of entomologists engaged on the more strictly practical side of entomology. Say, then, 8,000 pages represents the average annual product relating evidently to practical entomology, and you have 16 volumes published each year on our specialty. Unfortunately, a good deal of this—too much of it—is repetition by compilation. Judging by the publications of our own country, about one-fourth of the matter relating to strictly economic entomology is repetition, being either compilation or repeated observation. At the present time both compilation and repetition of work are valuable and necessary. The official practical entomologist is compelled to do this work for the audience for which he is employed to write. But he should not permit this pressure to divert his attention entirely from research. The true naturalist is never so happy as when pushing into the unknown territory of his domain. His fellows should stand up for him and lend him encouragement when he finds it necessary, in order to do original work, to break away from short-sighted taskmasters. "Science is nothing if not free" applies with special pertinence to biological science. If the biologist is to become a producer he must not be made a drudge and kept constantly in harness.

OUR FACILITIES FOR PUBLICATION.

Time was when the economic entomologist was cramped for opportunity to publish the results of his studies. At present in this country his facilities are very exceptional. In the bulletins and other publications issued by our National Government the entomologists possess excellent vehicles for sending abroad anything they may wish to put before the public, and a great deal of valuable economic and other entomology comes from that quarter. The experiment station bulletins, too, are so many journals for the scattering of information of this sort, and have disseminated during the past ten years entomological information that would not without them have found the light in the next quarter century.

The workers employed at the Department of Agriculture and at the experiment stations are reaching the public through newspapers and magazines as never before, and the influence of this can be perceived by the greater interest shown in such matters by the layman wherever we meet him. No doubt some of the effect on the popular mind now to be perceived is the result of the years of work in class rooms done for many weary years by teachers of biology in the agricultural colleges, but there has arisen in the past ten years a quickened interest that can only be credited to the work of the experiment stations and of the Department of Agriculture at Washington since its reorganization.

FALSE HERALDS.

Workers along biological lines have suffered of late from the writings of people who are not scientists but get what purports to be scientific information at second hand. The misstatements they sometimes make and the sensational stories of results secured which they publish often make the real results published by the real worker appear commonplace by contrast. Professor Somebody is represented as having made a wonderful discovery, which he never claimed to have made. With the wide newspaper comment resulting from the remarkable nature of the discovery he is made to appear a very remarkable man. People of a community in which lives an honest and patient seeker for the truth look upon the latter as a failure when such brilliance is flashed in their faces, though their humble fellow-citizen investigator may be worth a dozen of the sort with the manufactured reputation. He must keep his temper, however, since his word, though worth its weight in gold, will not be received until the sensational claims for the so-called discovery are exploded in publications as sensational, or more so, than those announcing the discovery. Economic entomology has not suffered as much in this way as have some related lines of investigation, and it is fortunate that it is so, since the correction of these wild stories costs energy and time that can be better occupied. Such stories are to be discouraged by every means in our power, since their final effect is to destroy confidence of the public in the results of our labors. To take from the average man his belief in a thing having a touch of the wonderful about it and which, therefore, he really likes to believe, always places real results along the same line under his suspicion thereafter.

OUR OPPORTUNITIES FOR INVESTIGATION ARE EXCEPTIONAL.

With increased facilities for publication we have had a very satisfactory improvement of late in the opportunities for experiment and observation along the lines of our favorite study. If we wish to observe the diseases of young trees, the general interest of nurserymen, stimulated by the demand for healthy stock which has been encouraged by State inspection laws, helps such observations along instead of discouraging them, as was sometimes done formerly from shortsightedness and selfish motives. If we wish to test the effect of treatment of any kind we have our experiment farms, where we can arrange carefully planned experiments with the knowledge that our results will not be lost to us by the carelessness or incompetence of others, as sometimes happens when one attempts experiments on premises not under his control. Most of us have some funds at our disposal for the purchase of tools, books, equipment for laboratories, insectaries, and the like, so that we can at this opening up of a new year felicitate ourselves on the enjoyment of privileges not possessed by naturalists at any other period of the world's history. I wish it could be said also that the salaries paid us were commensurate with the labor performed and the self-denial that must be exercised by anyone who devotes his life to such work. It is not a money-making profession, and at the end of his working days the official entomologist is left on the world to make shift as best he can on the pittance he and his family have been able to save by skimping themselves. The man who spends the best part of his life in honorable service of this sort ought to be able to retire, when his capacity for good work begins to wane, decently, at peace with the world, and with his self-respect unimpaired. He can not do this on a pension. He should be paid a reasonably liberal salary while he is working at the top of his bent for the public good. I have had this feature of the provisions made for our work somewhat forcibly brought home to me recently by a very severe attack of fever, during which there was a good chance of my earthly labors closing abruptly.

Neither scientists nor teachers receive adequate pay in this country, for their services to the public. Artisans, farmers, tradesmen, physicians, and lawyers are all in a better position as to remuneration.

THE TEACHING OF ENTOMOLOGY IN AGRICULTURAL COLLEGES.

The value of a study of entomology either as training or for the purpose of acquiring knowledge of practical value is far too generally underrated in what may be called our government schools of science. The influence of educational tradition is still mighty throughout the land. In spite of the teachings of the great minds of all periods—of Socrates, Aristotle, Bacon, Comenius, John Locke, Huxley, and Herbert Spencer—the pedagogy in many of our colleges and high schools is not considered well founded unless based on the study of languages, of which Greek and Latin are those of chief importance. This persistent fallacy and prejudice often leads to a crowding out of instruction of much greater value as knowledge, and of equal or superior value as a means of training the mind. Why the study of the two languages named should train the mind better than a study of German and French or English has never been satisfactorily explained by advocates of the classical education. To my mind it has just one advantage, namely, the excellent text-books that have been developed in the long time during which these dead languages have been taught, and the large numbers of well-grounded teachers available. They can be found in most good high schools and colleges, whereas first-class teachers of modern languages are much less common; in fact, skilled teachers in these languages have always seemed to me to be rather rare in our public schools. But if the study of modern languages gives the same kind of training, and in addition opens up a world of useful knowledge bearing on problems of vital concern to us and not to be secured from Greek or Latin, why should anyone hesitate a moment in choosing courses in which modern languages instead of ancient languages are made the foundation of an education? I am speaking here for a reading knowledge of modern languages and with the good of biological instruction in mind.

The languages of such men as Oken, H. and Fritz Müller, Sprengel, Heer, Leydig, Weismann, Koch, Schioedte, Ratzeburg, Metschnikoff, Schiner, and Latzel, and of Reaumur, Morren, Lyonet, Lamarck, Cuvier, Viallanes, Signoret, and Pasteur contain more than half of what is new in the science of the times. And what information can the biologist extract from Greek or Latin? Excepting the writings of Aristotle, there is nothing in either language worth a month's study to acquire. They are most excellent training for the memorizing faculty. This must not be denied. But so is German, French, and entomology. "But," some of our friends have argued, "the study of ancient languages furnishes a culture that is not supplied by nature studies." I have known some excellent Hellenists whose culture was obscured by a disposition to tell vulgar stories, and I am told by others that they have observed this trait in Greek scholars. Perhaps we should expect nothing else from the study of the great epics whose scenes revolve about a Trojan dandy who ran away with another man's wife, and the incredibly bloody exploits of the mythical Greek hero Achilles.

I must beg leave to differ, also, as to the accuracy of the thinking developed by this sort of study. In a Greek history used as a text-book in a high school known to me, and in which no provision is made for the study of modern languages, the "Homeric question" is stated, and after remarking that there are differences between the Iliad and the Odyssey which suggest a different author for each, and that some authorities believe both to be collections of lays written by a number of bards, the author concludes: "It certainly seems more reasonable to believe in one Homer than in many," which to an entomologist seems a very lame and indefinite conclusion. The very location of ancient Troy is unknown. Even Schliemann's admirable investigations leave the matter unsettled. Of the remains of the nine cities unearthed by him on the Hissarlik Hill in Asia Minor, he believed the second to be the Troy of the Iliad, but Dörpfeld, his colleague, asserts that the sixth city is Troy. Perhaps neither is right. Looking over the evidence, a naturalist is satisfied of only one thing, namely, that this series of cities, one above another, provides a very good confirmation of the views held by archæologists, from facts learned in other ways, as to the stages in the progress of mankind toward civilization.

It may seem that I am going too far outside my theme in thus calling attention to the uncertainty in the facts and vagueness in conclusions drawn from Greek history, but the difficulty urged by those who have public schools in charge when they are asked to make room for biological or other related instruction is lack of time in the course. At the same time, it may be, instruction in Latin and in Greek history is given. I know one such case. Undoubtedly too many things are taught in our public schools, a condition leading to lack of thoroughness in everything. But it does not seem reasonable to exclude in favor of an ancient language subjects which would contribute immediately to the success of scholars when they went out into this modern world of science.

I have already mentioned the claims sometimes made for the superior culture afforded by ancient languages as compared with nature study. Quite frequently it is added that the study of nature leads to irreligion, that study of science tends toward materialism. To this we all dissent. But perhaps this dissent has never been better expressed than by Herbert Spencer in the following:

> Suppose a writer were daily saluted with praises couched in superlative language. Suppose the wisdom, the grandeur, the beauty of his works were the constant topics of eulogies addressed to him. Suppose those who unceasingly uttered these eulogies on his works were content with looking at the outside of them and had never opened them, much less tried to understand them. What value should we put upon their praises? What should we think of their sincerity? Yet, comparing small things to great, such is the conduct of mankind in general with reference to the universe and its cause. Nay; it is worse. Not only do they pass by, without study, these things which they daily proclaim to be so wonderful; but very frequently they condemn as mere triflers those who show any active interest in these marvels. We repeat, then, that not science, but the neglect of science is irreligious. Devotion to science is a tacit worship—a tacit recognition of worth in the things studied; and by implication in their cause. It is not a mere lip homage, but a homage expressed in actions—not a mere professed respect, but a respect proved by the sacrifice of time, thought, and labor.

The study of entomology and kindred science furnishes knowledge of the greatest value. When pursued with sincerity its effect is refining. It is a culture study. Its tendency is not toward irreligion.

THE STUDY OF ENTOMOLOGY AS MENTAL DISCIPLINE.

As a training of the mind entomology is superior to the study of any language whatsoever. The man who has mastered LeConte and Horn's Classification of the Coleoptera of North America so as to use it readily and with accurate results has had a training in minute and exact observation, in comparison and in judgment, that very few studies will give. Every great mind that has occupied itself with methods in education has insisted on the supreme importance of the study of objects, of nature, as a foundation for all other studies—upon the natural process of dealing first with objects, then comparing them with other objects, and thus finally acquiring general truths. Observation, comparison, reflection are the mental processes that lead to real knowledge and to the advancement of learning. We may learn lack of respect for authorities by going back to the soil for premises for our thinking. So much the better. Authorities differ, as we have seen in the references to the authorship of the Iliad and the Odyssey and to the location of ancient Troy. Show me a man who by training or otherwise has acquired the habit of thinking for himself, basing conclusions upon his own observation as largely as possible, and I will show you an effective man in any of the relations in which men are placed. Show me a man whose observational and reflective faculties have been blunted by a prolonged course of study of authorities as they appear in books, and the chances are that you will show me at the same time a man of vacillating judgment, unable to deal effectively with everyday affairs.

The study of entomology teaches the inductive method of thinking which has made this century notable. The material for use in its study is readily and cheaply obtained in large quantity. No other branch of biology is so completely available for purposes of instruction except botany, and I hold that it should have a place beside botany in every science school. As a corrective to the undue leaning upon authority inculcated by purely literary studies, it should have a good effect on students taking language courses.

THE TEACHING OF ENTOMOLOGY.

But entomology must be well and thoroughly taught. And herein lies the greatest difficulty in getting for it the recognition which is its due as an agent for education. Our boards of trustees often select teachers upon the assumption that anyone can teach any subject, with a little preliminary coaching, or else go to the opposite extreme and demand a man of exceptional special learning, forgetting that teachers, like poets, are most often born, and if not born, must be made by careful training. No man is fit to teach entomology or any other subject who has no knowledge of modern educational methods and no good conception of the principles and purposes which underlie them as a means of training the mind to its greatest effectiveness. One may be a learned entomologist and be utterly unfit to teach. But the teacher must at least know his subject so well that he can take his pupils straight to nature. This is vital. The man or woman who is dependent on a text-book has no business occupying a position as a teacher of entomology.

We have not enough well-equipped teachers of entomology in our agricultural colleges at present. Nothing is so much needed to pave the way for the experiment-station worker. Until a larger proportion of our farmers have had a taste of the scientific method in the course of their education a great deal of value being done for them will not be grasped and made of use. And let me say again, in leaving this subject, that the training in entomology must be thorough, even if to accomplish this it is necessary to confine attention to a single insect. A nucleus of exact knowledge will later attract about it other knowledge of the same and different sorts, and thorough training, though brief, will greatly help to this end.

ENTOMOLOGY AND HUMAN DISEASES.

I come now to a consideration of a feature of our subject that has only recently assumed prominence. The relation of insects to diseases is a very interesting and important one, and one to which entomologists should devote more attention. Some excellent work relating to species and life histories has recently been published, but I would be glad to claim for my fellow-workers more of the credit for the discovery of the relation borne by mosquitoes to yellow fever and other diseases. No investigator is better equipped than the entomologist for such investigation. There is opportunity yet for valuable work in this field, and entomologists should at least cultivate all the territory on their side of the line dividing entomology from medicine. It should not be said of us that men who have had no training in our specialty must come over into our domain and collect for themselves entomological information which we have neglected. This is economic entomology, if ever there was any, and we should demonstrate that we are able to furnish to the world all the facts along the line that may be required. In teaching the subject, too, this relation of insects must receive due attention.

The fact recently demonstrated, that the mosquito *Stegomyia fasciata* Fab. [*calopus* Meig.] conveys yellow fever, and that therefore the disease can only occur as an epidemic within the limits of the distribution of this insect, is one of the most important made known by the study of epidemic diseases in recent years. This mosquito is known to occur throughout the world between the latitudes 39° north and about 37° or 38° south. In this connection it may be remarked that the yellow-fever mosquito occurs throughout most of Kentucky, and that yellow-fever cases originated in Louisville in 1878 to the number of 20. I am informed by the city health officer that the seven cases treated at the Lexington hospital during the fall of 1905 were all refugees from Louisiana. The facts now known with reference to this insect and its relation to yellow fever show in a very lucid way the reason for the delving for seemingly unrelated knowledge practiced by many entomologists. Herein is the justification of the devotee of pure science. The facts unearthed by him concerning the structure of the beak or stomach of a mosquito, without a thought beyond adding this knowledge to the common stock, may prove, when all is known, to have a very important bearing on the welfare of human kind.

The relation of flies to cholera has been studied now with sufficient care to warrant the belief that these insects are important agents, if not the chief ones, by which this dread malady spreads. Uffelman's experiment in which he obtained 10,500 colonies of the cholera Spirillum from a fly confined with a culture of the organism, and Macrae's tests of boiled milk exposed to flies in a jail at Gaya, India, where cholera was present, are convincing to most minds as to the pernicious part these insects take during cholera outbreaks.

Flies are accused also of conveying tuberculosis by carrying *Bacillus tuberculosis* from sputum to milk and other foods. At any rate the bacilli have been found both in their excreta taken from walls and in their alimentary canals.

The part taken by fleas and other insects in conveying leprosy is another subject well worthy of investigation by entomologists favorably situated for the purpose.

The spotted fever of Montana, known to be due to an organism named by Doctors Wilson and Chowning *Pyrosoma hominis*, should have attention from the entomological standpoint, since this organism is of the same nature as those causing malarial troubles, and this points to an intermediate host, in all probability an insect or a tick.

The relation between malaria and *Anopheles maculipennis* Meig. is now very well established, but there are other related species and genera, such as *Myzomyia funesta* Giles and *Pyretophorus costalis* Loew of West Africa, known to carry the disease also, and it is not at all improbable that still other insect agents may yet be discovered in the United States or some of its possessions. Here, in these latter especially, is an opportunity for the study of insects having to do with disease that has never received the attention it deserves.

Quite a good many other diseases are believed to be carried by insects, but the instances given serve my purpose of pointing to the work to be done.

A great field for original work lies also in the study of insects having to do with ailments of stock. We know much of the part taken by *Boophilus annulatus* Say in conveying Texas fever. But there are many things yet to be learned about the tick, and still more to be made known concerning the life histories and habits of the various insects associated in one way or another with domestic animals, and very probably in some cases concerned with their diseases. We are accustomed to leave this part of our territory to be tilled by veterinarians, but in doing so are making them a gift of a valuable part of our possessions.

INSECTS AND PLANT DISEASES.

In the study of the relations of insects with the diseases of plants we have never shown the interest that this subject deserves from its very great importance. That insects convey such diseases as pear blight is now very well established, but I have been impressed more than once in the course of a study of the habits of an insect with the fact that their injuries were not by any means limited to the direct destruction of the tissues of plants. Dr. Erwin F. Smith, of the Department of Agriculture, has called attention to the inoculation of plants of the cucumber family with the virus of a blight carried in the mouth-parts of insects. Undoubtedly the spores of the rots of fruits and of the canker of bark are often conveyed by insects in this manner, and in the case of peaches and some varieties of plums this has seemed to me to be the chief source of infection. All of these matters need more study and experiment. They constitute one of the most inviting fields known to me for the labors of the entomologist who has some knowledge of bacteriological technique.

INSECTS AND FLOWERS.

Another field for investigation, lying in the border land between entomology and botany, has received but little attention in this country and should soon be occupied by our economic entomologists. Excepting the painstaking work done by Charles Robertson, accounts of which have appeared in botanical journals, and that of the late C. V. Riley on the fertilization of *Yucca filamentosa*, we have little in the way of published observations on the relations of insects and flowers. The subject is one of vast importance from the standpoint of agriculture, and in this period of activity in all problems having to do with heredity and breeding entomologists should more generally take an interest in the subject and throw upon it what light is to be derived by investigations made from the entomological point of view. We have left this matter thus far too largely to botanists, and while they have done well with it, no doubt with our different training and knowledge we could, with a little study, add many facts which escape their observation. Riley's work on the pollination of Yucca is but an earnest of the interesting things that fresh study in this field would very probably bring to light.

APICULTURE.

In the honey bee we have an insect more completely at our disposal than any other. It is a domestic animal, and was such even in the days of ancient Greece. We have no insect that has been given so much care, thought, and observation, and we have learned the facts concerning its habits and life history better than we have learned those of any other insect. I venture to say, further, that no other domestic animal is equal to it in interest from a scientific point of view. It is courageous, industrious, cleanly—qualities that we are accustomed to regard as the possession of the best of mankind. In its provision for the future, its laying up stores against days of scarcity, its careful closure of all crannies in its quarters that may admit cold air and allow the escape of heat, and in the care for its young and for the mother of its colony, it affords a lesson in civic virtue furnished by but few, if any, of the so-called higher animals.

It has always seemed strange to me that the honey bee is not more generally employed by teachers of entomology in the illustration of the ways and structures of insects. With the movable-frame hive it is very easy to present to a class all the stages of the bee and all the remarkable facts concerning its housekeeping. It seems to me that the instructors who have a knowledge of this insect and know how to handle it have an invaluable source of illustrative material, furnishing all the essential facts of insect structure, transformation, habit, and relations to nature at any season of the year. Why, then, do our instructors so often ignore this excellent material for practical work and fail to draw upon the wealth of accurate information published concerning the habits of bees? It is the most valuable body of knowledge relating to one insect that is available for the illustration of the fundamental truths of their subject. They can not afford to neglect it, although they sometimes do so, much to the detriment of their teaching in entomology, I must believe. What I have just said has no reference to the utility of the honey bee to mankind at large. The honey crop of California and some other States is a valuable one, and it may be doubted whether the demand for good honey at a reasonable price was ever fully supplied in the eastern United States. The subject of apiculture ought on this account to be given attention in every agricultural or entomological course. Every farmer should be taught how to supply at least his own family with honey. Bee keeping is not practiced as generally as it should be on the farm. But to the teacher of entomology I regard a theoretical and practical knowledge of apiculture as of the greatest value. I am disposed to think that most teachers who refrain from acquiring a practical acquaintance with bees are deterred by a fear of the stings. It has been often said before by expert bee keepers, but I think has not so often been said to teachers, that the danger is not at all serious. An old bee-keeping acquaintance once remarked that bees always sting a fool and a coward, and I have sometimes observed myself that when persons of a certain character come near when I am handling a colony they are likely to be sent off at a gallop. Any man or woman of intelligence and reasonably steady nerves, with a few appliances, such as a smoker and veil to start with, can open up and take out the frames filled with brood, or honey, and covered with bees, from a hive of Italians or Carniolans with complete safety, and once accustomed to it will often dispense with both veil and smoker. Try it. It is an important part of the outfit of the entomological instructor, and the experiment-station man who has occasion to discourse before farmers' institutes will find it sometimes very useful in helping out a programme. It is astonishing how little is known by a large proportion of farmers about keeping bees properly. Excellent books on the subject are obtainable. Good special journals may be secured for a trifle. Special columns in agricultural papers are devoted to the subject, and in spite of it all one finds many farmers still keeping bees in box hives and unfamiliar with simple facts in the economy of a colony that have been repeated in one way or another again and again for more than two hundred years. It is for the station entomologist and teacher to remedy this state of affairs. But he will make little impression until after he has acquired such a practical acquaintance with apiculture that he can go through a hive, take out a queen and clip her wings, cut out unnecessary queen and drone cells, hive a swarm deftly, feed his colonies when necessary in fall and spring without permitting robbing, winter them successfully, and produce enough good honey to pay all expenses and leave a small surplus. When he can do all these things he can hold his own with the hard-headed ones who still believe the box hive better than any other and regard the old-style black bee as the greatest honey gatherer and hardiest bee known.

SERICULTURE.

It is too soon to make very positive statements about the outcome of the project set on foot at Tallulah Lodge, Ga., having for its object the establishment of silk growing in the United States. Such attempts have been made before and have failed. The chief reason for these failures is believed to be the small wages earned by those who rear the worms, in proportion to the time required. Our people, it has been said, can earn more at other employments. It seems probable, however, that this is not the sole or even the main cause for the failure thus far to establish silkworm rearing as an industry in the United States. People are prone to do what the majority of those about them do. There is a fashion in these things as in wearing apparel, and when most of one's friends and neighbors are enthusiastic in the growing of cotton, oranges, corn, or rice, it is natural that the interest in such things should pervade and dominate every member of a community. It requires time and persistence, under such conditions, to gain favor for other pursuits, and I apprehend that it is this preoccupation of the American mind with other businesses, as much as anything else, that has hindered the development of silk growing in this country. Inertia in human affairs is the rock upon which more than one commendable enterprise has gone to pieces.

Let us hope that this will not be the fate of the silk-growing enterprise at Tallulah Lodge.

On a tract of 3,500 acres of land bordering the Tugalo River, Georgia, Mr. Louis Magid has planted large numbers of the white mulberry and has, since 1902, been actively engaged in teaching orally and by the press the essential facts in the rearing of silkworms. His journal, "Silk," has greatly helped in arousing an interest among entomologists and others scattered over the country beyond the immediate influence of his practical operations and personal influence. The prospect seems good for a successful launching of the industry this time, and entomologists should aid him to the extent of getting material, and teaching at the State colleges the life history and best methods of rearing the silkworm. Of the thousands of insect species in existence, the silkworm and honeybee are the only ones thus far appropriated by man as his servants. A thorough practical knowledge of both should be a part of the equipment of every professional entomologist.

It is asserted on the best of authority that our climate and soils are perfectly adapted to the silkworm and its food plant. From my own knowledge, I can say that it is easily reared in any part of the United States in which I have seen it tested. The silk produced here is believed to be not inferior to that produced anywhere else in the world. The rapid development of silk manufacturing in this country, and the large quantities of raw silk that must be imported to keep our factories occupied, is another incentive to those endeavoring to set on foot the production of the raw silk. Among foreign countries, France only is said to manufacture more silk fabrics than this country. Fifty silk mills are reported to have been established in seven States of the Union in 1903 alone. Statistics gathered show that we pay annually something like $100,000,000 to foreign countries for raw and manufactured silks. It would, we may suppose, add very materially to our prosperity if silk raising could be developed to such an extent as to keep most of this money at home.

NURSERY AND ORCHARD INSPECTION.

I come now to a feature of the work of the official economic entomologist that has during the past ten years attracted more attention than any other. Nursery inspection has become one of the most exacting if not one of the most important departments of his work. It has brought him into relation with the machinery of his State government and required of him in this relation duties and a kind of mental activity quite foreign to that of the student and scientist. Some of these duties are not pleasant to one of his training and usual character, but the work required has had its value to the people, whether it has been best for the entomologist or not. I suppose no real naturalist with such work in his hands but has at times been led to ponder the question as to whether in this inspection work he was not going too far aside from the investigations in which he is chiefly interested and which by training and disposition he is better fitted than anyone else to prosecute. Can not this purely practical work be done by a class of men who are by nature satisfied with it as an occupation? Experience has, I think, shown that it can not be, in a satisfactory manner, without the help, by supervision or otherwise, of the scientific worker; and I think it is always to be regretted when such work falls into the hands of those who have no interest in it beyond the salaries to be obtained. It seems to me that this organization should take a stand for inspection by the entomological expert, since otherwise the issuing of certificates becomes a farce that will ultimately prove a discredit to the craft. There are many things about this line of work that I should like to dwell upon—the merits and defects of our State laws, the desirability for greater uniformity in such laws, the importance of having a national law providing for such inspection as can not well be carried on by the States, the kinds of insects whose presence should be regarded as of sufficient importance to condemn stock, the desirability of providing for both insect and fungous troubles under one inspection, and, especially, methods of treating condemned stock. Each one of these topics might well afford a programme for an entire meeting of the Association. I am impelled, however, to add a few words concerning fumigation as a means of ridding stock of scale insects. From purely theoretical considerations it was, at the outset of our inspection experience, regarded as a sort of panacea for scale and most other insects. More experience has shown this to be only generally true. There are insects that survive exposure to any of the charges of gas that are commonly recommended by inspectors. What shall we do for them? The nurseryman does not like to apply anything to his trees that sticks and thus tells a story to those who may buy treated trees. The inspector, on the other hand, if he be conscientious and honest, does not wish to certify such stock when merely fumigated. Still another serious difficulty arises under laws requiring fumigation of all nursery stock. Plants vary widely, I find, in their susceptibility to injury from hydrocyanic-acid gas of the strength commonly prescribed, and nurserymen rightfully complain of loss inflicted on them from this source, by the killing and severe injuring of perfectly healthy stock of certain kinds. I must say, as an inspector, that I do not approve of some of the laws enacted, because of the hardships of this sort resulting from them, and also because of the restrictions they place upon a free and unhampered competition between dealers in nursery stock in all parts of our country. A greater uniformity in inspection laws seems to me necessary if we are to retain the support and confidence of those whom inspections more immediately concern.

OTHER WORK.

There are other special developments of our subject upon which one might dwell. We have all been deeply interested in the work being pushed by the cotton-growing States and the Department of Agriculture at Washington with a view to learning how the injuries of the cotton boll weevil may be controlled. Already these investigations have furnished valuable hints in this direction, and we are led to hope and believe that this scourge of the cotton fields will soon be reduced in numbers and destructiveness by measures resulting from the work now in progress.

CONCLUSION.

In concluding let me say briefly what I consider the important work for the economic entomologist in the near future. In the first place, we must have more capable, enthusiastic, trained teachers of our subject, and the entomologist who is now engaged in such work as a mere makeshift should be made to give place to the teacher who feels the importance of his mission as an educator and is willing to expend labor and thought on his work.

Our nursery inspection laws should be perfected and made more nearly uniform, and a precise method of procedure should be planned for such inspections, subject always to such changes as local conditions may demand.

More attention should be given to the insects concerned with disease, and to their relation to flowers as agents in cross pollenization. Apiculture and sericulture should be cultivated, both because of their instructional value and for their importance in the arts.

The recent progress made in our field of endeavor is most gratifying. We are living in a period of the highest activity and most productive study in the investigation of living things, and may expect soon to see results of knowledge and skill in dealing with such subjects such as have never before been brought together for our benefit. We must not neglect or underrate our opportunities. When it is all done and our time becomes a matter of ancient history, I trust that the part taken by entomologists in contributing to the wealth and learning and culture in this "age of science" may be pointed to by our descendants with gratitude and respect.

At the conclusion of the president's address the secretary was ordered to extend the thanks of the association to President Garman for his interesting and valuable address, and to send to him greetings of the season and best wishes for his speedy recovery.

Mr. Newell stated that in his opinion entomologists, with but few exceptions, had neglected giving the attention and study to insect problems affecting the public health that the importance of the subject justified. Entomologists have laid great stress upon the importance of their work in combating insects injurious to crops and fruits, and have made many estimates, showing, in dollars and cents, the amount of damage done, yet the public health and human life is of far more importance than the prevention of mere financial loss. The control of yellow fever and of malaria is an entomological problem entirely, yet it has been largely in the hands of physicians; and the medical fraternity, because of the impossibility of obtaining from the entomologists adequate knowledge regarding the life histories of insects instrumental in spreading disease, have themselves been forced to take up entomological and life-history work. The insect problems which are intimately connected with the dissemination of diseases, both of human beings and of live stock, are certainly of sufficient importance to warrant much more attention being paid them by the entomologists. The latter should be able to anticipate, in a measure, the entomological knowledge that is likely to be needed by physicians and should, by study and investigation, prepare themselves to furnish this information when it is needed—oftentimes in dire emergencies, when there is no leisure for investigation and life-history work.

Mr. Britton said that physicians often appear loath to ask information of entomologists. There ought to be an effort made on both sides, however, to get together and work in harmony. It is an important fact that yellow fever may occur in other places than the natural habitats of Stegomyia. In the year 1794, 160 cases occurred in and about New Haven, Conn. It is probable that these originated from mosquitoes brought on a ship from the West Indies. How far north does the Stegomyia occur in the Mississippi Valley?

Mr. Hunter answered that Stegomyia has been found in St. Louis.

At the conclusion of the discussion on the president's address, the report of the secretary-treasurer was read and approved.

An assessment of $1 was levied on the members present.

Mr. Herbert Osborn, chairman of the committee on nomenclature, presented the following report:

REPORT OF COMMITTEE ON NOMENCLATURE.

At the last annual meeting of the association your committee presented a list of names for adoption as recommended for exclusive use and also a second list for consideration during the year. The secretary distributed them to all members and the first list was also sent to some two hundred agricultural journals and periodicals with the request of the society that these names be used in these publications. With a few exceptions, the names so adopted seem to have been used by all official entomologists, and it is sincerely hoped that the practice may become universal, as it is firmly believed that a uniform practice in the use of the common names of insects will not only favor the distribution of accurate information about insects, but will serve a most useful purpose in the education of the public regarding a subject which appears to them beset with much difficulty. The cordial responses from members is much appreciated by the committee, and it desires simply to state that in a subject where such wide diversity has existed some concessions will be found necessary, and it is hoped that a general agreement on a considerable list of names will eventually lead to a much more universal agreement.

From the list submitted for consideration during the past year we are now able to select about forty which have been approved by all who have taken the trouble to return their lists with sanction or objections. This list is submitted for the consideration of the Association at this session along with a second list which embraces names quite generally but not universally approved. A general response would help the committee to a more certain conclusion. The lists returned this year were but eighteen in number, but geographically covered the territory from New Hampshire to Hawaii. If we assume that those not answering had no serious objections to the names listed, we may conclude that for quite an extended list we will be able soon to secure general adoption and uniform practice by such a body of entomologists as will make uniformity an assured fact.

Perhaps the greatest diversity now occurs in the matter of hyphenating compound names, and while lack of uniformity in this is certainly much less serious than the use of totally different names, it seems as if some general principle might be adopted which, barring the persistence of printers and proof readers, might secure some degree of uniformity. The greatest number of corrections on the present list consisted in the insertion or the elimination of hyphens, and many entomologists of high repute insisted on exactly opposite practice in a considerable list of names. The committee feels that this matter may be left to the individual taste or to the etymological rule in practice in different printing establishments without sacrificing the main principle for which it is working, but will be pleased to have instruction or expression of opinion from the Association on this point. Some have urged that the committee take up the question of scientific names with the hope that some more uniform and settled practice may result. Doubtless this will follow, but we feel that for this year at least we should concentrate effort on the common names.

We present herewith a list for final adoption and one for further consideration. Unless a name is very generally agreed to, it had better be put on the preferred list and only given final adoption on the exclusive list when general agreement is reached.

The list for further discussion is not to be published, but circulated among members privately. The list printed below includes the names adopted at the seventeenth annual meeting as well as those adopted at the eighteenth:

LIST OF NAMES RECOMMENDED FOR EXCLUSIVE USE.

American cockroach	*Periplaneta americana* L.
American dagger moth	*Apatela americana* Harr.
Angoumois grain-moth	*Sitotroga cerealella* Ol.
Apple-leaf skeletonizer	*Canarsia hammondi* Riley.
Apple-aphis	*Aphis pomi* L.
Apple maggot	*Rhagoletis pomonella* Walsh.
Army-worm	*Heliophila unipuncta* Haw.
Ash-gray blister-beetle	*Macrobasis unicolor* Kby.
Asiatic ladybird	*Chilocorus similis* Rossi.
Asparagus beetle	*Crioceris asparagi* L.
Bag-worm	*Thyridopteryx ephemeræformis* Haw.
Bean-weevil	*Bruchus obtectus* Say.
Bedbug	*Cimex lectularius* L.
Black blister-beetle	*Epicauta pennsylvanica* De G.
Black scale	*Saissetia oleæ* Bern.
Blood-sucking cone-nose	*Conorhinus sanguisuga* Lec.
Boll-weevil	*Anthonomus grandis* Boh.
Boll-worm	*Heliothis obsoleta* Fab.
Bronzed cutworm	*Nephelodes minians* Guen.
Brown-tail moth	*Euproctis chrysorrhœa* L.
Bud-moth	*Tmetocera ocellana* Schiff.
Buffalo tree-hopper	*Ceresa bubalus* Fab.
Cabbage aphis	*Aphis brassicæ* L.
Cabbage-maggot	*Pegomya brassicæ* Bouché.
Carpet-beetle	*Anthrenus scrophulariæ* L.
Carpet-moth	*Trichophaga tapetzella* L.
Cattle-tick	*Boophilus annulatus* Say.
Cecropia-moth	*Samia cecropia* L.
Cheese skipper	*Piophila casei* L.
Chestnut weevil	*Balaninus rectus* Say.
Chinch-bug	*Blissus leucopterus* Say.
Clover-hay worm	*Hypsopygia costalis* Fab.
Clover-root borer	*Hylastinus obscurus* Marsham.
Clover-stem borer	*Languria mozardi* Latr.
Codling-moth	*Carpocapsa pomonella* L.
Colorado potato-beetle	*Leptinotarsa decemlineata* Say.
Corn root aphis	*Aphis maidi-radicis* Forbes.
Cotton-stainer	*Dysdercus suturellus* H.-Schf.
Cottony maple-scale	*Pulvinaria innumerabilis* Rathv.
Cottony cushion-scale	*Icerya purchasi* Mask.
Dingy cutworm	*Feltia subgothica* Haw.
Elm-borer	*Saperda tridentata* Ol.
Fall canker-worm	*Alsophila pometaria* Harr.
Fall web-worm	*Hyphantria cunea* Dru.
Glassy cutworm	*Hadena devastatrix* Brace.
Granary-weevil	*Calandra granaria* L.
Grape leaf-folder	*Desmia funeralis* Hbn.
Grape flea-beetle	*Haltica chalybea* Ill.
Grape-phylloxera	*Phylloxera vastatrix* Planch.
Gypsy-moth	*Porthetria dispar* L.
Harlequin cabbage-bug	*Murgantia histrionica* Hahn.
Hessian-fly	*Mayetiola destructor* Say.

Hickory borer	*Cyllene picta* Dru.
Honey-bee	*Apis mellifera* L.
Hop-aphis	*Phorodon humuli* Schrank.
Horn-fly	*Hæmatobia serrata* R.-D.
Horse bot-fly	*Gastrophilus equi* L.
House-fly	*Musca domestica* L.
Indian-meal moth	*Plodia interpunctella* Hbn.
Larder-beetle	*Dermestes lardarius* L.
Leopard-moth	*Zeuzera pyrina* L.
Margined blister-beetle	*Epicauta marginata* Fab.
Mediterranean flour moth	*Ephestia kuehniella* Zell.
Onion thrips	*Thrips tabaci* Lind.
Oyster-shell scale	*Lepidosaphes ulmi* L.
Pale-striped flea-beetle	*Systena blanda* Melsh.
Palmer-worm	*Ypsolophus ligulellus* Hbn.
Peach-borer	*Sanninoidea exitiosa* Say.
Peach-scale	*Eulecanium persicæ* Fab.
Pear psylla	*Psylla pyri* L.
Pear-slug	*Eriocampoides limacina* Retz.
Pea-weevil	*Bruchus pisorum* L.
Pigeon-tremex	*Tremex columba* L.
Pistol case-bearer	*Coleophora malivorella* Riley.
Plum-curculio	*Conotrachelus nenuphar* Hbst.
Plum-gouger	*Anthonomus scutellaris* Lec.
Potato stalk-borer	*Trichobaris trinotata* Say.
Putnam's scale	*Aspidiotus ancylus* Putn.
Rice-weevil	*Calandra oryza* L.
Red-legged locust	*Melanoplus femur-rubrum* De G.
Rose-chafer	*Macrodactylus subspinosus* Fab.
Rose scale	*Aulacaspis rosae* Bouché.
Saddle-back caterpillar	*Sibine stimulea* Clem.
San Jose scale	*Aspidiotus perniciosus* Comst.
Screw-worm	*Chrysomyia macellaria* Fab.
Scurfy scale	*Chionaspis furfura* Fitch.
Silkworm	*Bombyx mori* L.
Spring canker-worm	*Paleacrita vernata* Peck.
Squash-bug	*Anasa tristis* De G.
Squash borer	*Melittia satyriniformis* Hbn.
Stalk borer	*Papaipema nitela* Guen.
Strawberry crown-borer	*Tyloderma fragariæ* Riley.
Strawberry leaf-roller	*Ancylis comptana* Fröhl.
Striped blister-beetle	*Epicauta vittata* Fab.
Tarnished plant-bug	*Lygus pratensis* L.
Tomato-worm	*Phlegethontius sexta* Joh.
Walnut case-bearer	*Mineola juglandis* Le B.
Walnut-sphinx	*Cressonia juglandis* S. & A.
Wheat-head army-worm	*Heliophila albilinea* Hbn.
Wheat midge	*Contarinia tritici* Kby.
Yucca-moth	*Pronuba yuccasella* Riley.
Zebra-caterpillar	*Mamestra picta* Harr.

NOTE.—The hyphenization in this list differs radically from that in use in the Bureau of Entomology.—ED.

The report of the committee was on motion adopted, and the secretary was instructed to have the approved list of names printed and distributed to members. The report of the committee on cooperative testing of insecticides was presented by Mr. Burgess.

REPORT OF COMMITTEE ON COOPERATIVE TESTING OF INSECTICIDES.

Your committee, appointed at the last meeting of this Association to consider the question of cooperation in testing proprietary insecticides, respectfully submits the following:

It seemed best to the committee as their first step to ascertain how general a desire existed for cooperation in the testing of insecticides. They therefore prepared a circular letter of inquiry on the subject, which was sent to more than fifty persons engaged in economic work in this country. Unfortunately, however, circumstances prevented a prompt sending of this letter, and as a consequence the answers are still coming in, and it has not been possible for the committee to go over them and formulate any plan to present at this time. It may be remarked that the answers show about as many different ideas on the subject as there were answers, a condition which will necessitate much more consideration by the committee than would be needed if they were more in agreement. Your committee can, therefore, only make this statement now and ask either for an extension of time or the appointment of another committee in its place to continue the consideration of the subject.

On motion, the report was accepted and the committee continued.

Mr. Sanderson brought up the question of the method of publishing the proceedings, regretting that the present method seemed to make it necessary to cut down or eliminate certain papers from the published proceedings. He thought it feasible, if necessary, for the Association to publish its own proceedings. On motion, it was resolved that a committee on publication be appointed to make recommendations before the close of the present meeting regarding the best method of publication. The chair appointed as such committee Messrs. Sanderson, Burgess, and Hunter.

AFTERNOON SESSION, MONDAY, JANUARY 1, 1906.

The Association attended the symposium held under the auspices of Section K of the American Association for the Advancement of Science on "Yellow fever and other insect-borne diseases."

MORNING SESSION, TUESDAY, JANUARY 2, 1906.

The Association met in joint session with Section F of the American Association for the Advancement of Science. Dr. H. B. Ward, vice-president of Section F, in calling the meeting to order, said that it seemed to him that the many points of common interest to members of both the Association of Economic Entomologists and Section F were ample warrant for the holding of a joint session. He thought the plan was one that would probably be advisable to continue in the future.

The following two papers, taken from the programme of Section F, were then presented. They will be published in full elsewhere.

THE PROBLEM OF WING ORIGIN AND ITS SIGNIFICANCE IN INSECT PHYLOGENY.

By Herbert Osborn, *Columbus, Ohio.*

[To be published elsewhere.]

PRELIMINARY OBSERVATIONS ON THE VARIATIONS OF UTETHEISA VENUSTA DALMAN.

By Mel. T. Cook, *Santiago de las Vegas, Cuba.*

[Abstract.]

The literature recognizes three species (*U. bella*, *U. venusta*, and *U. ornatrix*) and three varieties (*hybrida*, *terminalis*, and *stretchii*) of this genus. These cover a very wide range. The species and varieties are separated primarily on color characters. After examining a very large number of specimens, many of which were reared in captivity, the writer concludes that the intergradations are such as to reduce these three species and three varieties to one species. The writer has also bred and reared a number of these insects, from the study of which he reaches the same conclusion as indicated above. The work will be continued.

The following paper was presented:

THE CORN ROOT-APHIS AND ITS ATTENDANT ANT.

(*Aphis maidi-radicis* Forbes and *Lasius niger* L., var. *americanus* Emery.)

By S. A. Forbes, *Urbana, Ill.*

Two great dangers threaten the perpetual prosperity of the North American corn belt; one, the gradual exhaustion of some essential element of soil fertility, and the other, the gradual increase of insects especially injurious to the corn crop. Of these two dangers the latter is, I believe, the more immediate and the more difficult to meet.

It is the more immediate, first, because the exhaustion of any ingredient of the soil is a process of subtraction merely, while the increase of insects is a process of multiplication; and, second, because farmers are generally accustomed to return to their farms, in more or less appropriate fertilizers, some part at least of the substances which they remove from them in their crops, while they are but little accustomed as yet to shape their farm management or to vary their agricultural practices in a way deliberately to avoid insect injuries.

It is the more difficult to meet because each can act for himself in respect to the fertilization of his land, uninfluenced and unharmed by the indifference or ignorance of his neighbor, while the insects bred by any farmer in a community are likely to infest the farms of all, and finally, if continuously ignored, to become generally destructive, like an epidemic of disease. This epidemic condition has, in fact, already been reached in certain considerable neighborhoods of Illinois, and no doubt in other of the corn-growing States as well; neighborhoods measured by hundreds and thousands of acres, where injuries by the corn root-aphis, the corn root-worm, and the common white-grubs have steadily increased until they bid fair to become permanent factors of the situation unless general measures are taken for their control.

The most immediately dangerous of these insects at the present time is the corn root-aphis, which has shown a destructive capacity in recent years easily understood when one knows its life history and ecology. It will be a scandal and a reproach to the American farmer and to the American entomologist if we allow to grow up under our eyes so great and permanent an enemy to corn culture as this insect is capable of becoming, and we ought to raise an earnest voice of warning, instruction, and advice while the difficulty is still local and the insect still controllable.

This aphis was first recognized in 1862 by Walsh, who reported at that time that a farmer at Rock Island, Ill., had discovered, toward the last of May, minute insects in prodigious numbers on the roots of corn in one of his fields, and that they had apparently destroyed from a half to three-quarters of the crop so far as to necessitate replanting. Walsh, visiting the field a fortnight later, obtained many wingless specimens, from which he bred 15 winged females. He noticed many small brown ants among the roots of the corn infested by the aphis, and inferred by analogy an association of the usual form between these two insect species. I first began to study this aphis in 1883, and virtually all the facts now known concerning its life history, ecology, and economic relations have been made out at my office in Illinois by myself and my various assistants.

THE LIFE HISTORY OF THE APHIS.

The life history of the corn root-aphis is in no way peculiar. All the main features of it have been repeatedly published and are doubtless sufficiently familiar to all; and I have to report under this head only some minor details made out within the last two years. A highly successful series of breedings made in my insectary by Mr. J. J. Davis, a junior student in my department, working at the time as my assistant, gives us some additional data concerning the rate of multiplication of these insects under what were evidently optimum conditions.

Most of these aphides were reared in small glass vials, each with a layer of moist cotton in the bottom and containing a young food plant. A single aphis just born was placed on each plant, the vial was wrapped with paper to exclude the light, and its mouth was closed with dry cotton. As soon as the plant began to wilt a fresh one was introduced, the aphides being carefully transferred to it by means of a camel's-hair brush. Sometimes a glass tube was placed around a food plant while growing in an earthen pot, the bottom of the tube pushed into the earth and the upper end stopped with cotton as before, the whole being darkened by a paper wrapping. That these artificial conditions were highly favorable to the corn root-aphis was shown by the fact that among several hundred specimens bred and reared in this way not a single one developed wings, although winged aphides were appearing abundantly in the insectary at the time. We have much evidence that the development of winged aphides is greatly stimulated, if not sometimes caused, by some deficiency in conditions for the maintenance of an increasing population—usually by a diminishing food supply.

By the use of these data, together with others already in my possession relating especially to the earliest generations of the year, I am able now to present a virtually complete calendar for this species of the annual succession of its generations, from the so-called stem-mother—the generation which hatches from the egg—to the egg again in fall. Beginning with the *first* to hatch in the spring, if we follow down the series of the *first born* of each generation we find that 16 successive generations may appear, counting the eggs laid in the fall as the last. If, on the other hand, we begin with the *last* to hatch from the eggs in spring and follow down the series of the *last* born of each generation, there are but 9 generations in all; from which it follows that the number of mid-born generations is 12—the mean number for the year. The average interval between successive generations of the first born is 11 days, that between the successive generations of the mid born is 16 days, and that between generations of the last born is 18½ days.

The first generation may be found in the field from April 8, our earliest date for the hatching of the eggs, to June 20, our latest date for the birth of the young of the second generation, a period of 73 days. The eighth generation—the longest lived of all, if we except the eggs—continues from July 14 to the last of October, a period of 106 days. On the 1st of May aphides of the *first two* generations may coexist in the field; on the 1st of June, those of the first three generations; on the 1st of July, 5 generations, from the second to the sixth, inclusive; on the 1st of August, 7 generations, from the fourth to the tenth inclusive; on the 1st of September, 9 generations, from the seventh to the fifteenth; and on the 1st of October, 10 generations, from the seventh to the sixteenth.

We have found eggs hatching in the nests of the small brown ant, *Lasius niger americanus*, from April 8 to May 22, a period of 44 days. Our earliest record of the occurrence of the bisexual oviparous generation in fall was September 5, and the latest births of this generation occurred on the 30th of October. A few oviparous females were still living indoors November 28. Males and females were first seen pairing September 30, and this is also the earliest date at which eggs have been found.

The oviparous generation does not correspond to any single one of the annual series, but bisexual forms may appear in any generation in existence at the time when conditions are right for their development. In our insectary work of this year sexual forms originated in September and October from representatives of 5 different generations, varying from the seventh to the eleventh of a series reared in confinement after June 22. This appearance of the sexes is evidently favored, if not actually produced, by a low temperature—a fact illustrated by the occurrence of sexual forms, September 5, 1905, when the weather was extremely cool for that time of the year, the daytime temperature of the insectary usually ranging from 60° to 66° F. We have had two instances of females whose first young were viviparous and the last oviparous. Another reproductive aberration was exhibited by a viviparous female taken in the field in the pupa stage on the 23d of June, and transferred to the insectary, where within the next few days she gave birth to 6 young previous to her final molt. She then suspended reproductive operations for a few days, molted and acquired wings, and afterwards produced 21 more young.

The number of molts is invariably four, and reproduction follows sometimes within a few hours of the last molt, and usually by the next day. In 36 instances, of which exact record was kept, the number of living young varied from 20 to 84 for each female, with an average of 41. Any one disposed to calculate the theoretical reproductive capacity of this species can easily do so from the data given—12 mean generations and a multiplication ratio of 41.

Such a calculation is, of course, worthless for any scientific end, because it involves a physical impossibility—that is, the maintenance of optimum conditions for all the progeny of a single female the whole season through. It is conceivable, however, if not believable, that optimum conditions might continue in an occasional instance for as much as three successive generation periods, and it may help us to understand the facts sometimes observed if we know that the product of reproduction for these three generations under such conditions would amount to about 66,000 descendants for each female.

The average number of young produced in our experiments by a single female in a single day was 4, and the largest number was 12. The time elapsing from the birth of the female to the birth of her first young varies from 21 days in early spring to 6 days in August. For a series of 10 generations, beginning June 23 and ending with the appearance of the sexual oviparous generation in fall, the average age of the female at the birth of her first young was 7.8 days, at the birth of her last young it was 16 days, and the female may live from 1 to 6 days longer. The average total life period of a viviparous female was about 24 days, although 30 to 35 days is not unusual. The oviparous generation is rather longer lived, the average for 15 individuals being 26 days, with a maximum of 61. Life is longer, growth is slower, and reproduction more deliberate in the cooler parts of the season, both spring and fall, than in the warmer. An aphis isolated September 18 began to reproduce in 11 days, brought forth young—56 in all—for 31 days, and died November 7 at the good old age of 51.

THE ATTENDANT ANT.

The absolute dependence of the corn root-aphis upon its attendant ants is doubtless well understood. It is almost invariably found in charge of that most abundant of all American ants, *Lasius niger americanus*, the commonest ant of pastures, meadows, and cornfields throughout the greater part of the United States. The life history of this ant was fairly well given by me in the eighteenth report of the State entomologist of Illinois.

It hibernates underground in the fields in comparatively small colonies of workers, 50 to 200 or more in each, often with larvæ of various sizes and sometimes with eggs. A queen will occasionally be found among the hibernating workers, although eggs are sometimes laid by isolated queens for new colonies in fall. The queen seems sometimes to spend the winter entirely alone or else to leave the old colony very early in spring. April 7 of this year, for example, a queen ant was found in a cornfield in her cell, alone, with neither eggs nor aphides near her. Pupation begins during the latter part of May in central Illinois, and winged sexual forms, male and female, begin to emerge about a month later and continue to appear from time to time at least until October.

A single colony of worker ants may extend its burrows in the cornfield under an area 3 or 4 feet in diameter and to depths usually varying from 1 to 4 or 5 inches, but the deeper chambers are sometimes 6 or 7 inches below the surface. During a summer drought the ants may bury themselves a foot or more, piling up in sluggish heaps in the deeper chambers of their nests.

These ants are thoroughly devoted to the root aphides in their charge, although not wholly dependent on them for food. In ant nests without aphides we have sometimes found the débris of various insect bodies—larvæ, beetles, and the like—and in one case a common white grub. We have also seen this ant eating an earthworm.

Until this year I have never known it to injure directly the corn plants, among whose roots it mines so diligently, but late last May my attention was called to a field near Champaign, Ill., heavily infested by these ants, which were present in unusually large colonies, and in nearly all cases with no root aphides in charge. Some 4,000 ants in 24 colonies had less than a hundred aphides among them—less than 1 aphis to every 40 ants. Forty to 50 per cent of the hills of this corn were suffering seriously, because the softened kernels had been eaten out by the ants while the plant was still too small to feed sufficiently by the roots. This field was in oats last year, in corn in 1903, and a meadow in 1902.

RELATIONS OF ANT AND APHIS.

The relations between the aphides and the ants are so intimate and important that the numbers of the aphis are strictly limited by the numbers, activities, and industry of the ants. That the latter are fully equal to their usual opportunities is shown by the fact that through the spring months a large proportion of the burrows which they have excavated in the fields are without aphides, being evidently prepared in advance of the existing supply. It is only toward the middle of the summer that one will find, as a rule, every ant colony with its aphis family in charge.

The care taken of the aphides by the ants is well illustrated by a number of incidents reported to me by one of my assistants, Mr. E. O. G. Kelly, from among his observations in the field last spring. April 12, for example, he watched for two hours and a half an ant nest, near which a few small smartweed plants were growing. An ant coming up with a young aphis in its mandibles, carried this about 2 feet and placed it on a smartweed near the ground. Within the next 20 minutes, six more ants transferred each a single aphis from their underground burrows to smartweeds above ground. In about an hour and a half one of the ants returned for its aphis and took it to the nest, and 35 minutes later all had been carried back. One of these ants, which was so marked that it could be recognized on its return, carried to the nest the same aphis which it had previously brought out. It was a common thing also to see ants transfer young aphides from the roots of sapped and withered plants to those still young and fresh. May 5, 10 aphides were taken from a smartweed root and placed on the bare ground. They crawled actively about, and 2 of them entered a crack in the earth as if to escape the light. One of these was found by an ant, which carried it away. Two small ones crawled about 4 feet and stopped as if exhausted, but 2 larger aphides traveled more than 10 feet in an hour and twenty minutes without finding any food plant. All were seemingly averse to the light, and crawled away from the sun.

Once a corn root-aphis taken from a plant and placed on the ground was found by an ant and carried away to a distance of 4 feet. It was then left to itself while its attendant ant dug down to the roots of a plant of foxtail grass (Setaria), when the aphis was seized and carried into the burrow, where it was afterwards found by digging, contentedly sucking sap from the root.

Ants often take possession of young aphides as fast as they are born and carry them to new plants, and they are similarly interested whenever oviparous females are producing eggs. Curiously, they pay no especial attention to these females themselves, although the eggs are snatched up and carried away as fast as they appear. They value highly the golden eggs, but take no care of the geese.

INJURY TO CORN.

What this pair of associate pests may do to a corn crop is well shown by conditions found this year in a field of corn in Ford County, in central Illinois—a great corn year, in a great corn county, in the midst of the great corn belt. This 20-acre field, in corn for only the second year, and in oats two years ago, had been evidently infested the whole season through by the corn root-aphis and by nothing else. Immediately beside it was another field, the first year in corn, and virtually free from noticeable insect injury. For an exact exhibit of the consequences of the aphis infestation careful comparison was made in September of the condition and yield of 2,000 hills, taken at random from each of these two fields. In the infested field 23 per cent of the hills were vacant—that is, wholly without plants—and another 21 per cent contained only small dead stalks—44 per cent of the hills either vacant or dead. In the other field 5 per cent of the hills were vacant and none were dead. In the infested field the plants varied from 6 inches to 6 feet in height and numbered 125 per hundred hills. In the uninfested field the corn ranged from 6 feet to 8 feet in height, with 216 stalks per hundred hills. In the infested field only 4 per cent of the stalks bore ears, and in the uninfested field only 4 per cent of the stalks were barren.

In the uninfested field 2,000 hills bore 4,024 ears, 201 of which were small; in the infested field 2,000 hills yielded a total crop of 95 ears, all nubbins. Sixty-eight per cent of the hills in the first field were still infested by ants and 67 per cent by aphides, while 69 per cent of the vacant hills, in which the corn had died, still showed by the presence of old ant burrows, now deserted, the cause of their death. In brief, the one field yielded an excellent crop of corn and the other was wholly ruined by the root-aphis alone, yielding neither fodder nor grain worth taking into account.

This was no isolated instance; it was simply a strongly marked example of aphis injury in that neighborhood, wherever corn had grown on the same ground for so little as two years in succession. The corn root-aphis has simply become epidemic there. Winged females swarm out of the older fields in late spring and early summer in such overwhelming numbers that any field is likely to be injured by them and to become so heavily infested that aphis eggs enough will be left in the ground in fall to work the complete destruction of the crop the following year if the ground is planted to corn. One year at a time in corn is about the limit under such conditions. Whether even so prompt rotation as that would hold this ant-aphis pest permanently in check will appear from what I shall presently have to say concerning the fate of the aphis if the ground containing its eggs is planted to some other crop than corn.

Furthermore, I regret to say that this Ford County neighborhood is only one of several known to me in various parts of Illinois which are similarly injured and endangered. It is because the conditions here described may become established anywhere that corn is made continuously the leading crop that I have thought my topic an especially appropriate one for this general meeting of the American economic entomologists.

NATURAL CHECKS ON INCREASE.

The possibilities of serious permanent injury to corn culture by the root-aphis are greatly increased by the fact that these subterranean aphides, while in no way inferior in reproductive capacity to species of aerial habit, are not nearly so subject to rapid wholesale destruction by rains, or by parasites and other insect enemies. Long-continued or oft-repeated rains sometimes retard their multiplication, it is true, and may even reduce their numbers somewhat, but no changes of weather have any such effect on them as on the grain aphides, for example. While the corn leaf-aphis (*Aphis maidis* Fitch) is enormously parasitized, and is commonly attacked by the usual kinds of aphidivorous insects, *Aphis maidi-radicis* is never parasitized, so far as I know, and it is but little subject to destruction by other insects underground.

An exception should, perhaps, be made to this last statement with respect to the aphis ant itself. The mysterious disappearance last May of all the ant and aphis population of a 20-acre field of oats in which the food plants of the aphis had nearly all been killed led me to experiment with ants and aphides kept in confinement under starvation conditions. A colony of ants, well established in an artificial nest of the kind devised by Miss Adele M. Fielde, were given a group of aphides on a fresh corn plant. This was then allowed gradually to dry up until it no longer afforded food to the aphides, and these, of course, soon ceased in turn to make their usual offerings to the attendant ant. Seeming to despair, at length, of making any further use of their aphide protegés, the ants finally ate them up, and continued so to do with all the fresh ones given them.

I strongly suspect that the same thing happens sometimes in the field, and that, when the food plants of an aphis family fail them and no more can be readily found, their masters and owners—for such their ant attendants really are—do the best thing possible under these hard conditions and convert their milch cows into beef.

PRACTICAL ECONOMIC MEASURES.

The most obvious means of lessening or preventing injury by this insect is a rapid rotation of crops, leaving no land in corn more than a single year; but this measure is very inadequate, because, however the field is finally cropped, it will at first spring up to smartweed and pigeon grass and other common weeds, on the roots of which the aphides live and breed abundantly until, say, the latter part of May. Then if the field is sown to oats, the shading and sapping of the ground by the crop plant will dwarf the weeds and thus reduce the food supply of the aphides. One important consequence is shown by a comparative observation made last May on the composition of the aphide colonies in hills of corn, as related to the density of the aphide population. Fifty considerably infested hills contained an average of 105 aphides to a hill, and 225 lightly infested hills contained an average of 5 aphides to a hill. In the lightly infested hills 21 per cent of the adults were winged, or were pupæ about to acquire wings, while in the worst infested hills the winged and pupæ amounted to 64 per cent of the adults. That is, as the food supply fails the aphides escape starvation, in great measure, by getting wings and flying away. Many of these winged migrants doubtless perish, but many of them are found by the ants, which are mining everywhere as if in preparation for their advent; and whenever one is found a new family presently appears on a newly-infested plant, and, multiplying at that time at a rate of 40 to 1 for every week, a fresh start is soon made and the game goes merrily on. The effect of rotation is thus a merely temporary check on increase, followed by a wider and more rapid distribution of the attack on corn. We must evidently find something better than this, or something additional to it, at least, if we would get an effective control of this dangerous pest.

Treatment of the seed with kerosene or turpentine before planting completely protects the young plant for several weeks, the odor of these substances persisting in the ground for a surprising time, but unfortunately this treatment often seriously injures the young corn itself—just why and under what conditions I have thus far been entirely unable to make out. At any rate, the results are so uncertain and so unaccountable that I think the method much too dangerous for general use.

Much the most promising and successfully preventive method is such a management of the soil, in fall or winter or early spring, as to break up and scatter the nests of the ant and to disperse their contents—the ants and their young and the aphides and their eggs—again and again through the dirt, destroying, at the same time, the young vegetation as fast as it springs up. Thus ants and aphides may be starved together, or, at the worst, the ant may escape from the fields, leaving the scattered and buried aphides behind to perish.

As a test of this method, I carried on various experiments in the spring of 1904 and 1905 in several selected localities in different parts of Illinois, giving to a part of each infested field the usual spring treatment as a preparation for corn, and giving to the remainder a special additional treatment which stirred the earth deeply and repeatedly and mixed it up thoroughly in the interval between the earliest date for plowing and the usual time for planting corn. These experiments may be summed up by saying that three times disking of a badly infested field, previous to planting late in May, reduced the ants and the aphides in the field by something over 92 per cent, and the number of hills infested by each by 64 per cent for the ants and 82 per cent for the aphides. Disking twice in succession reduced the number of insects by 65 per cent for the ants and 84 per cent for the aphides, and the number of hills infested by each by 59 per cent and 75 per cent, respectively. The most remarkable effect was got by disking once as soon as practicable after a heavy beating rain. This reduced both ants and aphides by 90 per cent in the number of insects and by approximately 60 per cent in the number of hills infested.

A PREVENTIVE ROUTINE.

The general practical outcome of these observations and experiments may best be given in the form of an agricultural routine for the corn farmer whose crop is liable to injury by the corn root-aphis, either because it is grown on land previously infested by that insect or because of a general abundance of the aphis in his neighborhood. Rapid rotation with an especially short period in corn, limited as a rule to a single year; early, deep, and thorough preparation of the soil for corn, with a diligent use of the disk harrow after the ground is plowed, and general measures for the maintenance and increase of soil fertility, are the chief features of this routine. It is better that the land should lie a day or two between successive diskings, and careful advantage should be taken of cold, beating rains to disk the land as soon thereafter as it is fit to work. If to this we add early and continuous cultivation of the crop, as deep in the beginning as the corn will stand, and if we further advise that corn should never, in any event, be grown on land known to have been infested by this insect the year before, we shall have done all that our present knowledge of this aphis and its attendant ant will warrant.

It is of course also to be understood that each farmer has in his hands, in considerable measure, the interests of his neighborhood, and that no man should be permitted to raise on his own land, by reason of his negligence, insects which will spread to the property of others to their serious injury. The moral and legal principles whose growing recognition we owe to the introduction and spread of the San Jose scale apply just as forcibly to the insect and fungous pests of general agriculture, and some day, I do not doubt, they will be just as thoroughly enforced.

Mr. Burgess asked when, in the case of the field culture experiments, the counts of aphides remaining alive were made. Mr. Forbes answered, as soon after the experiment as it was believed that the ants and aphides had established themselves; usually this was in about a week, but it was sometimes delayed by bad weather.

Mr. Morgan asked if any relation had been discovered between the rate of multiplication of the aphis and the vitality of the corn plants, as influenced by soil or climatic conditions.

Mr. Forbes answered that no experiments had so far been made for this purpose, but that some were planned.

Mr. Morgan said that he had observed that whenever cool nights come on, lowering the vitality of the plant, the common cotton aphis is more abundant.

Mr. Quaintance had observed that they were more abundant during late spring and also in early fall than during the summer.

Mr. Morgan observed further that in new fields cotton was little affected, but on worn-out ground aphides were abundant. Had this been observed in relation to the corn root-aphis in Illinois corn lands?

Mr. Forbes replied that in that part of Illinois in which the corn root-aphis is abundant it is difficult to find worn-out corn land, and that the condition referred to had not been observed.

Mr. Sanborn asked what relation the migratory form of this aphis has to the infestation of new fields. If it is necessary for the aphis to be cared for by ants, it would seem as if the chance of its being found when migrating into a new field would be slight.

Mr. Forbes said that ants are such great explorers that the chance was not so small as might appear.

Mr. Sanborn asked how far the aphis flew.

Mr. Forbes said that he did not know exactly; it depended on the strength of the wind.

Mr. Webster stated that Professor Sajö had called attention to the fact that many insects like the aphides would climb to some elevated object, like a stem of grass, and deliberately give themselves to the wind to be carried away by it, perhaps for long distances. He had himself observed that the ants seemed to be always on the watch for the aphis in the cornfields. While he was familiar with the experiments and results obtained by Doctor Forbes, he would like very much to see how they would work out in the hilly country of the South. The corn root-aphis had during the past summer been reported as very injurious in some parts of Virginia, where farmers did not seem at all familiar with it, and he wondered if these cultural methods would apply there as well as in the prairie country of Illinois. He had many times noted that where a field previously in corn had been plowed in spring and sown to oats there would be an occasional ear missed at husking that when plowed under would send up a cluster of young plants, and the roots of these would be infested by the root-aphides, attended by ants. He expressed the hope that Doctor Forbes would experiment with fertilizing ground with barnyard manure as a possible repellent, as he had observed that in portions of fields where this manure had been applied before plowing there were fewer root-aphides.

Mr. Osborn called attention to the fact that since the aphis can not exist without the ant, we have here a condition in some ways analogous to parasitism.

Mr. Sanderson called attention to the fact that in the case of the strawberry root-aphis (*Aphis forbesii* Weed) the eggs are laid upon the stems and foliage of the plant and are not cared for by the ants, but that the ants are entirely responsible for carrying the aphides down upon the roots of the plants in the spring, for tunneling around the roots of the plants, and very largely for carrying the aphides from plant to plant and thus spreading the pest. This would seem to be a transitional stage in the care of aphides given by ants from that given the aerial species to that afforded the corn root-aphis. What is the percentage of migrants to wingless insects in the corn root-aphis?

Mr. Forbes replied that it varies too much to be expressed in averages. The migrants, however, seem to be more abundant in the earlier generations.

In the absence of the author, the following paper was read by Mr. Osborn:

OBSERVATIONS UPON THE MIGRATING, FEEDING, AND NESTING HABITS OF THE FALL WEBWORM (HYPHANTRIA CUNEA DRU.).

By E. W. Berger, Ph. D. (J. H. U.), *Columbus, Ohio.*

The majority of the observations upon which this paper is based were made at Cedar Point, Sandusky, Ohio, during the past summer, while I was at the Lake Laboratory of the Ohio State University. The webs of the fall webworm were abundant on all sides, and those who had spent preceding summers at Cedar Point were under the impression that the webworm was on the increase. After a few days of casual observation it was decided to make a more careful study of its habits and to determine if it is double brooded at that place. While a few specimens pupated in the laboratory during the latter part of July, none of them transformed into adults, and no positive results were obtained in regard to a possible second brood. Acknowledgment is due Prof. Herbert Osborn for his interest and for his generosity in placing valuable suggestions and facilities at my command.

FOOD PLANTS.

The worms were observed upon the following plants: Walnut (*Juglans nigra*), choke-cherry (*Prunus virginiana*), common wild black cherry (*Prunus serotina*), willow (*Salix* sp.), elm (*Ulmus americana*), boxwood (*Cornus* sp.), hackberry (*Celtis occidentalis*), and wild grape (*Vitis vulpina*). The webs were abundant everywhere upon the choke-cherry (Pl. I, fig. 2) and the common wild black cherry, some trees of the latter having nearly one-half of their foliage destroyed. Willows were also nearly always populated with a few or many broods. The few walnut trees (Pl. I, fig. 1) present were literally defoliated, and these will be the subject of the next topic. Elm, boxwood, and hackberry were frequently infested, but never to the same extent as the previously named trees. In only two instances did I observe the webworm feeding upon the wild grape, and then only when the grape leaves grew among the leaves of willow and choke-cherry. I did not observe a single instance of the worms feeding upon the poplars at the Point. This is quite at variance with previous observations. In Riley's bulletin upon the webworm in Washington in 1886,[a] *Populus balsamifera* and *P. tremuloides* are named among the trees that suffered most. Both these poplars occur at Cedar Point, but no webs were observed upon them.

Following I give the first five trees named in Riley's list. These are arranged in the order of the damage done:

Acer negundo (box elder).
Populus alba (European white poplar).
Populus deltoides (cottonwood).
Populus balsamifera (balsam poplar).
Populus tremuloides (American aspen).

The same report further states that poplars, cottonwoods, and the ranker growing willows were the principal subjects of attack in 1886 in New England.

Of the species of trees attacked at Cedar Point, four (walnut, wild black cherry, choke-cherry, and willow) appeared to be the favorite food plants of the worms, and these are, respectively, 41 (*Prunus serotina* is not named by Riley), 75, and 14 in Riley's list of 108 food plants. In the Yearbook of the Department of Agriculture for 1895, 120 is given as the number of food plants listed. Again, of all the species of food plants named by Riley, 42 genera and about 26 species are represented at Cedar Point, but of these only 8 were observed to be used as food by the worms.

Throughout the State generally, so far as my limited observations extend, and from a few other reports, the common wild black cherry (*Prunus serotina*) is the tree most generally attacked; but walnut, elm, hickory, pear, apple, sugar maple, and silver maple suffer more or less. Walnut trees when attacked suffer most, as the following topic will show; and Mr. Cotton, assistant inspector of nurseries and orchards, has informed me of similar conditions near Cadiz, Harrison County, Ohio.

The following observation is interesting and shows how capable the female is in the selection of a favorite food plant upon which to lay her eggs. One day I observed a web upon a hedge of Osage orange. Closer investigation revealed the fact that the web was not properly upon the Osage orange at all, but upon a small wild cherry that grew there and which had escaped my notice. E. D. Sanderson[b] refers to the webworm as being particularly fond of a neglected Osage-orange or wild-cherry hedge. I have repeatedly observed it this last summer upon wild-cherry trees that grew along an Osage-orange hedge, but I do not recall seeing it upon the Osage orange itself. Professor Osborn[c] states that he observed the webworm

[a] Our Shade Trees and Their Insect Defoliators, Bul. 10, Div. Ent., U. S. Dept. Agric.

[b] Bul. No. 56, Del. Agric. Exp. Sta., June, 1902.

[c] Insects Affecting Forest Trees. Proc. Columbus Hort. Soc., vol. 17, 1902.

specially abundant in that year upon the elm. These and the several facts previously noted in regard to the favorite food plants of the worms seem to indicate that the food plants vary from year to year and perhaps from place to place. It has been suggested that there may be several varieties of the worm, but at present I can do no more than call attention to the facts.

ON WALNUT.

There are only a few walnut trees at the Point, but the worms played havoc with these: while of all the great abundance of choke-cherry only two instances were noted where the infestation was at all similar and so extensive. A clump of five walnut trees (Pl. I, fig. 1), each about 6 inches in diameter, became literally defoliated and about 150 nests were counted upon them. I have observed, however, that the number of nests does not necessarily indicate the number of broods, since a large brood may desert its web, divide, and each division form new nests. (See Other Observations.) When food became scarce the worms began to migrate down the trunks of the trees and over the ground, here and there covering the limbs and trunks, and also the ground about the trees, with web. This migration occurred chiefly at night, when the worms literally covered the ground for a radius of several feet about the trees, and all was activity. The migrating worms generally rested, as is customary for them, during the day. In this case they mainly rested in temporary webs often located at the base of the trees. Many of these webs were of extraordinary size and composed of a number of successive sheets of silk arranged parallel with their plane surfaces and about one-fourth inch apart. In this way the capacity of a web was greatly increased, and I estimated that one of the largest contained not less than 2 quarts of the worms.

The worms migrated mainly eastward to a clump of choke-cherry bushes close by and westward to a large hackberry tree about 40 feet distant. Some webs of migrants were also found in two other hackberry trees about 50 and 100 feet, respectively, to the southwest and northwest. The migration extended over a period of about ten days, from August 1 to August 10. In four days the number of nests in the chokecherry bushes increased from 6 to 25, and the worms literally stripped the bushes as they advanced. There were only a few native broods upon the choke-cherry bushes. I could always distinguish these from migrants by the presence of dried leaves in the nest, there being none of these in the nests of migrants. Then, again, a nest of migrants almost always contains worms of various sizes. The absence of dried leaves, together with the presence of worms of several different sizes, I consider to be a very good test for distinguishing a migrant nest from a native nest. The advance into the choke-cherry bushes (Pl. I, fig. 2) was quite comparable to the exit from the walnut trees. The worms first built large nests at the base of the bushes, with considerable web upon the ground, and then advanced upward from night to night. Many of these nests were of the kind described above—that is, composed of parallel sheets of silk.

The migration to the hackberry was not so striking as that to the choke-cherry bushes, but was even more interesting. At first the worms congregated in temporary webs in the crotches of the larger limbs, but they gradually advanced upward from day to day and built webs in the smaller branches. I first observed the worms traveling up the hackberry tree at 5 p. m. of August 3. I found a few worms climbing up the large tree and two webs with worms in the first and second large crotches about 7 and 10 feet above ground, respectively. There were also a few worms climbing up one of the main ascending limbs about 20 feet above ground. There was no web spun about the base of the tree, but the caterpillars observed 20 feet above ground had some web spun upon the limb. This latter web, as also the number of worms within it, increased from day to day until it extended about 8 feet in length and surrounded the greater part of the limb, which was perhaps 7 inches in diameter and free from smaller limbs. This web was apparently not a resting place, but mainly a route of travel, for the worms seemed to be more or less on the move all the time. The webs in the crotches mentioned, I decided, were resting places for the worms during the day. I think there can be no doubt that the worms in the hackberry came from the walnut trees. Worms were observed upon the ground in the early forenoon headed toward the tree. Again, there were no webs with dead leaves in them; in fact, the tree showed no evidence whatever of having been previously infested, and the worms were of several different sizes.

The next day—August 4—I observed nests upon limbs farther up in the hackberry and fewer caterpillars in the nests in the crotches. I also noticed nests in the very top of the tree among the leaves, which showed evidence of being stripped. Four days later—August 8—the number of worms in the lower nests (in the crotches) was rapidly decreasing, while there were more nests in the top of the tree, which could now be seen from the outside and at some distance. A few worms were seen climbing up the trunk, and a few could still be found in the webs upon the walnut trees. This was also the situation upon the following two days, when I left the Point.

The condition upon the other hackberry trees mentioned, 50 and 100 feet southwest and northeast, respectively, from the walnut trees, was quite comparable to that already described. In the southernmost of the trees just mentioned I observed only a few webs, but all the in-

FIG. 1.—WALNUT TREES INFESTED BY THE FALL WEBWORM.

View looking north, Lake Erie in background; Cedar Point, Sandusky, Ohio. From photograph by Prof. H. Osborn.

FIG. 2.—CHOKE-CHERRY BUSHES BADLY DEFOLIATED BY FALL WEBWORM.

Cedar Point, Sandusky, Ohio. From photograph by Prof. H. Osborn.

dications were that these came from the walnuts. Upon the northernmost one I found five nests in the forks of the tree, with a few other webs quite at the top. This was on August 8 and only two days before the termination of my observations. All the indications were that these were migrants, and I concluded that they came from the walnut trees, because there were no other infested trees near; in fact, no trees of any kind nearer than the walnuts. This fact is interesting, because the worms had to travel not less than 100 feet.

Mr. W. B. Herms, who remained at the laboratory until August 31, was kind enough to observe the worms for me after my departure, and reported that they advanced only a little farther east into the choke-cherry bushes and became fewer in numbers, evidently having wandered off in search for a place to pupate. The trees began to show new life, and by the time Mr. Herms left were quite green again. Riley, in his report, previously mentioned, states that many of the trees even began to flower.

A small hop-tree (*Ptelea trifoliata*) immediately under the webs in the walnut trees was injured but little, the worms evidently having a decided aversion to it. At one time a small web was spun in it, and some worms were wandering about, but they all soon deserted it.

In the early part of the forenoon I usually found some stragglers upon the ground, evidently en route from the walnut trees, and which had been overtaken by daylight. These were found 10 to 30 feet from the walnuts and invariably headed away from these. The majority traveled eastward to the cherry trees and westward to the hackberry trees. Some, however, were wandering to all points of the compass, the smaller number to the north and the south. To the south was a plot of bare sand, and to the north also sand, but with more grass and no trees. The routes to the east, west, northwest, and southwest were more shaded. I should add, perhaps, that the soil here, as everywhere at Cedar Point, is lake sand, and seldom more than sparingly covered with wild grass. Upon none of the stragglers observed did I discover a trailing thread of silk; in fact, I found but little silk anywhere along the lines of travel except to the east, where the choke-cherry bushes were only a few feet from the walnut trees. I found many dead worms along the line of travel, some plump and fresh, others dried up. Many were found in little pits the size of an ordinary heel. It occurred to me that these worms had died from the heat, since all the lines of travel were exposed, more or less, to the sun's rays during some part of the day. Again, the majority of the dead worms were found to the south, where the sun was hottest. To test my surmise that the dead worms upon the ground died from excessive heat, I placed three in a small pit of the size mentioned. They labored incessantly in an effort to get out, and all died within ten to twenty minutes (one in ten, one in fifteen, and one in twenty).

As the great majority of the worms traveled eastward to the choke-cherry bushes and westward to the hackberry tree, it seems plausible to assume that the worms have some sense of direction, probably being guided by the proximity of the trees to which they migrated. But I do not think that they have the "keen sense to guide" them which Riley states to have been the case for the worms in Washington. Judging by my observations upon the stragglers, namely, that they wandered very much in all directions from the cherry trees, and would wander 40 and 100 feet when there were plenty of food plants (choke-cherry) within 10 or 15 feet, it appears to me that the caterpillars wander very much at random, depending upon chance to find some other food plant. In fact, it seems to be very much of a "cut and try" method. In abundance there probably was a straggler for about every 5 feet of ground surface. In the afternoon I found very few of them.

One may contrast the infestation of a tree by migrants with the normal infestation from eggs by stating that in the former case it is centrifugal and in the latter centripetal. When it is centrifugal the migrants travel from the trunk to the larger limbs and then to the smaller ones, building their webs on the limbs or in the crotches. From these webs they go out to the leaves to feed. When infestation is centripetal eggs are laid upon some of the outermost leaves, from which the larvæ then work toward the center of the tree, eventually traveling down its trunk, provided their number is so great that they require more food than the tree furnishes.

FEEDING HABITS.

My observations in this direction clearly show that the worms feed but little, if at all, during the day. At night they leave the nests, or thicker parts of the webs, and move about freely upon the leaves in the thinner parts or those bordering the webs. To determine the periods of feeding I made observation at all hours of the day, but rarely found any but young broods, below the second moult, busy feeding. The few exceptions to this rule were several broods lined up to feed at about 11 a. m. on a rainy day and now and then a colony in some shady place.

At night this is altogether different. With the beginning of darkness the worms break camp and move out upon the leaves, even to the extent of 2 feet and farther from the nest, to feed. Then they may leave the web altogether and feed unprotected except by the darkness, without even a thread of silk to cover them.[a] This observa-

[a] There may have been a fiber of silk connecting the worms with their web, although I have no observations on this point. It is generally understood, however, that such is the case.

tion I believe distinctly indicates that the webs serve mainly for protection from enemies during the day.

I found the caterpillars during July breaking camp at about 7.15 p. m., and by 7.30 they were feeding; at 10 p. m. and at 3 a. m. also they were feeding, there being only a few individuals, evidently getting ready to molt, in the nests; at 4 a. m., daybreak found them homeward bound. Younger broods, below the second moult, were observed to be slower in coming home. Only one observation was made at 3 a. m. and two at 4 a. m.; between 7 and 10 p. m. frequent observations were made.[a]

The black-billed cuckoo was seen feeding upon the worms at different times. Dr. William E. Kellicott, whose work gave him opportunity to observe the contents of toads' stomachs, kindly consented to make special note of these, in order to determine to what extent the toads at the Point feed upon the webworm. His observations are wholly negative, however, probably because he never used the toads until about twelve hours after collecting, when nothing but the harder parts of beetles, crickets, grasshoppers, and the like could be identified. He expresses doubt that the toads feed much upon the caterpillars. Riley's bulletin states that the toads fed freely upon the worms.

GROWTH AND MOLTING.

A brood of small worms, which I judged could not be over a few days old, was transferred to another cherry tree more favorably located for observation. The twig upon which they lived was cut off and tied to a branch in the new location. It was only after several days that the caterpillars migrated to fresh leaves, the old ones in the meantime having become quite dry. They did not seem to thrive after that, and during 22 days, the time that they were under observation, they grew but little, if any, in length, as shown by actual measurement. They began to molt in 12 days from the time that they were first observed. Thus it appears that their first molt occurs 12 or 15 days after hatching. Another slightly older brood (on some willows), which measured one-fourth inch (6.25 mm.) in length measured one-half inch (12.5 mm.) after 22 days, having thus grown one-fourth inch in that time. This brood became mixed with an older brood with which it went to live, so that nothing in regard to its molting could be determined. Another

[a] I tried to corroborate these conclusions upon feeding by an examination of the digestive tracts of specimens collected at different times of the day. Thus I dissected specimens collected at 7 and 10 a. m. and at 1 and 5 p. m. Not less than 20 specimens were examined, but little difference was observed except that I concluded that the anterior parts of the digestive tracts of the latter were less gorged.

brood which had evidently just molted twice when it came under my observation molted again after 12 days. The observations just noted indicate 12 to 15 days as the interval between molting. Allowing five molts per season, this gives us about 2 months for a worm to mature, which is about the time required at Cedar Point. Mature worms average 18.75 to 25 mm. in length (0.75 to 1 inch). At the rate of growth above indicated (6.25 mm. in 22 days) we again get about 2 months for a worm to mature.

Judging from the number of loose heads and headless skins in the nests, I conclude that the head molts first, and that the worm then slips out of the old skin by this opening. I do not recall finding an empty skin with a head. In only a few instances do I recall that the thorax had a small, longitudinal slit dorsally. The last molt occurs after the cocoon—a loose flimsy affair consisting mainly of the hairs of the caterpillar with but little silk—has been formed and lies stored away at the posterior end of the pupa.

In some specimens about to molt, and which I dissected, I found the digestive tract empty and the new hairs formed beneath the old skin.

OTHER OBSERVATIONS.

It has already been remarked that a brood may divide into two broods, and that two broods may unite. Again, a brood may desert its old web and form a new one. I frequently noticed that many webs contained worms of several different sizes, and this fact first suggested to me that two or possibly several broods might unite in a single web. I found later that a brood of smaller worms, somewhat isolated at the end of a branch, traveled 18 inches along a bare stem to reach green leaves. Every inch of this distance was covered with quite a dense web of silk. This brood came into close proximity with an older brood, and instead of returning to its own web took up its abode in the web of the older worms. This is a perfect illustration of the union of two broods. A similar occurrence was observed with another larger brood, which finally had to travel several feet to get to its feeding leaves. This brood eventually divided, one division taking up its abode within the web of another brood near by, while the second division built a new web of its own. It appears that the worms found it more convenient in this case to take quarters with their near neighbor, or to build a new web, than to return to their old nest. This observation illustrates both the union and the division of broods, as well as the building of a new nest.

The following observations in a measure also illustrate some of the above points, besides several others in webworm economy: I cut out a nest at 3 a. m., while the worms were out feeding. At 4 a. m., when all were coming home, these were wandering about aimlessly. Eventually a portion settled down and spun some web within a piece of folded paper which had been used as a label for the nest. The majority, however, formed a new nest among some dead leaves left after cutting out the old nest. Another paper was then placed near the first piece. The next day a number had located under this and had spun some web, but the paper was not at all folded. Later all the nests were cut out, including the pieces of paper, with the result that a portion of the worms settled down in a new web which they built underneath the largest stem of the branch, while the rest returned to a neighboring nest about 18 inches distant, from which the smaller individuals of this brood—a double brood—had come some days before.

Three nests were cut out and placed on the ground near some choke-cherry bushes. In all three instances the nests were fastened to the ground with web after the first night and some silk spun upon the ground for some small distance about the nests. The first brood built web upon the ground for a distance of 2 feet from its nest to a leafy stem of the choke-cherry, to which it migrated. Only a few worms returned to the nest upon the ground after the first few days. The majority remained in their new quarters and soon had spun quite a dense web.

The history of the second nest is quite similar to the first, except that I could find no web spun upon the ground leading to the choke-cherry, a distance of 3 feet. These worms remained for a longer time in their nest, deserting it gradually, and, it is presumed, went to the choke-cherry, where a few specimens were occasionally found, although no new web was observed.

The history of the third nest is somewhat different. The nest was cut off August 5 and placed upon the ground between the porch and choke-cherry bush. The nest was 2 feet from a leafy branch of the cherry near the ground and about 1 foot from the porch. On the morning of the second day apparently all the worms were in the nest, and a web had been spun upon the ground near by and the side of the porch. At 9 p. m. of the same day (August 6) the worms were wandering about the web upon the ground and the porch. A few were on the railing of the porch and on the floor near by. On the morning of the third day all had evidently returned to the nest. At 9 p. m. the worms were wandering over the nest and the ground near by (the web upon the side of the porch had been destroyed); there was no evidence that the worms were going to the cherry. On the morning of the fourth day apparently all the worms were again in the nest. On the morning of the fifth day the nest was deserted by all but a few worms. Only a few could be found upon the cherry tree, and the presumption is that they became scattered upon this.

Of 13 webs found in the choke-cherry brush which had been cut and spread about the outside of the laboratory to protect the loose sand against the wind, 4 were wholly deserted, while 9 contained from 12 to many worms.

COLOR VARIATION.

A few notes were made upon the different colors on the worms. My notes are not sufficient, however, for the determination of any laws or modes of variation, and the observations were only made in order to get a better idea of the color variation. A careful study along this line would be a subject by itself, requiring all the observer's best effort for a number of weeks. But no doubt some very interesting scientific results would be obtained if a series of observations of this kind were platted and curves made to show general frequency, mode of variation, etc.

Eighteen worms were examined, and following are the results. In each case the colors are enumerated with a figure in parentheses denoting the number of worms having that color. I had no standard colors to compare, so that the colors named are probably only approximately correct, which does not invalidate the object here in view. Under the second, third, and fourth divisions the body colors given are the dominant ones, while the "stripes" are narrow lines running longitudinally. The worms examined were from a lot that I had taken to the laboratory at least a day previous, and none had molted during that time.

Head.—Black (10), brown (4), dark brown (2), light brown (2).

Body (*without stripes, 3*).—Black (1), blue-black (1), light slate with darker back and venter (1).

Body (*with stripes, 15*).—(I) Dorsad: Lead color (1), black (6), light lead (1), dark lead (2), lead stippled black (1), green slate (3). (II) Laterad: Light lead (3), lead (2), dark lead (2), green slate (5), greenish yellow (1), black (1), stippled black (1). (III) Ventrad: Light lead (2), lead (2), dark lead (8), blue-black (1), green slate (2).

Stripes.—(I) Dorsad: No stripes (7), light (3), cream (6) very faint (2). (II) Laterad: No stripes (1), 2 cream (4), 3 cream (6), 2 faint light (3), 1 faint (2), 2 light (1), 1 cream (1).

Feet.—(I) Thoracic: Black (13), dark brown (1), brown (2), light brown (2). (II) Anterior abdominal: Black (7), dark gray (4), gray (1), gray-brown (2), dark green (1), olive green (2), light (1). (III) Posterior pair: Black (5), gray (1), dark gray (4), light gray (1), gray-brown (3), dark green (1), olive green (2), light (1).

Tubercles.—(I) The two dorsal rows: Black (7), dark (2), brown (4), dark brown (1), light brown (2), light orange (1), light (1). (II) The two dorso-lateral rows: Black (10), black and orange (2), brown (2), dark brown (2), light brown (2). (III) The four lateral rows: Orange (8), light orange (6), dark orange (1), brown (1), light brown (2). (IV) The four ventral rows: Black (1), dark (4), light orange (1), brown (1), light brown (1), gray-brown (2), lead (4), green-yellow (1), green slate (2), light (1). *Hairs.*—(I) Dorsad: Golden brown (1), white (8), brown (5), light brown (2), gray (1), black and white (1). (II) Laterad: White (13), gray (3), brown (2).

While writers generally mention the great color variability of the larvæ and that there are light and dark colored ones, I do not know that anyone has attempted to put the variability in a tabular form.

The appreciable economic loss from the webworm is generally not great and but few trees are ever endangered. Small trees can, of course, easily be defoliated by one or a few broods. In localities where the worm is double brooded the situation may become serious and considerable loss ensue. But by a little attention with a torch or by cutting out and destroying the webs a great deal can be done to eliminate this pest.

The following paper was read by the secretary:

THE CARE OF ENTOMOLOGICAL TYPES.

By T. D. A. Cockerell, *Boulder, Colo.*

It has long seemed to me that something ought to be said about the duty of museums, universities, etc., in properly caring for and rendering accessible the types and cotypes of insects in their possession. I do not refer to the institutions where the collections are systematically neglected, but to the best we have, where everything is supposed to be just as it should be. Quite too often we hear that a given type "can not now be found," and I suppose that few museums could at a moment's notice produce a list of types in their possession. Within the last few years I have visited two of the largest collections of insects in the world, one in Europe and the other in America, and have found types and cotypes which I had myself sent hidden away among the unassorted accessions, where nobody knew where to find them. They were not in any danger of destruction, to be sure, but they were for the present forgotten, and with the lapse of years they might well be in danger of complete oblivion.

The trouble comes, of course, from the fact that in most institutions certain orders are neglected from the lack of men to care for them. My own favorites, the bees and Coccidæ, are specially unfortunate in this respect, and I very rarely have the happiness of seeing collections of them that are in any way satisfactory. When recently in Washington I found the Coccidæ of the Department of Agriculture in process of arrangement, according to an admirable plan, so that here at any rate it will be easy to find any specimen upon the premises.

I was, of course, delighted at the sight; but it is exceptional and indicates a noteworthy reform. It is not to be supposed that every institution can follow it, because it means practically the entire time of at least one man.

I do not suggest that it is practicable to put all the collections in order everywhere; the thing is manifestly out of the question. I venture to propose, instead, two things:

(1) That all types and cotypes of groups not yet perfectly arranged shall be kept apart themselves in perfect order, pending the classification of the whole series to which they belong. In this way it would be possible to examine them, both for purposes of study and to see that they were not being injured.

(2) That all institutions receiving types and cotypes should publish annually lists of them, so that students might know what was available. These lists should include types based upon specimens already in the collection. Such lists would be far more valuable for practical purposes than the usual accession catalogues of museums, which remind one of the inventory of some old-fashioned curiosity shop. They would also amount to the public acknowledgment of the types received, with the accompanying recognition of responsibility. As a model of such a list as I propose, I can not do better than refer to the list of type fossils now being issued by the United States National Museum.

Those who describe new insects often have long series of cotypes which they would gladly distribute for the benefit of students if they could feel more certain that they would be properly cared for and made readily accessible.

The following paper was then read:

NOTES UPON A LITTLE-KNOWN INSECT ENEMY OF COTTON AND CORN.[a]

By WILMON NEWELL, *Shreveport, La.*

The cotton crop probably numbers among its insect enemies as many different species as any other crop of equal importance, and the literature treating of cotton insects has now become voluminous. With the study and attention that has been given cotton insects during the past few years one would not expect to encounter a species, seriously injurious to the cotton plant, concerning the habits of which little or nothing has been written.

[a] *Cicada erratica* Osborn, The Ohio Naturalist, Vol. VI, No. 6, pp. 497–498, April [14], 1906. At the time Mr. Newell's paper was presented this insect was considered as a variety of *Cicada nigriventris* Walker.—ED.

During the past summer a Cicada (fig. 1) was found doing serious damage over a considerable area in the Ouachita Valley of Louisiana. A search through the literature available to the writer has not revealed any reference to such a species as of economic importance, and although we are far from familiar with the details of its life history, it seems advisable to call attention to its destructiveness when occurring in considerable numbers, especially in view of the possibility of its becoming a serious pest should it become distributed over the cotton belt and occur in as great abundance as it does at present in the Ouachita Valley. In addition to this consideration, the habits of the insect are, so far as observed, decidedly interesting.

While collecting insects around an electric light in Shreveport on the evening of June 7, 1905, five Cicadas, two of which were males,

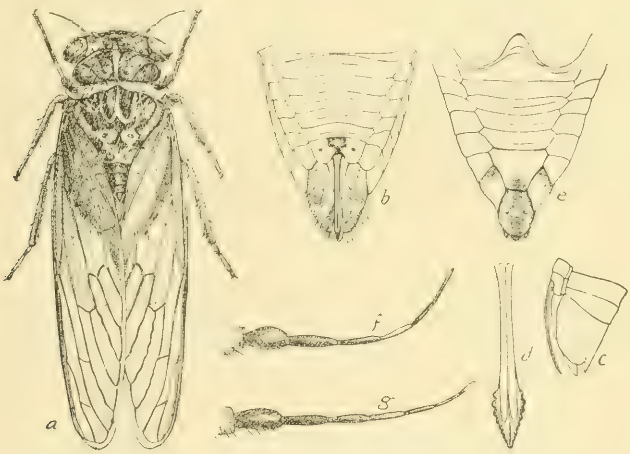

FIG. 1.—*Cicada erratica: a,* female; *b,* ventral view of female abdomen; *c,* side view of ovipositor and sheath; *d,* ovipositor; *e,* ventral view of male abdomen; *f,* antenna of female; *g,* antenna of male. All more or less enlarged (drawing by Miss Charlotte M. King).

were taken, and as they were new to the writer they were sent to Prof. Herbert Osborn, of the Ohio State University, who identified them as *C. nigriventris* Walk. var. (?)[b]

The work of the insect was first called to our attention by Mr. August Mayer, a well-known planter of Shreveport, who brought to the office of the crop-pest commission early in June cotton plants containing numerous egg punctures. While Mr. Mayer had not succeeded in locating the insect making the punctures, he had found the injury well distributed over his entire cotton field, although the damage was by no means excessive and did not compare with the more serious and extensive injury found in the Ouachita Valley later.

[b] Afterwards described by Osborn as *Cicada erratica*, n. sp., as stated in the preceding footnote.—ED.

The punctures in the cotton plants brought by Mr. Mayer were later identified as having been made by the species referred to.

On June 15 a number of adults were taken in a field of alfalfa at Vanceville, 7 miles north of Shreveport, and here, for the first time, the empty pupal cases were found. These occurred singly in various parts of the field, sometimes upon the ground, but more often clinging to the alfalfa plants a few inches above the ground. Their condition indicated that the adults had emerged from them not more than a few days previous.

About the middle of June newspaper reports told of serious damage to corn and cotton crops in the Ouachita Valley by "locusts," and these reports were of so unusual a nature that Messrs. E. S. Hardy and J. B. Garrett, assistant entomologists in the employ of the commission, were dispatched to that region to make an investigation. Mr. Hardy repaired to Columbia, Caldwell Parish, and Mr. Garrett to Logtown, Ouachita Parish, each conducting his investigation independently of the other. Neither gentleman was apprised of the findings of the other until after the reports of both had been submitted, and on all features of the problem which came under the observation of both their reports were identical. Local conditions, however, made it possible for each of the investigators to observe phases of the situation inaccessible to the other, and from the reports of both these gentlemen the following notes are taken.

The area of principal damage was found to extend from a short distance south of Monroe to a point several miles south of Columbia, and was confined, so far as could be learned, to the alluvial lands of the Ouachita Valley.

Near Logtown Mr. Garrett found the damage to both cotton and corn to be general over the farm of several hundred acres upon which he made his observations, the owner of the plantation estimating that about 20 per cent of his young cotton plants had been killed as a result of the egg punctures of the Cicada. Through this section and as far north as Monroe Mr. Garrett observed the insects in such abundance that they were continually seen flying against the windows of moving passenger trains.

In the vicinity of Columbia Mr. Hardy found the insect even more abundant and destructive. Upon one farm a cotton field was found in which the damage was so heavy that the owner found it necessary to plow the field and make a second planting, and on a large plantation the injury over the major portion was such as to render the prospects for a crop very uncertain.

Mr. I. C. Bridges, owner of a large plantation near Columbia, stated that the Cicada had done more or less damage each season for the past twenty years, but had not at any time been as destructive as during the season of 1905. In fact, Mr. Bridges furnished the only authentic account of the insect's prevalence during previous seasons that we were able to obtain. According to his observations the adults usually appear in June and, after egg deposition, disappear before the middle of July. Mr. Bridges, as well as others, was unanimous in saying that the insects were most abundant during dry seasons and in believing that prolonged rainy weather was fatal to the adults.

No predaceous enemies of the Cicada were noticed, but one farmer furnished a graphic description of an insect "with two stings," which sometimes caught and killed as many as 20 to 30 locusts "in a few minutes." Neither Mr. Hardy nor Mr. Garrett was able to locate the friendly insect corresponding to this description.

The cicadas were found in abundance in both corn and cotton fields between June 18 and 23, their preference for the corn being evident. The males were relatively scarce, for out of 80 specimens taken at random only 3 were males. This may possibly be accounted for by the fact that the females, preferring corn in tassel for egg deposition, were localized in the corn and cotton fields, while the males may have been generally distributed through the fields and forests and therefore much less in evidence. In case the adult males are shorter lived than the females, this would also account in part for the relative scarcity of the former.

Adults were not at any time found feeding, and the damage done was exclusively by the puncturing of twigs and stems by the females for egg deposition. In the case of the young cotton plants the punctures were made in the side limbs, in the main stem, and occasionally in the leaf stems. Punctures in the latter resulted in death of the leaves, and any considerable number of punctures in the principal stem was invariably followed by the death of the entire plant above the point of injury. The bud just below the injury sometimes gave rise, after the death of the top, to a sprout which gave promise of developing into a plant, much as a peach bud develops into a tree.

In the case of corn the attack was confined entirely to the stem supporting the tassel, death of the tassel resulting. Practically the only real damage to the corn is the diminution of the amount of pollen available, the ultimate damage in a case of injury of this kind being hard to even surmise. The egg punctures (fig. 2) were much more abundant upon corn tassels than upon the cotton stems and were located much nearer together, possibly because of the corn presenting less resistance to the ovipositor of the female than the more fibrous stalk of the cotton plant. A number of tassels, showing about the average damage, were taken to the laboratory and the eggs and punctures counted. The stems supporting three tassels contained 297, 181, and 215 egg punctures, respectively. A count of the number of eggs in each of many punctures in corn gave an average of 4 to 5 within each. The three stems referred to therefore contained in the neighborhood of 1,188, 724, and 860 eggs, respectively. It seems not unlikely that the eggs in each tassel represented the quota of a single female. Four females, which were taken while ovipositing on corn, were dissected and found to contain 192, 461, and 410 eggs, respectively, all of which were of nearly full size and apparently ready for immediate deposition. There was, of course, no way of determining how many eggs had been deposited by each of these females before her capture, nor how many more might have developed in the ovaries had she been left to continue depositing. It does not seem likely that the average number of eggs deposited by each female is less than 350, and if all the punctures found immediately adjacent to each other prove to be the work of only one female, the average number of eggs deposited will be found to be in the neighborhood of 1,000.

FIG. 2.—Eggs and egg punctures of *Cicada erratica: a*, egg punctures in stem of corn tassel; *b*, partial cross section of stem, showing eggs within cavities made by female. (Drawing by Miss Charlotte M. King.)

Upon the cotton plants, which were still small, the females were very timid, taking flight whenever one came near them, but in the cornfields they were much easier to approach. Mr. Garrett timed a number of females which were ovipositing upon corn tassels and found that the average time taken by the female to make an egg puncture and place from 3 to 6 eggs in it was from two and one-half to three minutes.

By June 23 Mr. Hardy found that in the vicinity of Columbia the adults were becoming less numerous, many dead cicadas being found in the fields and in the axils of the corn leaves. Large numbers of females, which had in some manner lost their ovipositors, were found flying in the cornfields, and occasional individuals, deprived of the entire abdomen, were found alive and active.

In the selection of places for egg deposition the females are decidedly cosmopolitan. Although the corn tassels were the preferred places, with the stems of young cotton plants as second choice, egg punctures and eggs were found also in the twigs of pecan trees, fruit trees of various kinds, cottonwood, sweet gum, honey locust, coffee bean, wild cherry, and in practically every variety of shrub or weed-like plant in or around the infested fields. Mr. Hardy found punctures and eggs in abundance in the boards of a roof covering a "cotton-seed house" in one of the infested fields. It is said in the infested neighborhood that when the laborers leave tools in the field while gone to dinner, the cicadas puncture the hoe handles so liberally that it is necessary to sandpaper the latter before they can again be used. We have not yet verified the existence of such an interesting habit on the part of the insect, although it is not entirely outside the realm of possibilities, for between barn roofs and hoe handles as host plants there does not appear to be any great difference.

In the roof of the shed-like building referred to, Mr. Hardy found old punctures, containing no eggs, evidently made the previous season, and this may possibly point toward one year as being the developmental period of the insect.

The egg is white, approximately cylindrical, bluntly rounded at the ends, and has its greatest width a little nearer one end than the other. The egg is slightly conformable to the cavity in which it is placed and is sometimes permanently distorted by unequal pressure against the surrounding tissues or against other eggs in the same cavity. In plants of a woody nature, having relatively tough bark, the upper end of the egg (next to the epidermis of the plant) was usually noticed to be more bluntly pointed than the lower. Eggs taken from punctures in corn tassels averaged 2 mm. in length by $\frac{3}{8}$ mm. in diameter. Within the puncture the eggs (fig. 2, *b*) are arranged side by side, not always parallel with each other, and usually extending downward at an angle of about 45 degrees with the surface of the stem in which they are placed. The egg punctures present an outward appearance not unlike those made by *Œcanthus niveus* De G. The puncture is rounded at its upper extremity and is pointed at the lower end. Punctures in young and tender cotton stems measured from $1\frac{1}{2}$ to 2 mm. in length by about $\frac{1}{2}$ mm. in width.

In cotton stems the punctures were not, as a usual thing, placed directly in a vertical line, but were arranged spirally, each puncture being placed a little to one side of the one next above it.

The number of eggs inserted through each puncture seems to be governed largely by the resistance offered by the tissue through which the ovipositor must be forced. Punctures in cotton stems contained from 3 to 5 eggs each, those in corn from 4 to 8, while in a weed having a hollow stem 75 eggs were found, all of which had been inserted through a single puncture.

We have not succeeded in determining the period of incubation, as eggs kept in the laboratory failed to hatch. The nymphal stage is not positively known to us.

The remedy for this insect will doubtless be found upon further study to consist of cultural measures. All of the cotton fields in which the injury was most severe were fields in which corn had been grown the year previous, and one farmer, in plowing a cornfield in the spring, noticed large numbers of insects which, from his description, must have been the nymphs of this species. If the nymphs are found to subsist upon the roots of corn or other vegetation in the cornfields, plowing at the proper time may prove to be an effective measure. The use of trap rows of an early variety of corn in the cotton fields, planted so as to come into tassel at the time of emergence of the adult cicadas, may serve to lessen the damage to the young cotton plants. Further studies of the insect's habits are necessary before satisfactory remedial measures can be suggested.

The following paper was then presented by the secretary:

HISTORY OF ECONOMIC ENTOMOLOGY IN HAWAII.

By Jacob Kotinsky, *Honolulu, H. I.*

"KOEBELE" METHODS IN ECONOMIC ENTOMOLOGY.

Entomology is never more fascinating to the interested layman in Hawaii than when presented in the alluring light of fighting pests by means of their natural enemies. In fact, this is the only kind of entomology that appeals to him. To the veteran economic entomologist such methods savor too much of "playing to the gallery" to sanction their adoption. And yet, reflected in sober thought, if by his manipulations man has overlooked the danger lurking in introduced insect enemies, has upset the balance of nature, can we not hope that by further manipulation he can further adjust nature with the balance in his favor? In other words, when plants or animals of a country are suffering unremittent serious injury from an insect pest it is reasonable to suppose, first, that the pest is of foreign origin, and, secondly, that the natural check to that enemy has been in some way eliminated. It is evident, therefore, that given the check species and with the elimination of its enemies we must succeed in creating a balance of nature in our favor.

INTRODUCTION OF INJURIOUS INSECTS INTO HAWAII.

When in 1820 the Boston missionaries came to the Hawaiian Islands they recognized the latent capabilities of the soil for yielding good crops, provided the plants were there. Taro and cocoanuts were good, but many more at least as useful plants were known to grow in other tropical and subtropical countries. There remained but the necessity to import them. And so, from that day to this the crusade of useful plant importation has been carried on in a most energetic fashion. Catalogues of dealers in ornamental and useful plants and seeds from the world over were diligently perused, and whichever pleased the fancy of the individual, and later the Government, was introduced, expense notwithstanding. Until comparatively recent times little was it suspected what evil pests these plant importations brought in their train. Fast as the country was being stocked with useful plants, the best from all over the world, it was equally fast being populated with most troublesome and injurious insects and fungi. Failures directly due to some of these were no doubt attributed to unsuitable climate, soil, etc. Time came when introduced vegetation, itself profusely inhabited by insect enemies that followed in its train about the world, drove the native flora and fauna into the mountain recesses. Time came also when the growing of one crop on immense areas—sugar cane—became a staple industry of the islands. Other crops were sought, and coffee growing seemed promising. But when their natural food increased the insects, too, began to prosper and multiply. The sugar-cane borer (*Sphenophorus obscurus* auct.) and cottony guava scale (*Pulvinaria psidii* Mask.), both introduced with their hosts, inaugurated a campaign of destruction. To save cane and coffee from imminent ruin some active measures against their insect depredators became imperative. The amount and variety of tropical vegetation adorning his dooryard has been from time immemorial the pride and delight of every resident of Honolulu. But these have of late years been marred by "blight." Cutworm, Japanese beetle, scale insect, aphis, and fungus are all "blight" to the Hawaiian. The streets were lined and yards were full of trees and shrubs dead and dying from the effects of a host of species of scale and other insects. Citrus trees and casuarinas were white with the cottony cushion scale (*Icerya purchasi* Mask.) and unsightly black with the dripping honey dew and consequent sooty fungus. Bad as the plants about some deserted residences still look, they stand no comparison with what they must have looked prior to 1890. The success attained by Mr. Koebele with *Vedalia cardinalis* Muls. was still proclaimed by the press, and about 1889 or 1890 this species was introduced into Honolulu. Here, too, this valuable little ally accomplished its mission and lent enthusiasm to the idea of the new economic entomology. In a note in Nature [a] Mr. Perkins records the fact that *Coccinella abdominalis* Say has been introduced, probably accidentally, from California years ago. It would probably have

[a] Vol. XV, p. 499, March, 1897.

accomplished its task of execution among the aphis here had not its parasite (*Centistes americana* Riley[a]) unfortunately been introduced with it. On his way to Australia, in 1891, Mr. Koebele released in Honolulu several specimens of *Chilocorus bivulnerus* Muls. Specimens of these he observed, though in limited numbers, in 1894 and 1897. None was seen since. So much for economic insect work up to the last decade of the last century.

THE ADVENT OF MR. KOEBELE TO THESE ISLANDS.

Although the sugar-cane industry was yearly growing more prosperous, the people of this Territory always feared the possible consequences of depending wholly upon a single industry. The continual agitation for another industry, which, because of the geological character of the islands, must be of an agricultural nature, always brought into prominence now one thing, now another. In the early nineties coffee growing was at the summit. Kona (so named from the district on the island of Hawaii where it was grown) coffee had acquired fame on the market for its exceedingly good flavor, and everybody was planting coffee. No one took into account the prevalence of *Pulvinaria psidii* Mask., which seems by that time to have been an old inhabitant of the island. But the day of reckoning was bound to come, and by 1892–1893 coffee fields were everywhere literally white with this scale. Some strenuous measures were inevitable or the new pet industry was doomed. It was useless to attempt to fight the pest with artificial means, because to every acre of cultivated coffee there are hundreds of acres overrun with wild guava, and much coffee grows wild, like cotton in the Southern States.

The Hawaiian sugar planters had by that time begun to learn the value of securing the best to be had of what they needed. They were ever, and still are, a set of progressive and aggressive men and the guiding spirit in movements of the kind we are considering. Mr. Koebele's work in the introduction of Vedalia was an inspiring illustration to them of what could be accomplished by means of natural enemies. And so they were determined to repeat the experiment of the Californians and secure Mr. Koebele to carry it out for them. Thus, conditions having attained a climax, the services of Mr. Koebele, the chief exponent of the new school, were engaged in October, 1893. He began, very wisely, by first shipping to Hawaii consignments of beneficial insects, native and introduced, from California. These consignments included several species of Hyperaspis, one of which, *H. undulata* Say, was observed some ten months later, though never seen here again since then. Many scymnids also were introduced, of which *Scymnus debilis* Lec., an enemy of *Pseudococcus* sp.,

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[a] Now recognized as a synonym of *Euphorus sculptus* Say.—Ed.

is now fairly common. *Chilocorus bivulnerus* was again sent in large quantities; yet, though observed as late as 1897, it was never abundant, and the writer doubts whether it exists upon the islands at present. *Rhizobius ventralis* Er. and *R. lophanthæ* Blaisd., which are still here and do valuable service, were then introduced. In his report for 1894 to the provisional government of the islands (pp. 98–101) Mr. Koebele lists the coccids found here and the coccinellids introduced from California. At that time, too, he sent several consignments of the toad, which was established here and, with as much cheer as is in the humor of a toad, performed the task imposed upon him of eating *Adoretus umbrosus* Fab. Much good would have resulted from the toad had not the mongoose proven so destructive to it.

About December, 1893, Mr. Koebele came to these islands and made a hasty tour of inspection to determine the nature and extent of the insect invasion. He reported his findings in the 1894 report, above referred to, and in March, 1894, sailed for Australia. During this trip "he has visited Australia, China, Ceylon, and Japan" [a] and sent from those countries many thousands of coccinellids, comprising some 200 species. More species, no doubt, would have been established then had Mr. Koebele had a competent entomologist stationed here to breed and take care of his consignments. For the same reason Mr. Koebele refrained from attempting to introduce parasites, as he states [b] that he sent coccinellids only, principally because he feared introducing new scale insects with the parasites. A very poorly concocted list of coccinellids, sent by Mr. Koebele during that trip, appears in the 1894 report to the minister of interior, pages 31 to 33. Of these coccinellids, perhaps no other species excelled *Cryptolæmus montrouzieri* Muls. Until this day its work of execution is evident on a good many species of Coccidæ. *Pseudococcus filamentosus* (Ckll.), otherwise a very ugly pest on many varieties of plants, dares not show its face for this useful ladybird. *Pulvinaria psidii*, once a threatening enemy of coffee, guava and other plants, is now far from a common species. Curiously enough, it will not touch the females of *Pseudococcus nipæ*, though it devours males with avidity. Few species of Pseudococcus are immune to it, in fact. The large variety of species of Coccidæ that it preys upon makes this coccinellid, it seems to the writer, a more valuable insect even than *Vedalia cardinalis*. *Platyomus lividigaster* Muls. and *Coccinella repanda* Thunb., the two most common and efficient aphis-eating coccinellids here, have alone saved many plants, especially citrus, Hibiscus, and sugar cane, from utter destruction. Unfortunately, the latter is subject to attack by *Centistes americana*. Strange to say, this parasite, while scarce in the

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[a] Rept. Min. Int., Dec. 31, 1895, p. 119.

[b] Rept. Min. Int. 1897, p. 114.

city, is fairly common in sugar-cane fields. Additional material of *Rhizobius ventralis*, too, seems to have been imported about this time. This useful ladybird is still in evidence, especially during the winter months of the year, upon trees infested with *Pseudococcus nipæ* Mask.

Unfortunately, the entomological reports published by Mr. J. Marsden are of too vague a nature to give one an accurate idea of the exact results of Mr. Koebele's importations. But in his roaming style Mr. Koebele gives, in his report to the minister of the interior,[a] a mine of information on the injurious insects, native and introduced, and their enemies found here. Over two years (1894–1896) seem to have been consumed in that trip of exploration, the results of which are no less a triumph than the original introduction of *Vedalia cardinalis* into California.

The shade, citrus, and coffee trees cleaned of their worst scale insects and plant lice, and the sugar-cane aphis materially checked in its progress, the intrepid fighter and acute observer and collector next turned his attention to Lantana and the hornfly (*Hæmatobia serrata* R.-D.), the two great impediments in the way of the cattle ranchman. Mexico being the native home of the former, and the latter being a common pest in the United States, Mr. Koebele turned toward the American mainland in 1898. California, Arizona, Mexico, and Peru were visited, and numerous insects shipped from there, as related in the entomologist's report to the minister of the interior for 1898, page 105. These comprised principally enemies of cow-dung maggots and parasites of the cabbage butterfly (*Pontia rapæ* Schrank). Some 20,000 specimens of *Copidosoma truncatellum* Dalman were liberated with the hope that they would prey on the larvæ of the numerous lepidopterous enemies here. From California a species of rock lizard (*Gerrhonotus carinatus*) was introduced and liberated on Lihue plantation.

In Morelos, Mexico, Lantana enemies were studied, but apparently none were then introduced. The introduction of plant parasites is always fraught with danger, and having been warned by authorities against such an attempt, Mr. Koebele seems to have refrained from the responsibility.

It is interesting to note that in the report last referred to Mr. Koebele devotes nearly two pages to remedial measures against the hornfly (*H. serrata*). This brings us to an interesting point in the activities of an economic entomologist in Hawaii. Granting that most of our insect pests, consisting, as they do, of introduced species, are most easily and as effectively kept in check by their natural enemies, we must remember that these are not always to be had at the entomologist's bidding. Repeated attempts to discover effective

[a] Dec. 31, 1897, pp. 105–137.

enemies of *H. serrata* have not met with success.[a] Ten years have passed in the meantime, and only temporary relief has been gained about barnyards by means of artificial remedies. Accordingly, the work of the official entomologist of Hawaii would embrace the following: (1) Efforts at introduction of specific enemies of the various noxious insects; (2) an all-embracing study of the pests, particularly those not checked by natural enemies; (3) experiments with cultural methods and remedies to be employed against injurious insects not otherwise taken care of; (4) a campaign of education along all lines, of those whose material interests are affected by insects.

We must reach the happy medium between the two extremes of exclusively "natural" and exclusively "artificial" fighters of insect enemies. In order to render aid to those whose crops or live stock are afflicted with pests not naturally bridled, we must study and prescribe cultural and insecticidal methods. By means of popular, well-illustrated publications we must acquaint our clientele with their enemies and friends in nature. Take clean culture, for example. In so far as it affects the life of the injurious insect we must advocate it. This, of course, implies a knowledge on our part of the methods of cultivation pursued in a certain crop, though on the face of it such knowledge seems beyond the range of our activity. In the absence of an effective enemy of *Sphenophorus obscurus* we advocate the stripping of cane and the burning of trash as a check upon that pest.

We have, it is true, some enemies of the purple scale (*Lepidosaphes beckii* Newm.) in *Chilocorus circumdatus* Gyll., *Orcus chalybeus* Boisd., and *Aphelinus diaspidis* How., but their economic value is very slight, and we should doubtless follow in wisdom's course by advising to shake the orange tree in order to expel what ladybirds there may be upon it and then spray it with an effective contact wash. Of course wherever possible we must bend our energies to import the natural enemy of every insect that is injurious. If funds for personal importation of such enemies can not be obtained we must resort to whatever other means are available. But we must bear in mind that the planter wants immediate, effective, and inexpensive means of fighting his enemies.

In autumn, 1899, Mr. Koebele went with Mr. George Compere to Australia and Fiji "to collect beneficial insects and plants for these islands," and the results are published in the report to the minister of the interior for 1900, page 36. *Ceroplastes rubens* Mask., once so common here, has been hardest hit by internal parasites sent during

[a] Since writing the above, *Spalangia hirta* Haliday, kindly determined by Dr. Wm. H. Ashmead, was bred from *H. serrata* pupæ collected on each of the islands.

this trip. The report just mentioned also includes observations on fruit flies, on the "Olinda bug" or Fuller's rose beetle (*Aramigus fulleri* Horn), on tineids bred from cotton, on silk culture in Hawaii, and on forest—principally koa (*Acacia koa*)—insects on Hawaii and Maui. From a scientist's standpoint the last report referred to is perhaps the most valuable of all. From this trip Mr. Koebele returned to Honolulu April 10, 1900, where he remained some two years. Inspection for insects on imported vegetation, which forms so important a work upon these islands at present, was up to that time either entirely neglected or placed in the hands of incompetents. This work seems to have been attended to by Mr. Koebele personally during these two years, and naturally was performed intelligently.

LANTANA INSECTS.

In 1899 the lantana scale (*Orthezia insignis* Dougl.) was discovered at Wailuku, Maui, by Mr. Gerrit P. Wilder. This discovery seems to have alarmed everybody but the ranchers, whom Mr. Koebele found distributing the insect in order to kill their lantana. Knowing the perniciousness of the animal and its destructiveness in Ceylon, Mr. Koebele, too, seems to have been considerably exercised over the coming of this unwelcome guest. Without much delay he rushed off to Mexico in the spring of 1900. His mission there seems to have had a dual nature. First, to find and introduce an enemy of *O. insignis;* second, since the ranchmen are so desperately anxious to kill off lantana as to place all vegetable life on the islands in jeopardy, to forestall an additional importation of this kind by introducing enemies of lantana not likely to affect other plants.

In Mr. Koebele's absence Mr. R. C. L. Perkins performed the functions of port inspector. Moreover, it was realized that the introduction of lantana insect enemies must be guided with the greatest possible caution, first, because of the absolute necessity of introducing species that are certain to confine their attention to lantana, and secondly, because Mr. Koebele had discovered that most of the lantana enemies in Mexico are infested with numerous parasites—primary, secondary, and even, I believe, tertiary. Mr. Koebele's superlative caution on the mainland had to be supplemented by a trained, careful entomologist here. For this work, too, Mr. Perkins was called upon, and he performed it, I believe, without remuneration. The tact, wisdom, and painstaking care he displayed in this trying task is borne out fully by the appearance of lantana everywhere at present.

What was accomplished during that trip is little short of marvelous. Perhaps a thousand species found on that plant in its native home were bred, examined, and their possible effects in their new home carefully weighed and considered. After due deliberation a number of them were selected to fight man's unequal battle with lantana. After eliminating their innumerable parasites they were sent on, and, after a second weeding out, liberated here by Professor Perkins. The result of their work is too evident to require comment. As a result of the combination of seed, flower, and leaf insects the lantana is now everywhere decidedly sick. In the lower places, where the water supply is more liberal, the plant is more resistant, but even there it is doomed. It is not our mission here to forecast the activities of these insects when lantana is no more. The primary object of ridding the country of lantana is well-nigh accomplished, and "apres nous le deluge."

While in Mexico it would seem Mr. Koebele prepared an article on *O. insignis*, which was published in the report of the commissioner of agriculture and forestry for 1902, page 54. Therein the author delineates the past history of the insect, its habits, plants likely to be attacked by it, and remedies against it, should they become necessary. In conclusion he urges strongly against its dissemination over the islands, although it was already known to exist on Maui and Oahu. Locally it is referred to as the "Maui blight."

THE SUGAR-CANE LEAF-HOPPER.

(*Perkinsiella saccharicida* Kirk.)

In Volume XXII, page 123, 1902, of the Planters' Monthly, Mr. Perkins sounds the alarm to the sugar industry in consequence of the sugar-cane leaf-hopper (*Perkinsiella saccharicida* Kirk.). This insect seems to have been introduced from Australia some time in 1897 and confused with the corn leaf-hopper (*Peregrinus maidis* Ashm.), which occasionally frequents cane fields. Ever since its introduction it has been on the increase, enjoying almost perfect freedom from natural enemies. Upon inquiry Mr. Koebele was informed that Mr. Otto H. Swezey had bred some parasites on leaf-hoppers at Columbus, Ohio. Mr. Koebele, therefore, journeyed thither, and bred and shipped many specimens to Mr. Perkins, who was left in charge here. Meantime, a native parasite (*Ecthrodelphax fairchildii* Perk.) was found attacking the cane hopper on Kauai, and numerous specimens of that insect were bred and distributed. Mr. Koebele also shipped hopper parasites from California, which were bred here and released. In the spring of 1903 the Territorial Board of Agriculture and Forestry organized a division of entomology, with Mr. Koebele as superintendent and Mr. Perkins as his assistant. In August of the same year the entomological arm of this Government was considerably strengthened by the addition of such powerful sinew as Messrs. G. W. Kirkaldy and F. W. Terry.

The introductions from the continent, as well as the native parasite, seemed to avail little, and a journey to Australia, the original home of the small but formidable hopper, was undertaken by Messrs. Koebele and Perkins in the spring of 1904. Many predaceous and parasitic insects of innumerable species were sent during this expedition, which closed about a year ago with apparent success. Several egg parasites (names published in Bulletin No. 1, division of entomology, Hawaiian Sugar Planters' Association Experiment Station) were introduced which promise to deal the death knell to the hopper host. In August, 1904, a reorganization of the entomological force took place, the Hawaiian Sugar Planters' Association having determined to fight its own battles by establishing an entomological division in connection with its experiment station. For this purpose they have secured the services of all the former entomologists of the Territory, adding Messrs. O. H. Swezey and F. Muir to the force. The Territory, on the other hand, while retaining the partial services of Mr. Keobele, has reenforced itself by engaging Mr. Alexander Craw, of California port-inspection fame, for the work of inspection and general supervision of its entomological division. Mr. Jacob Kotinsky was secured as his assistant, and Mr. C. J. Austin to help in inspection work.

Not a little credit for this entomological activity accrues to the Hawaiian Sugar Planters' Association. With a munificent liberality and with intelligent, well-directed efforts, in view of the urgent importance of the work, they have spared no pains to secure the best entomological help available to accomplish the desired ends, namely, the exclusion of noxious insects and the introduction of those which are beneficial.

Our history will be far from complete if we fail to record the creditable work in economic entomology accomplished by Mr. D. L. Van Dine, of the United States Hawaii experiment station, since its organization four years ago. A follower of methods pursued by the "fathers" of economic entomology on the continent nearest us, he has done much work of value to the inhabitants of these islands in general and to Honolulu in particular. In one respect he has no doubt excelled all other entomologists here, namely, by his popular publications and lectures. Our comparative immunity from mosquito onslaughts is due to his undaunted efforts in organizing a mosquito brigade and keeping the pest in check. With his popular bulletins and numerous lectures he has enlightened the lay mind on various entomological topics of immediate interest to everyone. The most regrettable fact in connection with the twelve-year history of economic entomology on these islands is the scarcity of popular literature, but with the present force at work it is to be hoped that this deficiency will be made good.

AFTERNOON SESSION, TUESDAY, JANUARY 2, 1906.

The following papers on miscellaneous insects were presented, discussion being postponed until the completion of the series:

NOTES FROM TEXAS.

By A. F. Conradi, *College Station, Tex.*

Toxoptera graminum Rond.—The southern grain aphis made such a thorough impression on the wheat farmers of northern Texas during that memorable outbreak of 1901 that at every recurrence of a sporadic attack the office of the State entomologist is flooded with letters. During two seasons we have been justified in consoling stricken sections with the forecast that the parasites were abundant and would no doubt hold the pest in check. The spring of 1904 was begun with good growing weather, but 1905 was one of the wettest in the history of the wheat belt of Texas. During both seasons the parasites were effective. Should therefore a cold, moist spell set in, it is a question whether these parasites would do the work, and the outcome could not be foretold. The writer has faith in crop rotation in checking the ravages of this pest. His observations tend to show that the attacks are much more serious on old wheat fields, while frequently rotated fields are entirely free. Thus the pest migrates from old wheat fields to rotated lands. Northern Texas has a good range of agricultural crops for systematic rotation. Many of the wheat fields have been sown to wheat for over fifteen years. A systematic rotation of cotton, wheat, corn, and alfalfa no doubt would greatly check the ravages of the "green bug." We furthermore have faith enough in the value of the parasites to establish a laboratory at College Station, hoping to be able to breed these natural enemies in sufficient numbers to supply these sections where sporadic outbreaks of the "green bug" occur. The value of the parasites in checking the outbreak of injurious insects is often so unmistakable in our work here in Texas that operating such a laboratory is fully justified. The chief outbreaks occur in the territory lying between meridians 95 and 98 and parallels 32 and 34.

Uranotes melinus Hbn.—This is a widely-distributed cotton pest in Texas. It threatens to be equally serious each spring. It is most injurious over the same area as the "green bug" (*Toxoptera graminum*), and southward between meridians 94 and 97 to the Gulf and westward between parallels 31 and 32 as far as Howard County. It is also seriously destructive in Nueces and Duval counties. Only the first brood is injurious, the second being generally checked by natural parasites. Should these parasites fail to appear some season, serious damage to cotton could only be avoided by most thorough application of Paris green or some other equally effective arsenical, *Loxostege similalis* Guen.—During the spring of 1905 this insect was terribly destructive over many of the cotton-growing counties of Texas east of the ninety-eighth meridian. In Texas it is primarily a cotton insect. It can be controlled with Paris green.

Epicauta vittata Fab.—In Texas this insect is associated with alfalfa. It appears in June and continues to the middle of July. Severe injury was wrought during the season of 1905, owing to the fact that growers were reluctant to use Paris green on alfalfa. Paris green dusted in the usual manner is thoroughly effective, and there is little danger of injury to stock by poisoning, especially where rain occurs before harvesting. The chief trouble in the application of Paris green by Texas farmers is that it is applied too profusely. Very often a hundredth part would be sufficient. The chief injury is done in the area between Austin, Wharton, and Houston.

Aphis gossypii Glov.—This aphis is the most destructive insect to garden crops in Texas. There is no satisfactory remedy known. Spraying with kerosene emulsion in the early stages is very effective, but reports of injury rarely reach the entomologist before the insect has become very destructive. The Texas department of entomology has experimented considerably with a dry tobacco fumigant, which gives promise, provided it can be operated practicably on a large scale. The chief source of reliance in securing a melon crop is in the abundance of parasitic enemies of the aphides. Experiments have been inaugurated for the coming spring to determine whether a supply of these parasites can be kept on hand to supply regions where they are scarce or absent.

Pomphopœa texana Lec.—This blister beetle is a serious plum and peach pest in the territory lying between meridians 98 and 99 and between parallels 33 and 34. Its chief injury is done in Clay County, where it is spreading from Thornberry as the chief center of infestation. It feeds on the petals, doing greatest injury at night. It is noticed when the plum and peach blossoms are in their prime. Feeding, mating, and egg laying go hand in hand. The female when engorged with several hundred eggs moves clumsily from blossom to blossom, scattering her yellow eggs as she goes. No observations on the larvæ are recorded in our notes on account of the impossibility of visiting the infested area at the proper time. The best remedy known at present is to jar the insects from the trees in the morning. They are clumsy, drop very easily, and are conspicuous, which makes it an easy matter to gather and destroy them.

Scolytus rugulosus Ratz.—During 1904 and 1905 this pest has spread considerably, and is now infesting nearly all of northeastern Texas east of Fort Worth and as far south as Terrell. It attacks chiefly apple and peach.

Nysius sp.—The species of Nysius which caused so much damage in 1904 were remarkable for their absence during the past season. They attack all of the cruciferous plants, and have injured Irish potatoes, wheat, and mesquite. No remedy is known to me.

Plectrodera scalator Fab.—This beetle is the most serious drawback to the growing of cottonwood as a shade tree. Its life history was worked out in northern Texas last season. The eggs are laid in cavities made by the adult on the trunk of the tree in June and are easily located by their cottony appearance. The larvæ become full grown by the following May. A tree less than 2 inches in diameter will invariably be killed. Thousands of young cottonwood trees are killed annually in this manner. A thoroughly effective method of destruction is the crushing of the eggs in spring and digging out the young larvæ. Examination should be made in southern Texas in the middle part of May, and in northern Texas in the first part of June.

Conotrachelus nenuphar Hbst.—The plum curculio is becoming very destructive to the peach orchards of Texas and the injury increases every year. In many cases over 25 per cent of the crop has been injured to such an extent as to be rendered unmarketable.

Corn weevils.—The rice weevil (*Calandra oryza* L.), Angoumois grain moth (*Sitotroga cerealella* Ol.), and granary weevil (*Calandra granaria* L.) are the most injurious insects of stored corn in Texas, and are here named in the order of their destructiveness. During the past two seasons the rice weevil has caused serious injury in the field and in the bin. During the past season it was found that the rice weevil began to migrate into the field during the second week in June. The Angoumois grain moth became very active a week later. On June 17 over 75 per cent of the adults of the rice weevil, as well as the grain moth, were entirely willing to leave the corn in the bin and migrate to the field. It is therefore important that the bins be fumigated twice after the warm weather sets in in spring, making the fumigations twelve days apart. In like manner, before the corn is stored in the fall the bin should be thoroughly cleaned and fumigated and every wagonload of corn before leaving the field should receive a charge of carbon bisulphid at the rate of 3 pounds to 50 bushels of corn. The wagon bed should be gas tight and covered with canvas or with a muslin previously saturated in linseed oil and dried. The fumigation should be continued while the grain is hauled home, as the shaking and jolting of the load will enable the fumes to penetrate every crevice. As soon as these recommendations are observed, the loss to corn in Texas will be considerably lessened.

INSECTS OF THE YEAR IN CUBA.

By Mel. T. Cook, *Santiago de las Vegas, Cuba.*

[Abstract.]

Of the field crops, the tobacco always suffers greatly from *Feltia annexa* Tr., which also attacks corn, velvet beans, cabbage, tomatoes, etc. *Prodenia commelinæ* S. & A., *P. eudiopta* Guen., *Chloridea virescens* Fab., and the larvæ of click beetles (Elateridæ) also do considerable damage. Comparatively little damage is done by *Phlegethontius sexta* Joh. Stored tobacco suffers greatly from *Lasioderma testaceum* Dufts.

The corn suffered greatly, and in some cases entire fields were destroyed by *Laphygma frugiperda* S. & A. *Heliothis obsoleta* Fab., *Feltia annexa* Tr., *Diatræa saccharalis* Fab., and certain coleopterous larvæ also did some damage.

The sugar cane suffered to some extent from *Diatræa saccharalis* Fab., *Heliophila unipuncta* Haw., and coleopterous larvæ. Both corn and cane suffered greatly from hemipterous insects.

Coffee suffered greatly from *Leucoptera coffeella* Stain., especially in the low lands.

Cotton was destroyed in various localities by the boll weevil (*Anthonomus grandis* Boh.) and in one place by *Eriophyes gossypii* Bks.

Vegetables suffered more or less from crickets, aphides, and coleopterous larvæ. Among the most common lepidopterous insects were *Pontia monuste* L. and *Plutella maculipennis* Curtis, on cabbage; *Diaphania hyalinata* L. on cucumber, pumpkin, etc.; *Lineodes integra* Zell. on egg plants; and *Papilio polyxenes* Fab. on umbelliferous plants.

Among the fruits, the oranges always suffer greatly from *Atta insularis* Guer., and in some parts of the island from *Solenopsis geminata* Fab. One of the most injurious enemies is *Pachnæus litus* Germ. The Coccidæ were numerous but usually kept in check by fungous and hymenopterous parasites. Among the other fruit insects were the *Robinsonia formula* Grt. on the canestel (*Lucuma rivicoa*), *Melanchroia geometroides* Walk. on grosella,[a] *Gonodonta maria* Guen. on custard apple (Anona), *Hypocala andremona* Cram. on Japanese persimmons, and *Apate carmelita* Fab. on avocado (*Persea gratissima*).

Among the most conspicuous enemies of the ornamentals were *Calpodes ethlius* Cram. on cannas, *Eudamus proteus* L. and *Erebus odora* L. on Leguminosæ, *Agraulis vanillæ* L. on passion flower (Passiflora), *Ithobalus* (*Papilio*) *polydamas* L. on Aristolochia, and *Pseudosphinx tetrio* L. on Plumeria.

[a] Perhaps a species of Cicca.—Ed.

SOME ECONOMIC INSECTS OF THE YEAR IN OHIO.

By A. F. Burgess, *Columbus, Ohio.*

The most serious pests observed or reported during the year will be considered under the following heads: Grain insects, orchard insects, and forest and shade tree insects. Some remarks will also be included concerning the mosquitoes of the State and a few other insects that caused injury.

GRAIN INSECTS.

The yield of wheat in Ohio for the year 1905 was above the average, but the acreage sown was considerably reduced. Very slight injury by the Hessian fly (*Mayetiola destructor* Say) was reported. Late in June complaints were made in nearly all sections of the State that the wheat heads were not properly filled out at the tip, and most farmers attributed this condition to the "weevil," which is more properly known as the wheat midge (*Contarinia* [*Diplosis*] *tritici* Kirby).

Several samples received with crop reports sent to the Department of Agriculture were examined, but no trace could be found of insects or insect work. Apparently the grain in the tips of the heads had failed to mature. On July 7 growing wheat near Columbus was examined and many heads found in this condition. Many of the straws and leaves had been attacked by the wheat rust, and a considerable number of plants were found which were injured by the work of larvæ of a species of Isosoma. Usually a hard spot was found between the second and third joint from the ground, which encircled the stem, cutting off the sap, and light yellow larvæ were found within.

Straws similarly infested were collected from shocks and stubble in Wood, Ottawa, Erie, Fairfield, Miami, Montgomery, Franklin, and Greene counties during July and August, which indicates that the injury caused this year was quite general throughout the State. As some farmers claimed that the actual amount of grain was from one-third to one-half less than the prospective yield, it is evident that a large loss resulted.

Parasites that were bred from these infested straws were determined by Prof. F. M. Webster as *Eupelmus allynii* French, which is a very common one, also a new species of Eupelmus and of Cryptopristus. The latter have not been described, but similar specimens have been bred by Professor Webster during the present year. The largest number of any of the parasites bred was of the latter species, and it is undoubtedly of considerable importance as a natural check of Isosoma.

ORCHARD INSECTS.

The San Jose scale (*Aspidiotus perniciosus* Comst.) has not caused so much damage to orchards as usual, owing to the amount of spraying that has been applied. Many gratifying results have been obtained with the lime and sulphur wash and its use has increased during the past year. Owing to the poor prospects for an apple crop, many orchardists believed it would not pay to spray in order to control the codling moth (*Carpocapsa pomonella* L.). The experience of the past three years indicates that, in spite of the many assertions concerning the ease with which this insect can be controlled, that frequent and careful spraying must be applied, and that orchards in unsprayed localities must receive special attention, particularly if the crop is light.

The plum curculio (*Conotrachelus nenuphar* Hbst.) caused considerable injury to apple orchards in the eastern part of the State according to observations made by Mr. Runner, one of the assistant inspectors. In cases where the greatest damage was done, the trees had not been systematically sprayed during the past few years. Eighty-five per cent of the fruit on one tree showed curculio marks and many of the apples had been punctured so many times as to be practically worthless. One spraying with Paris green during May gave little evidence of value for controlling the insect. Other orchards in the same section of the State that had been systematically sprayed for several years with arsenate of lead showed very slight injury.

During the past year the injury caused by the grape root-worm (*Fidia viticida* Walsh) has been slight and vineyardists have paid little attention to it. In several sections of the grape-growing area of the State serious losses resulted from the attacks of the grape berry moth (*Polychrosis botrana* Schiff.). In some vineyards examined the Concord, Niagara, and Catawba varieties were almost completely ruined and the actual loss was greater than last year.

FOREST AND SHADE TREE INSECTS.

The leaf-mining locust beetle (*Odontota dorsalis* Thunb.) has been notably abundant in the Ohio River counties during the summer. Hundreds of locust groves were practically defoliated, and the infested area was much larger than during the preceding year. The recent interest which is being taken in planting locust groves as a means of supplying posts, poles, and small timber is increasing, and this insect, unless checked in the future by some natural enemies, may be the means of causing great injury to young plantations of these trees.

Contrary to expectations, the elm leaf-beetle (*Galerucella luteola* Müll.) has not increased to an alarming extent during the present year and is known in only one locality of the State, viz, the city of Dayton. During the early summer many larvæ were present in localities that were badly infested the previous year, and many trees were defoliated. Large numbers of eggs were laid in July, but many of them failed to hatch. The weather after the middle of July was very dry and many larvæ of the second brood disappeared after molting once. An examination made in several sections of the city indicated that many of these larvæ died immediately after molting, and in such cases the trees were covered with fine dust, and the air was full of it. The only explanation for the general mortality of larvæ seemed to be that the dust had acted as a contact insecticide, thus effectually checking the increase of the pest. Some spraying was done during the summer, and this was, as a rule, effective.

The catalpa sphinx (*Ceratomia catalpæ* Bd.), an insect which has not previously been reported in Ohio,[a] was sent in from the southern part of the State this summer by Mr. G. A. Runner. A few large trees near Proctorville were almost stripped of foliage, and trees near Huntington, on the West Virginia side of the river, were seriously injured. On July 29 a new crop of leaves had been developed, and newly hatched larvæ of the second brood were feeding upon them. Many pupæ were found about 4 inches below the surface of the soil beneath the trees.

An investigation of the condition of catalpa trees in the city of Jackson, where they have been planted extensively along the streets, showed that this insect was present in large numbers and had been numerous for several years. Many owners were dissatisfied with the trees on this account, and some were cutting them. Quite extensive parasitism had appeared in Jackson, the species responsible for it being *Apanteles catalpæ* Riley, but large numbers of hyperparasites (*Hypopteromalus tabacum* Fitch and a few specimens of *Horismenus microgastri* Ashm.) were bred from larvæ. The record of the parasites reared from infested larvæ shows that they were outnumbered 4 to 1 by the hyperparasites; hence it was apparent that only a moderate amount of good was done in holding the sphinx larvæ in check.

Later in the season Mr. Runner observed the same species in Athens, Vinton, Meigs, and Gallia counties, all of these being located in the southeastern section of the State. He also found a small

[a] Prof. F. M. Webster informs me that he found this insect on catalpa trees in Lawrence County about the year 1896. The only published reference I have been able to find concerning it is a note that it occurs in "extreme southern Lawrence County, in Ohio," which he published in the Proceedings of the Indiana Academy of Science, in 1902, p. 100.

block of catalpa nursery stock which had been killed, owing to repeated defoliation by this insect.

The bagworm (*Thyridopteryx ephemeræformis* Steph.) has been found in the southern part of the State to a greater extent than usual this year, and *Melasoma scripta* Fab. has caused considerable injury by defoliating poplars in nurseries.

The willow borer (*Cryptorhynchus lapathi* L.) continues to spread, and the oyster-shell scale (*Lepidosaphes ulmi* L.) is a serious pest in the extreme northern section of the State.

During the past year a preliminary list has been published of the mosquitoes of the State. This has been accomplished through cooperation with Professors Osborn and Hine, of the Ohio State University. Seventeen species are known thus far to occur here, but no systematic collecting has yet been done with special reference to this family. Although the yellow-fever mosquito (*Stegomyia calopus* Meig.) has not been taken in the State, it is known to occur at Lexington and Louisville, Ky., and Evansville, Ind., the former locality being less than 100 miles from Cincinnati.

NOTES FROM NEW HAMPSHIRE.

By E. Dwight Sanderson, *Durham, N. H.*

An interesting feature of the past season has been an outbreak of *Cingilia catenaria* Cram., or "chain-dotted geometer," and commonly known as an "inchworm." The normal food plant of the caterpillars is the so-called "sweet fern" (*Myrica asplenifolia*), which often covers the rocky hillsides of New Hampshire, belonging to the same genus as the bayberry. During August these plants were stripped over considerable areas in many sections. When they had been defoliated the caterpillars spread to birch, wild cherry, apple, or whatever presented itself, including many common weeds. August 9, 1905, a piece of some 25 acres of stripped land, covered with scrub growth, was observed, upon which practically all of the sweet fern had been defoliated. The line of advance of the army of caterpillars was clearly visible, though at this time they were far less abundant than the previous week. Numerous predaceous and parasitic insects were found preying upon them, but probably 80 or 90 per cent were dying from disease. The exact nature of the disease remains unknown. The dead caterpillars became attached to the twig upon which they clung by means of fine threads—evidently of a fungous disease. Through the courtesy of Dr. L. O. Howard, specimens were submitted to the bacteriologists of the Bureau of Animal Industry, who reported that four organisms were isolated from the diseased larvæ, the most important being a bacterium. Preliminary experiments with a culture of the latter have been made upon larvæ of

Datana ministra Dru., without definite results, and further tests will be continued on the tent caterpillar (*Malacosoma americana* Fab.) in the spring. The effective work of this disease or diseases was quite miraculous, and we had great difficulty in rearing adults on account of it. Pupation took place August 10 to 12, and the moths emerged September 5 to 16. Moths were most abundant about the third week in September, when they occurred in such numbers as to attract attention generally, and could be seen in large numbers along the edges of streams and ponds. Moths were observed as late as December 1. Oviposition took place from about September 20 to the middle of October. The females alight on a weed or branch of any low-growing plant, and to this the egg may be temporarily attached, but it soon falls, and usually is merely dropped to the ground. The eggs are of a light-green color. The only previous record of outbreak by this insect that we have found is that by Doctor Packard in his Forest Insects,[a] of an outbreak in Pennsylvania nearly thirty years ago. The insect will hardly ever be of much economic importance unless its food habits change. Old residents in southwestern New Hampshire inform me that they remember three or four such outbreaks of this species during the last generation, but that each time the outbreak lasted but one season.

All of the common apple caterpillars, including the tent caterpillar (*Malacosoma americana* Fab.), red-humped apple caterpillar (*Schizura concinna* S. & A.), yellow-necked apple caterpillar (*Datana ministra* Dru.), and fall webworm (*Hyphantria cunea* Dru.) have all been unusually abundant this season.

The melon aphis (*Aphis gossypii* Glov.) also seemed to be more abundant than usual in the field and is possibly the most important enemy of cucumbers grown under glass. It is controlled very satisfactorily by fumigating houses with "the fumigating kind" tobacco powder.

During the summer of 1904 the brown-tail moth (*Euproctis chrysorrhœa* L.) spread as far north as Holderness and North Conway, N. H., nearly to the White Mountains. The spread for the present season has not been fully determined, but nearly all the southern part of the State is now infested. Although in many towns practically all of the nests were gathered last winter, there is a very noticeable increase this fall, and there can be little doubt that the moths again migrated northward from Massachusetts into New Hampshire as they did in 1904, when they spread over 60 miles in a few days.

The gypsy moth (*Porthetria dispar* L.) has, during September, been found for the first time in the towns along the New Hampshire coast. Every town from the Massachusetts line to Portsmouth was found infested, some 49 cases being found altogether in a merely

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[a] Fifth Rpt. U. S. Ent. Comm., 1890.

partial inspection along the main road, covering only a small part of each town. In two cases colonies were found which had been introduced in 1904. As far as we are at present able to ascertain, the infestation is confined to the coast towns. There can be no doubt that the insect was mostly introduced by the unusually heavy automobile traffic during the past summer. This suggests the possibility of introduction by automobile into New York or New Jersey. These infestations in New Hampshire represent an average spread of about 60 miles from the point from which the caterpillars must have been carried. This shows the possibility of a much more rapid spread of this dreaded pest than has been previously observed.

In the two cases where the pest was clearly introduced in 1904, from 25 to 30 nests were found in each instance this year. This is interesting as showing the possible annual rate of increase where the insect occurs in only small numbers. Where abundant, the increase is undoubtedly more rapid, though we have seen no observations upon the matter, for the predaceous enemies would not be relatively as effective. When it is considered that an egg mass contains 400 or more eggs, the mortality which allows but 25 or 30 females to mature is rather surprising.

An interesting case of injury by the toothed Dermestes beetle (*Dermestes vulpinus* Fab.) was brought to our attention in the fall of 1904. One of our largest manufacturers of ice-cream freezers sent us specimens of staves from tubs which they had exported to Germany for which payment had been refused on account of their having been badly injured by this dermestid. The Germans claimed that the insects probably laid their eggs in the uncut lumber and that they remained unnoticed until they developed in transit. This was, of course, impossible. The shipment was some six weeks in transit. The infested tub returned showed very clearly that the larvæ had eaten short burrows into the ends of the staves in which to pupate, some of the pupæ being found dead in them, but no larvæ. Undoubtedly the tubs were stored either at the dock or in the vessel near infested hides or other animal products, the larvæ swarming from them to pupate boring into the soft wood of the tubs. Previous records of such injury to wood are known.[a]

The entomological evidence furnished the company enabled them to settle the bill satisfactorily without loss. The incident brought out the present lack of exact knowledge of the life history of this and allied species and its importance to commerce; for, as in this case, the entomologist's evidence might fix the liability for loss upon the consignor, consignee, or transportation company.

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[a] See Insect Life, III, p. 344; Ent. Mo. Mag., IV, p. 161, 1884.

SOME INSECTS OF THE YEAR IN GEORGIA.

By R. I. Smith and A. C. Lewis, *Atlanta, Ga.*

Insects of the peach, apple, cotton, corn, grass, and grain crops are the ones that command the most attention each year in Georgia. During the season of 1905 several injurious forms have appeared on each of these crops, while in addition many insect pests of minor crops have been brought to our attention.

The San Jose scale (*Aspidiotus perniciosus* Comst.) still heads the list of scale insects in Georgia as being the best known and the most pernicious. The winter application of lime-sulphur-salt wash has proved to be an effectual remedy for this pest. One spraying in late winter is usually sufficient, though badly infested orchards are sometimes treated twice during the winter, preferably in December and February. For summer treatment of the San Jose scale we recommend the use of 20 per cent kerosene-soap emulsion on peach trees when the fruit is about 1 inch in diameter, or just after the fruit is gathered. Soluble petroleum oils have not been sufficiently tested in Georgia to justify our either recommending or condemning their use.

The cherry scale (*Aspidiotus forbesi* Johns.) is common in many orchards, but not often numerous enough to require spraying.

The peach lecanium (*Eulecanium nigrofasciatum* Perg.) has been found in a few peach and plum orchards this year. It is generally kept in control where lime-sulphur-salt wash is used during winter.

The West Indian peach scale (*Aulacaspis pentagona* Targ.) is still present in a few localities in middle and southern Georgia.

The peach borer (*Sanninoïdea exitiosa* Say) continues to be one of the most dreaded of peach insects. Repellent washes have not proved to be satisfactory in preventing the depredations of this pest. Work done by Prof. H. N. Starnes, of the Georgia experiment station, goes to show that mounding the earth around the base of peach trees about August 1 to compel the borer larvæ to establish themselves well up on the trunks, and the early removal of these mounds, about the last of October, followed by thorough scraping and worming and application of some caustic wash is the most satisfactory way of fighting this insect. This work may be supplemented by spring worming if necessary.

The fruit-tree barkbeetle (*Scolytus rugulosus* Ratz.) has been more in evidence this year than commonly; and this we think is due largely to the fact that many peach trees were injured by the cold winter of 1904–5, rendering them more susceptible to attacks from this insect. During June and July many letters were received from all parts of Georgia stating that this barkbeetle, or shot-hole borer, as it is more commonly called in Georgia, was killing numbers of trees in the young orchards. Investigation of several of these cases revealed the fact that many of the trees thus reported as being killed by the shot-hole borers had been previously injured and weakened by peach borers, cold weather, or through injury by cultivation or lack of same. In a few cases, however, apparently healthy trees were being badly attacked, leading us to the conclusion that healthy trees are sometimes seriously injured by the barkbeetle, in spite of opinions by eminent authorities to the contrary.

Numerous orchards last spring showed the work of the peach-twig borer (*Anarsia lineatella* Zell.), but the damage resulting was not great. Orchards which had been sprayed the winter before with lime-sulphur wash were for the most part uninjured.

The plum curculio (*Conotrachelus nenuphar* Hbst.) was abundant during 1905 in many orchards and caused considerable loss of fruit. Much good work toward controlling this insect in Georgia is done each year by gathering all fallen fruit every two or three days, this practice being followed by many of our largest orchardists. The jarring method for capturing the beetles is practiced in some few orchards with good results, but this method of fighting the curculio is not generally accepted because of the amount of labor necessary to successfully carry out the operation.

The southern June beetle (*Allorhina nitida* L.) was observed June 29, 1905, at Baldwin, Ga., eating the leaves off the young shoots of peach trees.

On April 8 a nurseryman at Rome, Ga., sent specimens of the tarnished plant bug (*Lygus pratensis* L.), and stated that they were severely injuring young pear stock in the nursery rows. May 22 a similar report came from Buff, Ga., except that the insects were working on young apple grafts. We advised spraying with kerosene emulsion at 15 per cent strength, which was found to be successful.

The gloomy scale (*Chrysomphalus obscurus* Comst.) is found in nearly all parts of Georgia on the oaks and maples. In the city of Atlanta it is almost impossible to find a tree not infested.

Several common apple insects have been injurious in Georgia this year, among which the following are the most important:

The woolly aphis of the apple (*Schizoneura lanigera* Hausm.) is nearly everywhere abundant, and particularly in the older apple orchards. The aerial form is not serious, nearly all the injury from this insect coming from the ground form, in which it is too often allowed to increase unmolested. Tobacco dust has been used with some success on the young orchards, but we have found it necessary to make at least two applications of dust each year to insure even partial success.

A series of experiments was started by our department with a view of finding a good remedy for the underground form. The work was mainly conducted by Harper Dean, jr., field assistant entomologist, and the result of the first year's work has been reported in the proceedings of the Georgia State Horticultural Society for 1905. The work with tobacco dust was not entirely successful; other forms of tobacco, alone and with kainit, also gave doubtful results. Kerosene emulsion at 20 and 30 per cent was found to be the best remedy, but further tests will be made before it is generally recommended. We have found that kerosene emulsion may be used as a dip for the roots of nursery stock without apparent injury to the trees. We have controlled the aerial form in the usual way.

The codling moth (*Carpocapsa pomonella* L.) has been noticed more or less in all apple orchards. In the best apple orchards of Georgia proper spraying methods are followed, and this insect reduced to a considerable extent.

The apple aphis (*Aphis pomi* L.) was present in a number of orchards, and in a few cases the damage to young trees was quite severe. We have found that a strong tobacco decoction is somewhat superior to kerosene emulsion for controlling this insect. Much good work could be done in young apple orchards during winter by finding and removing the twigs bearing the winter eggs.

The oyster-shell scale (*Lepidosaphes ulmi* L.) occurs in several apple orchards, and one report this year stated that a few trees had been killed at Rome, Ga.

The apple-tree tent caterpillar (*Malacosoma americana* Fab.) was reported from Washington, Ga., with specimens, on April 21, and from caterpillars collected at Hapeville, Ga., we reared adults, which emerged May 8. This caterpillar is apparently not very abundant in Georgia, though appearing every year.

Early in April the newspapers of Georgia began to report a serious invasion of caterpillars in Chatham County, near Savannah. These reports said that the caterpillars were present in such numbers that people had to dig ditches around their homes to stop the caterpillars from entering their houses, and that they got on the railroad tracks so thickly that trains could not pass. We immediately investigated these reports and found that the caterpillars in question were the forest tent caterpillars (*Malacosoma disstria* Hbn.), and that they were really present in alarming numbers in the swamps about 12 miles from Savannah. The caterpillars on April 27 had nearly stripped the trees over several acres, leaving only the evergreen species. The following forest trees were attacked: Oak (all species), sweet gum, hickory, willow, and also plum, peach, and apple trees. They did not attack the cultivated crops in the gardens, except cabbage, which had been eaten a little in one place. It was true that the caterpillars got into houses and caused much discomfort to the inmates, and in one place they got on the railroad track, rendering it slippery, so that trains had a hard time getting past. Many caterpillars were collected and placed in a breeding cage. May 8, caterpillars were beginning to pupate; May 24, moths were emerging rapidly; May 27, females were depositing eggs.

An interesting occurrence of injury to pecan trees was first brought to our attention April 7, when we received a letter from Monticello, Ga., stating that some insect was eating the buds and leaves as fast as they appeared from a grove of pecans, which averaged 10 to 12 feet high. Investigation brought out the fact that the damage was caused by two species of Lachnosterna, namely, *inversa* Horn and *hirticula* Knoch. The adults worked on the trees mainly at night, eating the opening buds and entirely preventing the foliage from developing. A method of jarring the trees at night and capturing the beetles on a sheet was suggested as a remedy.

Among the cotton insects several common forms have been present this year, and at least one species not heretofore considered of importance in Georgia.

The cotton caterpillar (*Alabama argillacea* Hbn.) was not as abundant as usual, though present in a number of counties in middle and southern Georgia. Its late appearance in considerable numbers rendered it of almost no consequence.

The bollworm (*Heliothis obsoleta* Fab.) was also rather unimportant this year, though we were expecting its appearance in considerable numbers, because of the great amount of injury reported in 1904. Remedial measures were not necessary so far as we are aware.

Luperodes brunneus Cr. made its appearance in nine places in at least six different counties in the period between June 20 and July 5. The counties in which it appeared were rather widely separated, thus rendering the outbreak the more remarkable. The beetles appeared in great numbers in all cases, feeding on the leaves, squares, blooms, and young bolls of the cotton plants. Their favorite place for feeding was in the opening blooms, from which they would eat the entire center and sometimes the petals. At night they would gather in solid masses on the under side of the leaves and in the squares. It was not uncommon to find as many as 100 on a single leaf. Untold damage was reported, the letters received stating that whole fields of 50 acres or more would be devoured in a few weeks if the beetles were not checked. The reports, of course, were sadly exaggerated, but the excitement caused by the appearance of this beetle was intense, while it lasted, and led us to investigate. We found it true that some plants were entirely destroyed and sometimes several hundred in a spot badly injured. Just where the beetles came from we could not tell. Paris green in dry and wet form was recommended as a remedy and was used in a few places. It was our intention to give the poison a thorough test, and a special trip to Vienna, Ga., was taken for the purpose of making an experiment. Upon arrival, however, the beetles had so far disappeared as to render poisoning unnecessary. Further investigation showed that the beetles disappeared in two or three weeks as suddenly as they had formerly appeared. For want of any accepted common name we have given this beetle the name, "the new cotton beetle," for it is new to the cotton growers of Georgia, and for a time it certainly looked as though the damage caused by it might be serious. The ultimate injury was not great, as the beetles did not spread far from where they first appeared.

The cotton red spider (*Tetranychus gloveri* Bks.) appeared in several cotton fields this year, sometimes covering 2 or 3 acres in a field. Dusting with sulphur and spraying with kerosene emulsion was said to give relief in some places.

Among other cotton insects collected in Georgia this year may be mentioned the sharpshooter (*Oncometopia undata* Fab.) and the cotton leaf-bug (*Calocoris rapidus* Say); also *Nezara hilaris* Say and the cotton aphis (*Aphis gossypii* Glover). None of the last four insects mentioned have caused serious damage, although the cotton aphis was abundant as usual.

On July 24 a letter came to the office from Statesboro stating that some worms had destroyed a 4-acre field of German millet. This insect proved to be the fall army-worm (*Laphygma frugiperda* S. & A.), as determined from one half-grown larva. Unfortunately, we could not get specimens to rear, as the worms all disappeared within a few days after the report. Our correspondent stated that the English sparrows devoured thousands of them, though we believe that they were then entering the ground to pupate. This same worm was observed in a pear and plum orchard in Augusta feeding on the crab grass. From larvæ collected at this point adults were reared September 9.

The Hessian fly (*Mayetiola destructor* Say) is found in all the wheat fields of Georgia. The spring brood appearing in many fields last spring must have come mainly from the volunteer wheat, as nearly all the wheat in the fall of 1904 came up so late—owing to dry weather—that it was not then infested. Wheat planted early this fall has been found infested to the extent of 96 per cent. Many of our wheat growers are being brought to see the value of late planting and destruction of the volunteer wheat.

Crambus pascuellus L. was reared from one larva collected from a corn field near Atlanta. Apparently larvæ of the same species were collected from corn at Ringgold and Summerville, though we were unsuccessful in rearing adults. This species, we understand from Doctor Chittenden, has never been reported as feeding on corn before.

At first its work was mistaken for that of the common Southern corn budworm (*Diabrotica duodecimpunctata* Ol.), which was noticed at several points in Georgia besides the places mentioned above.

Specimens of the common potato beetle (*Leptinotarsa decemlineata* Say) came in the mail frequently during April and May.

The harlequin cabbage-bug (*Murgantia histrionica* Hahn) was very abundant on cabbage, collard, and turnip during 1905.

On July 18 a crib of corn containing over 200 bushels of ear corn was found by Harper Dean, jr., at Cycloneta, infested with thousands of weevils (*Calandra oryza* L.). The destruction of the corn was almost complete when the weevils were discovered. The use of carbon bisulphid at the proper time would have saved many dollars to the owner of this corn. We mention this partly to show what little attention is given to many insects until the damage becomes so apparent that it can not be overlooked.

Several garden and field crop insects have been more or less common in Georgia this year, but space will not be taken here to mention them.

ENTOMOLOGICAL NOTES FROM MARYLAND.

By T. B. Symons, *College Park, Md.*

Insect depredations in Maryland the past year have not been out of the ordinary. The annual visitors have appeared, inflicting their usual injury to a greater or less extent.

The San Jose scale (*Aspidiotus perniciosus* Comst.).—As in many other States this is the paramount pest to combat. While the insect is now generally distributed throughout the State, there is every evidence of confidence among the orchardists that the pest can be successfully controlled. The State entomologist is here confronted with like troubles as, I presume, in other States as regards the patent insecticides which are being placed on the market. It is really amusing at times to observe how easily the orchardists and farmers are taken in by a smooth-tongued salesman. It seems difficult for them to wait and allow the proper authorities to experiment with any new solution and report the results. In regard to treatment employed in Maryland, we continue to find the lime, sulphur, and salt wash to be the cheapest and most effective remedy, and one universally used. Our experiments with the wash the past year lead us to believe that where only one application of the wash is made it should be applied as late in the spring as possible. Further, that it is advisable to use a stronger wash in treating badly infested apple trees, say 25 pounds of lime and 20 pounds of sulphur to 50 gallons of water. It was also demonstrated further that salt is not a necessary ingredient to the wash. The patent insecticides prominent on the market in this State have been given a fair trial, and in no case did the results prove satisfactory, while in making and applying the same we were particular to follow explicitly the directions given by each manufacturer. Rather extensive experiments were conducted in fumigation of nursery stock the past year. The strengths used varied from the normal 1–2–4 formula to six times the normal strength, and the time of exposure one-half and one hour in each case. The results were very satisfactory, as in many cases not a single tree in a lot of ten exposed in the strongest gas for one hour appeared to be injured.

The oyster-shell scale (*Lepidosaphes ulmi* L.) has been reported from several localities as doing much injury. It is peculiar that in the extreme western part of the State, where the San Jose scale is not present except in a few places, the oyster-shell scale seems quite generally distributed, especially on apple trees. We have observed many orchards to be very badly infested with the pest. Many reports and specimens have been received of this insect injuring and killing maple trees in several parts of Maryland. We are now conducting experiments with different treatments for this insect on maple trees.

The codling moth (*Carpocapsa pomonella* L.).—This, one of our annual pests, inflicted its usual injury in Maryland the past year. The results of our experiments in testing the profit to be gained by spraying apple trees with an arsenite at the proper time were very encouraging. The comparison of the per cent of good and wormy fruit from sprayed and unsprayed trees in the experiment station orchard shows the ratio of 1 to 10 in favor of the treated trees. This result to a greater or less extent was very plain in all the different varieties that were included in the experiment. No comparison could be drawn between Paris green and arsenate of lead for superior use as an arsenite.

The little leaf-hoppers of the family Jassidæ were especially numerous the past year. Of these the grape leaf-hopper (*Typhlocyba comes* Say) did considerable injury to grapevines. Several other species were observed doing unusual injury to various other plants.

The army worm (*Heliophila unipuncta* Haw.).—The appearance of this insect in early fall in injurious numbers, as observed by the writer on one farm in Prince George County, was one of the novel entomological features of the year. The insect was brought to our notice by a report that "a field of millet was being destroyed by some worm." We were unable to visit the place for some time afterwards. Upon investigation, however, we found several larvæ and a great many pupæ, which were located under rubbish around and in the field. The insect did not spread from this field, as is usually their habit. At the time of our observation it was too late to employ remedial measures except to prevent, as far as possible, their reappearance next season.

Several pupæ and larvæ were taken, one adult appearing a short time afterwards. As far as I am aware this insect has not been reported in injurious numbers in Maryland for many years past.

The cabbage hair-worm (*Mermis albicans* Diesing).—Four specimens have been sent to the office of the State entomologist for identification. Accompanying each the usual distress has been expressed as regards eating affected cabbage.

The southern corn root-worm (*Diabrotica duodecimpunctata* Ol.).—This insect has caused apparent total destruction of a small field of sweet corn on the experiment station farm. The fact that the piece of land was low and uncultivated for some time is an explanation for the severity of the attack.

The catalpa sphinx (*Ceratomia catalpæ* Bdv.).—The larvæ of this insect were especially numerous the past season. Many specimens were received at the office and much injury observed to catalpa trees in many parts of the State.

The woolly apple aphis (*Schizoneura lanigera* Hausm.).—This insect continues to cause injury in orchards as well as in the nurseries. The results of the use of two applications of tobacco dust in the nursery on Ben Davis apples were very encouraging.

Mosquitoes.—A preliminary investigation of this class of pests was begun in Maryland the past summer. The work was conducted by Mr. A. B. Gahan, assistant entomologist, and Mr. T. Homer Coffin. About 23 species were found in and around Baltimore. It is hoped that we may be able to make a thorough investigation of the number of species occurring in the State and employ means for suppressing them.

INJURIOUS INSECTS OF 1905 IN MINNESOTA.

By F. L. WASHBURN, *St. Anthony Park, Minn.*

This has been a year of surprises in that certain destructive pests have been unexpectedly active, while others, which we will always have with us and which usually work havoc each year, have done little or no injury during the past season. The Hessian fly (*Mayetiola destructor* Say) has been present on grains and grasses, but to a limited extent, not sufficiently noticeable to cause complaint. The chinch bug (*Blissus leucopterus* Say), companion pest of the Hessian fly, has been conspicuous by its absence, though a few were reported from one or two localities.

I have to report quite a serious loss to farmers who would raise alfalfa seed, through the voracious appetite of the red-legged locust (*Melanopus femur-rubrum* De G.), which prevented the formation of seed on many acres in Hennepin County. This was not reported to the entomologist until the damage was done. In fact, the farmers themselves did not realize the havoc which was quietly going on in their fields until too late to prevent it. I have little doubt that next season, forewarned as we are, a repetition of this can be prevented.

Early in the summer various species of cutworms were reported bad in certain sections, flax-growing districts being perhaps the worst sufferers. No specimens reached us with the complaints. In June many inquiries were received regarding galls on plums. This trouble was caused by a small mite known as *Eriophyes padi* Nal. It has been troublesome before this date, being reported from Minnesota in 1884. The cottony maple scale (*Pulvinaria innumerabilis* Rathv.) has been again a serious pest. The stalk borer (*Papaipema nitela* Guen.) was again destructive, as was the corn-ear worm (*Heliothis obsoleta* Fab.). A serious report of this pest reached us from Cannon Falls, where "every other ear" was said to be infested. We have had our usual quota of green cabbage worms, potato beetles, and insects affecting squashes and melons. Potato beetles were reported as being especially bad in the northern part of the Red River Valley. The white grub, larva of *Lachnosterna* sp., has ravaged lawns to a marked extent, its injuries being particularly noticeable in cemeteries and like situations, where large tracts of grass make it a difficult pest to conquer. In the course of our experiments we discovered that the grub could stand immersion in a very strong tobacco solution for several hours without serious results, apparently. Hellebore was used in various ways without success. We have in mind two preventive measures, which we shall test next season if opportunity offers.

Bruchophagus funebris How. was reared in quantities from crimson clover in July. Varieties of thistles, among them the Canada thistle, were noticeably preyed upon by the larvæ of *Vanessa cardui* L. and many of these weeds were killed thereby. While abundant, these caterpillars were not sufficiently numerous, of course, to eradicate thistles, and, it must be confessed, also turned their attention to garden plants—hollyhock, Calendula, etc.

Mention has been made above of a troublesome gall-producing mite on the leaves of plum. We have to report also, in this connection, cecidomyiid gall makers again injuring leaves of soft maple and box-elder; and the cockscomb gall locally abundant on leaves of white elm. In one county we secured specimens of the peculiar globe-like galls on red elms, caused by *Pemphigus ulmifusus* Walsh. The plum curculio (*Conotrachelus nenuphar* Hbst.) made its appearance felt on apples, as well as plums, and the New York weevil (*Ithycerus noveboracensis* Forst.), working on fruit trees, was complained of in some sections. A lepidopterous borer (*Podosesia syringæ* Harr.) attacked young ash trees near Adelaide, so weakening their trunks as to cause them to be broken down by the wind. A green sawfly larva worked on the leaves of ash trees, and is at present in our breeding cages, awaiting its transformations, that we may identify it.

Four houses in the Twin Cities—Minneapolis and St. Paul—to our certain knowledge, and there were doubtless others, have been overrun with the so-called "book-lice" (*Troctes divinatoria* Müll.). In these particular cases these tiny pests swarmed in bureau drawers and closets, over clothing on walls, and the backs of pictures, and, in fact, in every place where their presence was likely to disgust a sensitive housekeeper. We made an effort to free two houses of this unwelcome guest, and partial success was attained by the use of hydrocyanic-acid gas, the families vacating the premises in question for about thirty hours. We were unable to locate the starting point or breeding place of the insect in these two cases. It is significant that all of the residences known to be infested are new houses, built within a year, the present occupants being the first to use them. We are constrained to believe, from our observations, that these insects came from the space between the walls or under the floors, or both. A curious fact was noted in connection with this piece of work. I have always been led to suppose that this hydrocyanic-acid gas will not affect metal, if it is perfectly dry. We had every reason to believe that the silver and other metallic objects in these houses were free from moisture, and yet when we finished we found that the silver which was outside of the drawers in the dining room was tarnished, as was all the nickel on the range in the kitchen, and the exposed plumbing in the bathroom, which was plated with nickel. The silver was restored to its pristine brightness by a jeweler, but the family has been unable to get rid of the dull-brown discoloration on the nickel work. This could be easily prevented by the use of vaseline, if one had reason to suspect a recurrence of the trouble. Before this fumigation we suspected that these insects might have their origin in the filling between the floors. This filling is made of a dried seaweed. But if this was so, we failed to discover it upon taking up some of the flooring and examining the filling in question.

Another family, which for two years or more has been troubled by that very common household pest, the little red ant (*Monomorium pharaonis* L.), has appealed to the entomologist for relief. We find that these insects come from the walls of the furnace room in the cellar, supposedly having their nests between the double walls in this locality, or in the soil outside far below the frost line. At date of leaving St. Anthony Park we are still fighting this ant, having used many pounds of bisulphid, with an apparent lessening of their numbers, yet we still find some coming through cracks and crevices of the plastering.

An interesting piece of work of the year, and perhaps the largest operation of the kind ever conducted with hydrocyanic-acid gas, has been done in the elimination of the Mediterranean flour moth (*Ephestia kuehniella* Zell.) from a large mill. This mill is six or seven stories high, and we fumigated not only the mill proper but the warehouse, cleaning house, and elevator, amounting in all to over 3,000,000 cubic feet of space. We used a ton of cyanide of potash and a ton and a half of sulphuric acid. The operation was in every way successful. The bags of cyanide were lowered into the crocks on all of the stories from the outside without a hitch, and ventilation secured equally easily on all the stories.

A curious accident, if it might be called such, occurring after the fumigation—an accident which might happen in any such operation, probably, but since it would occur when the building was open for ventilation, would hardly result disastrously—came to our attention. We were in the mill, and the men were removing the crocks, when one of them came running to me, with a somewhat pale face, stating that when he took hold of the string to lift the fragment of the bag from the jar a piece of cyanide almost as big as his fist dropped into the acid and gas began immediately to be given off. It was an easy matter to shut off that room from the other part of the mill, where the men were working, and the open windows soon carried off the deadly fumes. Apparently, in tying the cyanide up in the paper bag a piece, probably not as large as the man in his excitement supposed, had become fastened in the conical top of the package and was held there by the paper until the bag was shaken.

A question of some interest to entomologists was raised in connection with this work, upon which I should be glad to hear your opinion, namely, as to what constitutes successful fumigation in a flour mill. After the operation to which I refer was finished, several of us made a careful search through the mill, and in some of the fine flour which had gathered at the base of the spouts on the first floor we found two living worms among the thousands of dead ones, and later one living moth was found flying in the mill. This firm at first made the absurd claim that the operation was not successful, since they had found these three living insects. I believe I convinced them, however, that they were mistaken in their judgment, arguing that in a mill infested as theirs was there were many millions of moths in some stage before the mill was in such a condition as to call for the radical treatment we had just given it, and that even if we found twenty times that number of larvæ after fumigation, and half of those larvæ should, barring accidents, transform into female moths and lay eggs, it would nevertheless be a number of years before the mill would be sufficiently infested from this source to need another treatment. They finally yielded my point. Since this matter may present itself to any one of us, it may be worthy of a moment's consideration upon your part. Of course, the best time to fumigate a mill is in the spring or summer, nevertheless in any season there are bound to be some larvæ or pupæ secreted around the crevices of the windows or in other situations where the gas does not affect them.

Out of the 77 nurseries in this State we have inspected, according to law, 45. As you will see by looking at the Minnesota law, inspection of all nurseries is not obligatory. We found the nurseries for the most part in excellent condition. A weak point in our law, however, has been brought to our attention. One or more nurseries evidently buy trees from the South, from a region affected by the San Jose scale, and sell to Minnesota patrons. It does not follow, necessarily, that their trees are infested with this dread scale, because those districts are fairly well controlled by inspectors, but it is not, as we know from experience, a difficult matter for an infested tree to be overlooked. The present law gives the entomologist no option; a man may own only a single acre of ground, or none at all; he may have only a thousand trees or less, on rented ground, his entire business consisting of buying and selling, yet the entomologist's certificate goes upon all trees handled by his agents, no matter from what part of the country the trees may come. This is probably a matter which can not be remedied here, and at any rate it would be more properly discussed in a meeting of horticultural inspectors, and not before this association.

Experiments against the leaf-hopper (*Empoasca mali* Le B.) in large nurseries have been continued during the past season. We have used kero-water—1 part kerosene to 15 parts of water—with considerable success. We find, however, that, although we killed the young hoppers, and the old ones also when well treated, nevertheless the trees are again infested from sources outside of the sprayed portion. The work will be continued another season. This pest has not apparently been as troublesome this year as in preceding years.

Our chief experimental work during this summer has been against the cabbage maggot (*Pegomya brassicæ* Bouché), and a report devoted to this pest will be made later. As far as we have gone with the work, we feel that the maggot can be controlled by the use of the well-known carbolic emulsion. Tarred paper disks are not practicable in Minnesota for many reasons. In the first place, cabbages are undoubtedly raised in much larger numbers here than where the tarred paper has been found successful. Secondly, the nature of the ground where cabbages are for the most part planted is such that the paper can not be so applied as to prevent the fly from ovipositing beneath it. Further, in cultivation the earth is thrown over the paper, and the men can not or will not keep the surface of the paper free from earth. Finally, cabbages are for the most part set so deep in Minnesota as to make it impossible to put the paper around the root and have it lie flat on the ground. In other words, cabbages are set below the origin of the leaves. In some instances we found that tarred papers had pinched the roots of young plants so as to apparently check their growth. In the burrow of one maggot we captured a cynipid parasite (*Pseudeucoela gillettei* Ashm.). To the best of our knowledge this parasite has not hitherto been reported from Minnesota. A number of predaceous beetles which were observed to feed upon the larvæ and pupæ of this fly were also captured. In the course of this experiment, and in spite of negative results obtained with the same substance in the East, we used air-slaked lime on a field contaiaing several thousand cabbages. We thought it ought at least to act as a repellent to the fly and as an irritant on the surface of the maggot, if it were kept dry by sufficiently frequent applications. There was so much rain, however, that it required constant work to remedy the results of the dominating wet weather. Nevertheless, the cabbages made a fine showing, a much better showing, I believe, than other fields not limed. In my opinion this was due, however, to the fertilizing power of the lime, since cabbages are among the comparatively few plants which respond energetically to lime. The recent Holland cabbage, so far as I can make out, is never affected by the cabbage maggot in Minnesota.

NOTES FOR 1905 FROM NEW YORK.

By E. P. Felt, *Albany, N. Y.*

The season of 1905 in New York was notable because of two unusual though fortunately limited outbreaks. Webworms (probably *Crambus vulgivagellus* Clem. and others) were exceptionally destructive to grass lands in Albany, Columbia, and Rensselaer counties in the latter part of May, and army worms (*Heliophila unipuncta* Haw.) appeared in large numbers in some Erie County localities.

Among fruit pests the codling moth (*Carpocapsa pomonella* L.) was exceptionally abundant and, on account of the light apple crop, inflicted considerable loss. The second brood appears to have caused the greater part of the injury. The apple maggot (*Rhagoletis pomonella* Walsh) is becoming destructive to fruit in New York State, particularly to the early varieties. Its work is so prevalent at Newark that sound early fruit was a rarity. Its depredations in the large orchards of Mr. Hart, at Poughkeepsie, were confined very largely to sheltered hollows. The rose beetle (*Macrodactylus subspinosus* Fab.) was exceedingly abundant in various sections of the State, depredations being reported from Staten Island, from the vicinity of Rochester, and at Grahamsville, Sullivan County. The scurfy scale (*Chionaspis furfura* Fitch) has been unusually prolific and destructive for the last two or three years in Dutchess County. The grape root-worm (*Fidia viticida* Walsh) is generally distributed in the Chautauqua region and quite injurious to vineyards here and there, especially to those on the lighter soils. The last season has been marked by the insects becoming decidedly more abundant in vineyards on the hills back from the lake that were previously comparatively free from the pest. The experiments in 1903 and 1904 were continued by general observations upon the vineyards in 1905. The result has shown beyond all question the practicability of preventing severe injury by means of timely cultivation for the destruction of pupæ and by the collection of the beetles.

Grass lands in various sections of the State have suffered, in addition to army worm and webworm outbreaks mentioned above, from injury by white grubs; and the abundance of spittle insects (presumably *Philænus lineatus* L. and *P. spumaria* L.) was remarkable.

Shade trees in a number of our principal cities have been very severely injured by larvæ of the white-marked tussock moth (*Hemerocampa leucostigma* S. & A.). The fall webworm (*Hyphantria textor* Harr.) has been somewhat common, particularly in the fruit sections of western New York. The elm leaf-beetle (*Galerucella luteola* Müll.) continues to be a serious enemy in the Hudson River Valley and is now said to be generally distributed throughout Glens Falls. The European elm case-bearer (*Coleophora limosipenella* Dup.) has become firmly established on Long Island. It has spread from Brooklyn to Oyster Bay, in which latter place it is nearly as destructive to elms as the elm leaf-beetle. The general appearance of injured foliage is somewhat similar in spite of this species being a miner. The work of this lepidopteron is at once recognized by the circular feeding orifice and the more rectangular shape of the semi-transparent areas. The maple Phenacoccus (*Phenacoccus acericola* King), first noticed as abundant and injurious in this section in 1901, continues to be somewhat destructive in the lower Hudson Valley. The rare woolly maple leaf aphide (*Pemphigus acerifolii* Riley) is unusually numerous on Long Island and in the Hudson Valley.

The economic results of applying oil to swamp and woodland pools was strikingly brought out this summer by the statement that at Lawrence the green-headed horsefly (*Tabanus lineola* Fab.) was decidedly more abundant than a few years ago when this community applied petroleum to many pools for the purpose of destroying mosquito larvæ. Later ditching operations have rendered the use of oil largely superfluous, and as a consequence horseflies are much more abundant than they were when the oil method was in force, a striking confirmation on a somewhat extended scale of Professor Porchinski's observations in Russia.

Mr. Washburn said he had found that carbon bisulphid as ordinarily used will not kill the eggs of the Mediterranean flour moth.

Referring to Mr. Conradi's paper, Mr. Webster said that a study of weather conditions would often enable us to, in a measure, forecast the abundance of insects. Thus, a cold, wet spring was likely to be followed by invasions of aphides, army worms, and cutworms. He had thought that the cold weather prevented the parasites of aphides from becoming abundant early in the season, but did not so affect the aphides. He had found the poison-bran mixture to work well in practice against invasions of cutworms. He had used it in large onion fields with success. He fully agreed with Mr. Burgess as to the importance of the jointworm in Ohio. From information received during the past season, he was quite certain that much of the damage charged up to the wheat midge had really been due to the work of jointworms. In northeastern Indiana some farmers had hesitated about sowing wheat last fall through fear of its ravages another year. The Cryptopristus had not seemed to him to fulfill expectations in holding the jointworm in check. He was rather surprised that Professor Washburn should have found no Hessian flies in Minnesota. One of his assistants, Mr. George I. Reeves, had been stationed in North Dakota during the entire summer, and had been assigned to Hessian fly investigations. Mr. Reeves had found that there were, in 1905, probably two well-defined broods of the Hessian fly, besides a continual reenforcement by adults continuing to emerge from last year's stubble (1904). The past might have been an unusually favorable season, but another year ought to give definite results. From present indications the maps showing distribution of the Hessian fly in the United States will have to be greatly modified. As yet there is no ground for believing that the pest occurs south of the Arkansas River, and rarely, if at all, west of the one hundredth meridian, except, of course, on the Pacific coast.

Mr. Hinds said that in recommending fumigation of corn with carbon bisulphid Mr. Conradi had said that it was not recommended for corn intended for seed. Was the unusual strength recommended the reason for this exception?

Mr. Conradi answered that in one experiment, in which soft corn was subjected to the carbon bisulphid for twenty-four hours, the germ seemed to be injured to a great extent. Under such conditions, therefore, it would seem advisable to lessen the strength somewhat in the case of corn that was to be used for seed. In the case of cowpeas he had used 2 pounds to 50 bushels of grain without injury.

Mr. Marlatt said that in the experience of the Seed Section of the Bureau of Plant Industry of the Department of Agriculture fumigation with carbon bisulphid was deemed perfectly safe and not affecting, when properly carried out, the germination of grains or miscellaneous seeds. The very large stock of seeds and grains of all sorts carried by this office is submitted to fumigation with carbon bisulphid as often as necessary to keep it free from insect pests, and usually several times a year.

Mr. Morrill said that he had made a small test on cotton seed, which was actually immersed in the liquid carbon bisulphid for a few minutes without injury to its germinating power.

Mr. Marlatt considered the use of 3 pounds of carbon bisulphid to 30 bushels of grain, as recommended by Mr. Conradi, as excessive and unnecessarily expensive. The fumigation in the manner suggested in the loose wagons seemed to offer the worst possible conditions for effectiveness, owing to the fact of the quick dissipation of the carbon bisulphid.

Mr. Conradi said that the corn used had not been husked when treated, and that because of this, as well as the rapid loss of the insecticide through the cracks of the wagon boxes, it was necessary to use the large amount recommended.

Mr. Marlatt said that some doubt had been expressed regarding the efficiency of tobacco dust for the woolly aphis of the apple. He quoted from memory the substance of a letter reporting the very successful use of this substance received from Mr. M. B. Waite, a pathologist of the Bureau of Plant Industry, who is also the owner of a large commercial orchard in Maryland near Washington. The test was made in a 6-year-old apple orchard containing about 1,800 trees, a good many of which (about one-fourth) showed more or less injury by the woolly aphis. Mr. Waite's description of the condition of his trees and of the treatment is here quoted:

> The trees had a wiry, slender, and somewhat more feeble growth than their uninfected neighbors, and the aphis could be found in varying quantities by digging up the roots. I bought a ton of tobacco dust in Baltimore, costing $25, and applied about a peck in a circle of 2 to 3 feet around each of the trees, which were on the average about 2½ to 3 inches in diameter, while the uninfected trees usually were 4 to 5 inches in diameter. Some smaller replanted trees, from 1 to 3 years old, in the orchard we gave about a gallon, and placed the tobacco dust in a smaller circle immediately around the little tree. The result was quite satisfactory. The growth this season has been more vigorous and the twigs strong and stubby. I think I can safely say that the remedy was a success. Perhaps it will pay me to repeat it another year, and I am sure I am going to go over all my young orchards, whether they are affected or not, and give them, say, a gallon per tree to trees under 2 inches in diameter and a greater amount to the larger ones.

Mr. Burgess said that it had given with him very satisfactory results in a small orchard of 5-year-old apple trees.

Mr. Washburn asked why Mr. Smith preferred the tobacco water to kerosene emulsion.

Mr. Smith replied that the kerosene emulsion was usually poorly prepared, while the tobacco water seemed more easily made by the ordinary grower, which was the main reason for the preference.

Mr. Sanderson said that he had found tobacco water was more efficient, more particularly the prepared tobacco extracts.

Mr. Smith said that in Georgia he could not get good results with tobacco dust for woolly aphis. On trees 10 to 12 years old he had found living aphis an inch underneath the dust six weeks after the application. This dust was analyzed and found of fair quality.

Mr. Washburn felt especially interested in Mr. Webster's remarks on the Hessian fly. He said that it had not been reported to him as injurious in any portion of Minnesota last season. He was confident that this was the state of affairs, because he had correspondents in almost every county in the wheat-raising district, and he further got clippings from all the county papers in the State, and he was certain that if it had been found injurious he would have been informed of it. He had claimed for several years that there might be more than one brood in Minnesota in favorable seasons, and Mr. Webster's corroboration of this as regards North Dakota was gratifying.

Mr. Sanderson, referring to Doctor Felt's statement regarding *Pemphigus acerifolii*, said that while this had formerly been regarded as a rare insect, it was certainly not now rare in some localities. He knew it was common in Delaware, Maryland, and Texas. He had regarded arsenate of lead as inefficient against the rose beetle, but a New Hampshire graduate had found that used at the rate of 4 pounds to the barrel it would kill them. Perhaps this was due to a difference in climate.

Mr. Marlatt said that it was a common experience at these meetings to have conflicting or opposing results from different sections of the country from what is claimed to be the same treatment for different insect pests, and the theory is commonly hazarded that the effectiveness or ineffectiveness in different localities of standard insecticides or methods of control is due to climatic differences. While there might be occasionally some basis for this belief, the theory did not appeal very strongly to him, and he thought it was being rather overworked. He believed that if a poison or other insecticide killed an insect in one locality it was very apt to accomplish the same result in another if applied in essentially the same way. The only climatic variations which were likely to affect the insecticide action are conditions of moisture or rainfall which would remove the insecticide before it had time to have its full effect; but certainly food poisons and contact insecticides, unless so influenced, should have the same results on ordinary insects within the range of the latter, and he believed that most of the differences alleged were to be explained on variations in the poison or methods of application rather than climate.

Mr. Sanderson differed from this view, expressing the belief that there were important physiological differences due to climate. This had been forcibly illustrated by the differences in effectiveness of various insecticides on the San José scale in the Southern and Northern States in the percentage of oils required to kill the scales.

Mr. Newell, referring to previous remarks on the factors influencing the abundance of aphides, said that he had noticed that the application of Paris green to the cotton plants caused an enormous increase in their numbers.

Mr. Summers said that he believed that the number of aphides was related more closely to the number of their predaceous enemies than to any other factor. When these were absent from any cause, either by chance or because of unfavorable climatic conditions, the aphides had such enormous powers of reproduction that they would soon become abundant.

Mr. Hinds said that in using Paris green for the boll weevil the Coccinellidæ were killed and the aphides multiplied in consequence.

Mr. Schwarz said that he was very much surprised that among all the insects mentioned in the preceding papers there was not a single new importation from a foreign country; neither were there any new American species. He could not regard *Cicada nigriventris* [a] as new. It has been received by the Department at Washington from southern Louisiana. He believed that when fuller collections were made it would probably be found that a complete series could be obtained, extending from the present noted locality in Louisiana westward through Texas into Mexico, where the species is common.

Mr. Osborn thought that while *Cicada nigriventris* might possibly have been incidentally noticed heretofore, Mr. Newell's paper had brought out in great detail some entirely new habits of the family. So far as is known, no other Cicada has a similar method of oviposition. It is true there is one prairie species that is known to live miles from timber, and which therefore presumably must oviposit in herbaceous plants. While there is some doubt about the determination of Mr. Newell's species, it certainly belongs to the *nigriventris* group, and may be merely a variety of it.

Mr. Newell said that it seemed very improbable that *Cicada nigriventris* should be found to extend continuously through Texas and into Mexico. A strip of territory about 50 miles wide along the western side of Louisiana and extending from Arkansas to the Gulf had been watched very carefully during the past year, and large general collections of insects made in different localities, and if the species had occurred anywhere in it in abundance it would certainly have been found.

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[a] See footnote, page 52.

Mr. Washburn called attention to the large number of carabids sometimes found in cabbage fields. He had found them extremely abundant where cabbage maggots were present and believed that they destroyed these, as he had found that when taken into the laboratory they would feed freely on both maggots and puparia. He could find no reference to this in the literature.

The following paper was then read:

NATIONAL CONTROL OF INTRODUCED INSECT PESTS.

By E. Dwight Sanderson, *Durham, N. H.*

At the close of a paper upon the cotton boll weevil, delivered before the last meeting of this association, the writer offered the following points for consideration:

> The boll weevil in Texas and the gypsy and brown-tail moths in New England are raising some points in the relations between States which before long will need careful discussion and broad-minded treatment. Here we have insects which the infested States fail to control, either through inability or neglect, and they spread beyond their boundaries. Quarantines against them are comparatively useless unless the insects are controlled in the badly infested regions. The National Government makes appropriations partly to aid in the study of the pests for the information of the inhabitants of uninfested States and partly to prevent spread, but it can have no authority in the latter respect without State legislation. * * * But why should one State tax itself to subdue a pest which is causing it loss and others gain from increased prices, as in the case with the boll weevil, to prevent it from spreading to them? On the other hand, if it is possible for the State to do so, is the General Government justified in assuming the task if it had the authority? These are questions of a broad nature which it seems to the writer are rather new and which must be met sooner or later. In their solution an association such as this should take a leading part.

Pardon the repetition of these remarks, but they form a fitting introduction to the present discussion. Further study of this subject in relation to the Federal control of similar matters has forced the writer to the conclusion that his statement above, "but it (the National Government) can have no authority in the latter respect without State legislation," is essentially incorrect and that the Federal Government may have full authority conferred upon it by Congress for handling the whole situation. The writer's attention to this whole subject has been brought about by the invasion of New Hampshire by the gypsy moth during the present season, to which he will refer later.

The history of legislation against insect pests in this country is too well known to the members of this association to need review. Some few points may, however, be mentioned to show its present status. Legislation against insect pests in the East was undoubtedly brought about by the introduction and dissemination of the San Jose scale on nursery stock in the early nineties. State after State passed laws concerning nursery inspection and the importation of nursery stock, and some concerning inspection of orchards, etc. Some of these laws were good, others bad. Confusion for the nurseryman resulted. In late years we have been engaged in attempting to secure as much uniformity as possible in these laws, and in this effort the organization of the National Association of Horticultural Inspectors has been of the greatest value. From the first it was seen that the matter of the control of nursery stock was properly a matter for control by the National Government, being strictly a matter of interstate commerce. As a result, on March 5, 1897, there assembled in Washington, D. C., a National Convention for the Suppression of Insect Pests and Plant Diseases by Legislation. The writer finds that but few of the present members of this association were present at that meeting, though all are probably familiar with its deliberations. This convention represented the horticultural interests of the entire country. It adopted a measure which it recommended to Congress, empowering the Secretary of Agriculture to establish an inspection of all importations into the United States of nursery stock, plants, etc., and of all which were subject to interstate commerce, and also recommended an outline for State legislation upon the same subject. This proposed legislation seems to the writer to cover the matter of the inspection and control of insects disseminated on nursery stock, plants, etc., in a most satisfactory manner, taken as a whole, though some minor points might now need modification. At this meeting Dr. L. O. Howard presented a paper, in closing, in which he is reported to have said:

> In conclusion the writer expressed his firm conviction that the establishment of such a service at the Eastern ports * * * would many times repay the horticultural interests of the country.

In the next Yearbook of the Department of Agriculture (1898), in a most interesting and valuable article upon the Danger of Importing Insect Pests, Doctor Howard again urged the importance of such legislation. He said:

> The remedy for this condition of affairs is obvious. Laws must be passed establishing a system of inspection of dangerous classes of merchandise, just as has already been done in the case of live stock, and just as has already been done in a partial way by the State of California. The passage of some such national measure as that recommended by the convention of horticulturists and agriculturists held in Washington, D. C., March 5, would seem, from a consideration of the facts here presented, to be abundantly justified by the constant danger which threatens our agricultural and horticultural interests.

The writer is not familiar with the inside history of the work of the committee on legislation appointed by this convention. In any event nothing came of it. It is the writer's impression that the matter at first received the opposition of influential nurserymen. Later, however, when it became necessary for the nurserymen to comply with many and diverse laws to their great inconvenience and annoyance, they evinced interest in securing national legislation on the matter. The chairman of their committee on legislation recently expressed to the writer his earnest desire that national legislation might be enacted upon the subject, but after practical experience in presenting the matter to Congressional committees seemed to feel that there was but little prospect of securing such action in the near future. The writer does not remember any serious discussion of the matter by any entomologist since Doctor Howard's article in 1898.

In many States the nursery and orchard inspection is now handled by separate State officials, relieving the entomologists of the experiment stations and State entomologists of this onerous police work. But in many States it is still a burden to the entomologist who would prefer to devote his time and thought to problems of research. That this work has impeded the development of economic entomology in many respects can not be doubted, though on the other hand it has undoubtedly had the effect of bringing many of us into closer touch with the people whom we are trying to serve. It would seem therefore that the entomologists of the country should be most interested in securing national legislation for this phase of insect control at least. That it is perfectly constitutional and practicable can hardly be doubted. The present work could be accomplished with much more efficiency, with greater protection to the horticultural interests, and with far less annoyance to the honest nurserymen of the country, and probably to the greater detriment of the man who fails to clean up his nursery. Why the economic entomologists have failed to interest themselves in this matter has always been a mystery to the writer.

But at this same national convention of 1897 a resolution was passed concerning Congressional appropriation to aid Massachusetts in its fight against the gypsy moth, as follows:

> *Resolved*, That this is a question of national importance, and that the National Government should assume the work of extermination or render substantial financial assistance to the State of Massachusetts for that purpose, that the work may be carried to a successful conclusion and this continent be thus saved from the ravages of another terrible insect pest.

In passing this resolution the convention recognized the responsibility of the Federal Government in protecting the uninfested States from the spread of the gypsy moth, which by precedent would involve the same aid for all other insect pests of sufficient importance to warrant it. It is in this phase of the question that New Hampshire is now particularly interested. We can probably, with the aid of an appropriation from the State legislature, which would not be burdensome and which the writer has no doubt will be made at the next session, prevent the spread and increase of the gypsy moth in New Hampshire by annual inspections along all highways liable to infestation. But without the expenditure by the State of Massachusetts of a very much larger sum and in a more efficient manner than is now possible under its present law, it will be but a few years until the gypsy moth will be so abundant in Massachusetts up to the New Hampshire line that it will be practically impossible to prevent its spread or to control it in New Hampshire.

New Hampshire is thus ultimately helpless to prevent the invasion of the gypsy moth, and the possible destruction of her grand old elms, shading the highways, her important lumber interests, and forest-clad mountains—the features which make the State one of the most beautiful and attractive in the Union—unless Massachusetts may be aided by liberal appropriations from the Federal Government, so that the further spread of the pest may be checked and it may be increasingly controlled where it is worst. To this end bills have been introduced during the present session by Hon. E. W. Roberts, of Massachusetts (H. R. 285 and 286), appropriating $250,000 for the extermination or control of the gypsy moth and $15,000 for the importation of parasites and predaceous enemies, to be administered by the Secretary of Agriculture. These measures have the hearty support of New Hampshire, and, the writer believes, of all the best interests in New England, and we trust that they may be indorsed by appropriate resolution by this association.

Yet, although we earnestly desire this appropriation for immediate use, it seems to the writer that the whole matter of the relation of the National Government to the control of insect pests is in an unsatisfactory condition. Who can guarantee that this appropriation will be repeated? How can it be administered under present laws, except through the officials of the State of Massachusetts? In New Hampshire we have no legislation upon the matter at present, and any action would have to be taken entirely with the permission of property owners—as at present no damage to property would be involved—and by the approval of the governor. If the National Government has the power to make an appropriation for this purpose, why has it not the right to provide the proper machinery for its administration, whenever the necessity may arise, from other pests in various parts of the country, without special subsequent action of Congress authorizing same; and if Congress has such perogatives, why should they not be exercised for the benefit of the agricultural and horticultural interests as well as for the city trees and for the entire country? To show the propriety, feasibility, and desirability of such legislation is the writer's purpose.

That national control of introduced insect pests would be of the greatest value can hardly be doubted after a brief glance at the history of the worst introduced insects of the last twenty-five years. Had there been a Federal official with authority to proceed and stamp out and control the San Jose scale when it first appeared in the East, could not its spread have been to a very large extent prevented, if not, indeed, entirely stopped? Or, similarly, if a Federal official had commenced the extermination or control of the gypsy moth in the eighties, before the work was taken up by Massachusetts, and had supervised the work of that State, being ready to step in and prevent the subsequent spread of the pest sufficient to endanger the neighboring States, would not the alarming conditions now existing have been to a large extent prevented? The same is true of the brown-tail moth. The gypsy moth committee of Massachusetts fully appreciated the danger of this pest, which in many respects is worse than the gypsy moth, but they had no funds with which to combat it. Later, a small appropriation was made, but it was entirely inadequate and was made too late to control the pest. Had the money been available when the brown-tail moth was first discovered, and efficiently administered, we have no doubt that it might have been effectively controlled. How much loss it will now cost in years to come is entirely problematical, unless the European parasites become of immediate value, for there is nothing to prevent its spread over the entire East within a few years. Last year it spread over 100 miles in New Hampshire. Again, when the boll weevil was discovered in southern Texas, a representative of the United States Department of Agriculture appeared before the legislature of Texas and advised legislation which would prevent for a few years the growing of cotton in the infested counties—which grew but a small amount—so that the pest might be exterminated; but he was literally laughed down. Had the Federal Government been able to step in at this time and enforce whatever measures seemed best to prevent the subsequent spread of this insect throughout the cotton belt, the subsequent loss of at least $22,000,000 to Texas alone in 1904 and the present certainly unpropitious outlook for the cotton interests of Louisiana and the Mississippi Valley might have been averted.

Might not the introduction have been prevented of the despicable little New Orleans ant (*Iridomyrmex humilis* Mayr) which is now becoming such a nuisance here in New Orleans and southern Louisiana and whose spread through the South it would now seem well-nigh impossible to prevent or restrict, and might not its spread have been controlled when it was first discovered had we had such national legislation and organization?

Other instances might be cited, but these are well known to all. Who can tell what pest may not invade some one of our boundary

States at any time and increase to such numbers that it will be impossible to prevent its spread before State legislation copes with it? It is to be regretted, but we may as well frankly admit that the present tendency toward Federal control of all of these police duties is almost entirely due to the inefficiency of most of our State legislatures in dealing with such matters. Until very recently the States have been very reluctant to delegate any power to make and enforce regulations to any board or official. In doing this the Gulf States in general have the most desirable type of legislation, permitting effectual work against any insect pests which may arise. In most of the States which have legislation upon insect pests the official administering the laws is hampered by petty restrictions and has no funds at his disposal for coping with any new pest which may require immediate action. The average State legislature is very wary of intrusting such powers to any scientist, assuming in many cases that it knows much more about the subject. The debates of the Texas legislature upon the boll weevil and the information given the writer by some of its members would prove amusing reading to the entomological fraternity. Congress, on the other hand, has consistently recognized that it must depend upon experts in such work and must give them sufficient latitude so that they can take immediate action when necessity arises. To this has been largely due the efficiency of the Federal law in very many matters in which the State laws have been conspicuously inefficient.

How many of our seaboard or frontier States have at the present time any system of inspection which will enable them to prevent the importation of injurious insect pests, or how many, even, could proceed to eradicate such a pest when actually within the borders of their State when over a few hundred dollars were necessary for its eradication? As far as I know, California is the only State having any adequate machinery for such work.

But it is objected that such work of exterminating an insect within a State would be unconstitutional, an interference with the rights of the State, etc. So it would seem, and so it at first appeared to the writer; but the present laws of Congress concerning the control of cattle and human diseases and the regulation of the importation of noxious animals effectually dispel this objection.

At the present time the Public Health and Marine-Hospital Service has charge of most of the maritime quarantine stations and may take charge of any others it sees fit when they are inefficient under State or municipal management. It furthermore may enforce interstate quarantines or may quarantine any portion of a State, and take such measures as it sees fit to eradicate disease in any locality when the local or State health officials, either through lack of legislation or inefficiency, fail to control disease, so that it threatens neighboring States. This has actually taken place in several instances.[a]

At the present time the Southern States are petitioning Congress for the National Government to take entire control of maritime and interstate quarantines, owing to the proven efficiency of the Government service in handling the yellow-fever outbreak during the past season. Surely there can be no better proof of the desirability of Federal control of quarantines than the present attitude of the Southern States, for no section of the country has had their experience with quarantines and no section has been more opposed to Federal quarantines in the past.[b]

By the Lacey Act[c] Congress has conferred upon the Secretary of Agriculture the power to make and enforce regulations to prevent the importation of noxious animals, and this act has now been enforced for five years. In essence, the law proposed by the convention of 1897 would cover the same ground for the prevention of the importation of insect pests.

But more stringent, sweeping, and effectual than either of these laws are those establishing and defining the duties and powers of the Bureau of Animal Industry of the Department of Agriculture.[d]

These laws and regulations empower the Bureau of Animal Industry to inspect all import and export domestic animals and all subject to interstate commerce for dangerous diseases. They empower it to proceed to stamp out such diseases as are deemed dangerous, and to purchase diseased animals at a fair appraisal when necessary to stamp out a disease. In this work the Bureau may and has repeatedly quarantined different States and sections of States. At the present time the regulations of the Bureau prohibit the movement of cattle from counties south of the Texas-fever line to other counties

[a] For a full discussion of Federal quarantine measures, see an article by James Wilford Garner, of the University of Illinois, in the Yale Review for August, 1905, pp. 181 to 205.

[b] See the Congressional Record of March, 1893, vol. 24, H. R. 9757, second session, Fifty-second Congress, debate, House, 717, 750, 793; Senate, 1037, 1243, 1337, for the lengthy debates in the House and Senate upon the present national quarantine law, which was admittedly a compromise measure.

[c] See Circular 29, Biol. Surv., U. S. Dept. Agric.

[d] See Regulations of the Secretary of Agriculture governing the Inspection, Disinfection, Certification, Treatment, Handling, and Method and Manner of Delivery and Shipment of Live Stock which is the Subject of Interstate Commerce, 1905. Issued under authority conferred on the Secretary of Agriculture by the acts of Congress approved May 29, 1884, Feb. 2, 1903, and Mar. 3, 1905, which acts are printed in it. Also see Administrative Work of the Federal Government in Relation to the Animal Industry, by G. F. Thompson, 16th Annual Report Bureau of Animal Industry, 1899, pp. 102–125, and Federal Inspections of Foreign and Interstate Shipments of Live Stock, by D. E. Salmon, D. V. M., 18th Ann. Rept. Bur. Anim. Ind., 1901, pp. 237–249.

within the same State, whether the cattle are for interstate commerce or not. These laws and regulations have been tested in the courts, and so far have been held constitutional.

Furthermore, Congress appropriates for the Bureau of Animal Industry a sum which is specifically for the control of outbreaks of disease. By this means the Bureau was able to proceed at once against the foot-and-mouth disease in New England in 1902. A deficiency appropriation was at once authorized by the next session of Congress (for $500,000, approved December 22, 1902), which enabled the work to proceed without delay. A similar amount was included in the regular appropriation for the Bureau for the fiscal year ending June 30, 1904, but the work had been so thoroughly done under the previous appropriation prior to that time that but little of the last appropriation of $500,000 was used. It was a portion of this unused balance, $250,000, which was subsequently appropriated for the investigation of the boll weevil and cotton culture, I believe.

Not only do the regulations prohibit the movement of diseased cattle or any cattle from a quarantined State or section, either by shipment or driving, but they prohibit allowing cattle to drift from one section to another. Furthermore, any hay, straw, or other material which may harbor disease from a quarantined area may be entirely regulated by the Bureau. (See Regulations 1, 6, 8, 19, and 43, particularly.) Further enumeration of the powers and methods of administration of this Bureau is unnecessary, but a perusal of the references cited may prove interesting to those unfamiliar with them.

If, therefore, Congress through these agencies is preventing the introduction of human and animal diseases and noxious animals, and their interstate movement, and eradicates or controls them in sections where their presence threatens the commerce and welfare of other States, why may not the spread of imported insect pests dangerous to plants be similarly regulated? The writer has studied the principles involved with some care and fails to see that they are not identical.

An interesting phase of the whole discussion, and one of local interest here, arises from the recent convention of the Southern States, which passed resolutions not only praying Congress that the National Government take charge of all quarantines, but that it proceed to the extermination of the yellow-fever mosquito. Whether extermination of this pest is possible or not I am not informed. From experience with other insects it would seem doubtful. There can be no question, however, that in order to control the yellow fever the breeding of *Stegomyia calopus* must be prevented. In the control of yellow fever the Federal Government would therefore have a perfect right to proceed against this insect as a menace to human health.

We have then the anomalous condition that the National Government can control the introduction and spread of insects which affect the health of man and the domestic animals, but that it has no laws against those affecting crops or plant life. Will the opponents of such legislation show wherein the principles involved differ? Is not the loss to plant life from insect pests far greater than to either human or animal life? How do the values of animal and plant products compare? According to the Report of the Secretary of Agriculture for 1905, the domestic animals of the United States were worth $2,995,370,277 in 1904. There are no figures as to the exact value of animal products, but estimating a similar increase from 1900, they would be worth approximately $2,000,000,000. The total value of farm products is estimated by the Secretary for 1905 at $6,415,000,000. Plant products would therefore be worth approximately $4,415,000,000, the ten staples alone being worth $3,515,000,000, while the value of all domestic animals and their products would be $4,885,572,394. In short, the plant products are more than twice the value of the animal products, and practically equal in value both the live animals and the products which they produce. These estimates include the value of the products of so-called "farm forests," but do not include the value of lumber or the virgin forests not on farms. Nor is the inestimable value of city shade trees and parks here considered. The losses occasioned by insects, exclusive of those to animals and stored products, have recently been estimated by Mr. C. L. Marlatt at $520,000,000, which is entirely conservative.

We would venture the assertion, therefore, that the annual losses occasioned by imported insect pests far exceed all losses of animals from disease and of those human diseases which are subjects of National quarantine. Of course we can place no money value upon human life, but were that possible, we have no doubt that the loss of plant products from a half dozen insect pests imported during the last quarter century would far exceed all losses from animal and human diseases which within that time have been the subjects of National quarantine.

The gypsy moth at present threatens the welfare of New Hampshire, Rhode Island, and, indeed, all New England, and, if unchecked, ultimately the whole country. Massachusetts has done, is doing, and we believe will do all in her power to check the pest within her borders. But why should her citizens be taxed sufficiently to prevent its spread to neighboring States? And what recourse have the other States if Massachusetts does not prevent such spread? It would seem that Massachusetts is maintaining a public nuisance as far as the neighboring States are concerned, but it is doubtful whether a suit could be entered against her on that ground even theoretically.

while actually it is, of course, entirely improbable. New Hampshire and other States can not appropriate to aid Massachusetts. Why, then, is it not the duty of the Federal Government to protect the interests of the neighboring States by checking the spread of the gypsy moth and aiding in its control. The same reasoning will apply to all other introduced insect pests of serious importance. We will all admit that the Federal Government may prevent their importation, but some of us would claim that as soon as a pest has come upon the territory of any State that the National Government is then powerless to prevent its spread to other States. This same argument has been fully thrashed over in Congress concerning human disease, and the present law as above outlined and administered seems to the writer to have fully demonstrated that the Federal Government has such a right and may make and execute such regulations as seem necessary. With such national laws and regulations we believe that the introduction and spread of insect pests, either by transportation or natural agencies, could be largely prevented. At present under the State laws they are not and can not be.

Your serious consideration as to whether it is not entirely feasible for Congress to so legislate as to empower the Bureau of Entomology, or such agency as it may deem best, to make and enforce such regulations as will prevent the introduction and dissemination of insect pests, and to appropriate sums sufficient to allow such work to be done at once, without awaiting special appropriations, is therefore urged. It would seem to the writer that only in this manner can we have efficient means of preventing the future importation and spread of insect pests which will cost the Nation millions upon millions of dollars, as those have done with which we are now familiar.

If such legislation seems desirable, no one association in the country could have more influence toward bringing it about than the Association of Economic Entomologists, through the wide acquaintance and close touch and influence with the interested organizations of its members in their respective States.

In conclusion, might not this association invite the officers of the National convention which met in 1897 to call a second meeting of that convention at such time as might seem best, and urge the organizations represented in it to vote sufficient sums so that wise counsel might be secured and the legitimate expenses paid of men who might work toward the passage of such legislation. To secure such another meeting would require at least several months, possibly a year's work. Is the time not ripe for such a movement? Should not the Association of Economic Entomologists be sponsor for it?

Mr. Webster said that as one of the original promoters of the horticultural gathering in Washington in 1897—he having drawn up the call for this meeting, as secretary of the executive committee—and with others joint author of the quarantine and inspection bill afterwards presented in Congress, and after two conferences with Senate and House committees, he had a pretty good opportunity to become acquainted with these matters. The failure of this measure was not the fault of Congress, as that body was ready to do what was necessary, but there was a lack of unanimity among the people as to just what ought to be done, and Congress had wisely decided not to do anything under such conditions of public opinion. The fact seemed to be overlooked that there was vast difference between an element that threatened human health and life, and one that only threatened certain products of the soil. Neither the boll weevil nor San Jose scale threatened human life or health, and therefore was not to be considered in the same light as Texas fever or yellow fever, and it was doubtful in his mind whether the Government could proceed in the same way to quarantine against or control the spread of the same. Certainly Congress had no authority to legislate regarding insect pests and plant diseases within the boundaries of any State, except as articles of interstate commerce. Congress might order a man to inspect certain premises in any State, but without legislative permission from that State he could not legally obey his instructions, except upon Government reservations. He was not opposed to any measure the object of which was the control of insect pests, but had learned from experience that not all reasonable or seeming necessary projects of this sort could be carried out. He always had and still believed that national legislation should come first and State legislation in uniformity therewith follow afterwards.

Mr. Marlatt said that he was in accord with most of the suggestions presented in Mr. Sanderson's paper and that he believed there was a distinct tendency on the part of the Federal Government to undertake legislation for the direct protection of people, both in the line of food products and in the protection from insect and other natural enemies, but that this would undoubtedly first be in the direction of protection or quarantine from foreign countries, and later looking to interstate control. Personally, however, he doubted the advisability of Congress spending large sums of money for the local control, or particularly attempts at extermination, of such well-established pests as the San Jose scale, the boll weevil, or the gypsy and brown-tail moths. It is perfectly legitimate, however, to provide for the checking or prevention of the spread of such pests, at least wherever there is a chance of accomplishing something in a practical way, and to attempt to stamp out any newly introduced enemy before it has become so distributed or well established as to make a successful outcome improbable.

Mr. Morgan called attention to the Texas-fever problem, which seemed to him of national importance. This problem, for reasons which are at once evident on considering the history of our knowledge of the disease, is largely in the hands of the veterinarian. Since, however, its relation to the cattle tick has become known, it seems that entomologists, throughout the quarantined section at least, could aid very materially the problem of tick extermination by devoting some time to life history and habit study and by cooperation with farmers willing to eradicate the cattle tick from their places. The extermination of the cattle tick from the United States is quite possible under an aggressive educational and cooperative campaign.

Mr. Sanderson, referring to an objection of Mr. Webster's, said that it was true there was a sharp distinction between plant diseases and human diseases, but that he thought the comparison ought to be made rather between the diseases of domestic animals and plant diseases. The laws concerning the diseases of domestic animals are even more drastic than those relating to human disease. He agreed that it was too late to attempt the extermination under national control of such well-established insects as the San Jose scale or the brown-tail moth.

Mr. Rolfs thought the time more favorable for national legislation than 1897. Nurserymen take a very different view of the matter now from that held then.

Mr. Hunter believed that the time was ripe for national legislation. He felt that there had been arising for several years a stronger and stronger belief in its advisability. He moved that a committee of five be appointed to report before the end of the present meeting, making recommendations regarding the National control of introduced insect pests. The motion was carried. The Chair appointed as such committee Messrs. Hunter, Sanderson, Morrill, Howard, and Hinds.

MORNING SESSION, WEDNESDAY, JANUARY 3, 1906.

BOLL-WEEVIL SYMPOSIUM.

The following papers on the boll weevil were presented, the discussion being postponed until the entire series had been read:

THE PRESENT STATUS OF THE MEXICAN COTTON BOLL WEEVIL.

By W. D. Hunter, *Washington, D. C.*

[Withdrawn for publication elsewhere.]

A CONSIDERATION OF THE CULTURAL SYSTEM FOR THE BOLL WEEVIL IN THE LIGHT OF RECENT OBSERVATIONS.

By A. F. Conradi, *College Station, Tex.*

The past season marked an epoch in cotton growing in Texas. Ever since the advent of the cotton boll weevil there has been a general inclination on the part of the cotton growers to the application of sprays or the operations of various kinds of machines and nostrums for the rapid suppression of the pest. The disappointments were many, yet people continued to hope along that line. They had almost superhuman faith that scientists would discover some simple boll-weevil exterminators. These hopes could not be satisfied, and the boll weevil was at one time regarded as the greatest curse in the cotton-growing section of the State. The various entomologists and the boll weevil commissioners received many requests for testing machinery. The most recent agitation was in regard to the efficacy of Paris green.

Although the cultural system had been recommended by the Bureau of Entomology of the United States Department of Agriculture as the chief source of reliance in securing a cotton crop, something simpler and quicker was desired. Now, however, the people are ignoring the different machines and nostrums and have ceased to look to such measures for relief. At the same time good cultivation is so thoroughly appreciated that many are at a loss to know whether the boll weevil ought to be regarded as a friend or an enemy. The progress of the boll weevil has created a revolution in cotton culture of far-reaching importance. This fact is fully realized by the thinking public, who are accepting the cultural system as the most reliable and rational procedure in the production of a cotton crop. The inquiries received by us bear out this point very forcibly. No longer do we hear the monotonous questions: "Which is the best machine with which to destroy the boll weevil?" "Which is the best arsenical with which to poison the boll weevil?" Not one such question was asked during the past season—not even questions similar to those. At present, however, inquiries received are: "Where can I get a good early cotton seed?" "Should the seed bed be flat-broke or ridged?" "Which is best—shallow or deep cultivation of cotton?" Other general information on cotton culture is often asked for. Again we are frequently in receipt of letters asking for advice as to the prudence of shipping cotton seed from infested to uninfested localities and for the method of fumigating the seed, showing that the farmer desires to take every precaution to avoid dissemination of the weevil through the markets. A great many inquiries regarding the fall destruction of cotton stalks reach us. Thus we are aware that in the future the cultural system will be the main reliance in the cultivation of cotton in Texas.

The first recommendation in the cultural system is early planting. Early maturing varieties should be obtained from territory uninfested by the weevil. The value of this recommendation is fully recognized and can be carried out in normal seasons in Texas. Last season, however, a great part of the cotton was planted late on account of the prolonged wet weather during the late winter and spring. The department of entomology of the Texas experiment stations planted its cotton on March 18. The weather was open for four successive days, and a considerable amount of cotton could have been planted over the State if the seed bed had been previously prepared. As it was, however, many farmers had to plow. It is thoroughly advisable that cotton be planted at such intervals of good weather in the rainy season, but the seed bed must first be prepared properly. The writer had an experience during the past season with the experiment station cotton referred to above that fully convinced him of the value of this recommendation. The seed bed had been flat-broken in winter and was in excellent condition at planting time. Without ridging the seed bed the cotton was planted. On March 21 another prolonged wet season set in and one-half of the cotton washed away. The other half germinated, and in spite of the prolonged saturation of the atmosphere and soil held its own, and when the weather cleared, about April 2, made rapid progress and was squaring April 18, the first lock opening July 15. As a rule, all cotton made in the locality of College Station should be made July 15—that is to say, any squares forming after July 15 stand a poor chance for making bolls in a weevil year.

The cultivation of this cotton was shallow, but repeated every ten days. This operation served as a mulch. It requires less labor than the deep furrowing by the middle busters, and was a better moisture conserver on account of the fact that the smallest possible surface was exposed to the drying action of the sun and wind.

FALL DESTRUCTION OF COTTON STALKS.

During three successive seasons we have closely watched the hibernation of the boll weevil. These observations were made during the fall, and checks were kept in cages. In the fall of 1903 the weevil went into hibernation, beginning November 17 at College Station. This was the night of the first heavy frost. In 1904 hibernation began November 7, following the night of the first heavy frost. During the fall of 1905 the entering into hibernation differed from those of 1904 and 1903 in that it was gradual and not so abrupt as in the other seasons mentioned. It was due to the prevailing temperature conditions. The killing frost was preceded by several light freezes, which, however unpleasant to the weevil, would not induce the insect to enter hibernation, since the days were invariably warm enough for the weevil to continue feeding. The experiment-station cotton was thoroughly frozen on the night of November 27—two to three weeks later than in the last two years—after which the weevil disappeared from the cotton field in the course of three days. These observations were made on the experiment station's own cotton. During the fall of 1903 observations were made on cotton stalks burned before frost, the effect of which, however, could not have been fully brought out on account of the miscellaneous purposes for which the plat was used the following year. During the season of 1904, in addition to the weevils already present in the fall, thousands of specimens were brought in from other fields to be used in experimental work, so that there was every opportunity for a large percentage of hibernating weevils to pass through the winter, a wooded ravine very near the cotton plants offering shelter. During the early days of September the cotton leaf-worms (*Alabama argillacea* Hbn.) made their appearance. They increased rapidly, and about October 10 there was not a green particle of cotton left in the field. The great number of weevils present disappeared. No opportunity was given the plants to put forth leaves again during the next rain, but all stalks were destroyed, put up in piles in the field, and burned about a week after the first frost, when it was certain that all weevils were in hibernation. The ravages of the cotton leaf-worm gave us the same condition as though we had destroyed the stalks about October 10. It followed that the injury to cotton this season amounted to nothing, notwithstanding the fact that we were delayed in planting in spring.

The cotton leaf-worm gave us a very conclusive demonstration of the value of the fall destruction of cotton stalks. If the cotton had not been destroyed the previous fall, damage would have been done by the weevil, yet without the thorough cultivation the absence of the weevil would not have secured us such a heavy cotton crop, which was fully shown by observations made on other plantations during the drought. The cotton leaf-worm, which for many years has been a great enemy to the cotton planter in the cotton States, was a very efficient ally during the fall of 1904 in destroying the hibernating brood of boll weevils on Upland cotton at College Station. During 1905 its efficacy in this respect amounted to nothing. The frequency with which it can be depended on varies in different localities. Some planters report that the worm is destructive in their localities during fall nine years out of ten. The writer has given careful attention to the study of the practical side of predaceous and parasitic insects, and is frank in saying that the extent to which this subject has been ignored under Texas conditions is regrettable. And, although this problem of enabling the cotton leaf-worm, whenever possible, to become an ally in boll weevil destruction is almost unimportant when compared with the value of many predaceous and parasitic species affecting other insect pests, it should be made clear to the farmer that if judiciously managed he may enable the leaf-worm to help him combat the boll weevil by allowing it full liberty in the cotton plantation during September and October. It is evident that where the caterpillars are not destroyed in late fall they will pupate and many more will successfully pass the winter. With the fall destruction of stalks, however, and a thorough cleaning of the fields, this obstacle could be removed.

WHAT IS MEANT BY THOROUGH CULTIVATION.

Frequently we are asked what is meant by thorough cultivation in the cultural system of the Bureau of Entomology. Attempts have been made to give as specific answers as possible, but we soon found that this would become a very intricate procedure on account of the varying conditions in different sections. Some seasons we must cultivate often; others less frequently. Again, cultivation varies with localities and soils.

The two principal results to be obtained by thorough cultivation are (1) a mulch; (2) the keeping down of weeds. When a crop of weeds has gained the advantage over the farmer's industry on account of a prolonged wet season, it is for the farmer to conclude what kind of cultivation he shall give the field to remove this stand of weeds. When this is accomplished, all his attention should be given to the maintenance of a mulch between the cotton rows. In bottom cotton, where moisture is abundant and heavy rains may occur during the growing season, the cultivation with a shovel plow may sometimes be best, as it serves as a drainage system. On Upland cotton, however, the problem is entirely different, and when the drought begins the cotton will suffer least in the well-mulched field. Thus by thorough cultivation we mean the maintenance of a surface layer of soil cultivated with sufficient frequency so as to form a blanket of dry soil at the surface. This will retard the evaporation of moisture. This blanket of dry soil must be the criterion for the intelligent farmer to judge how many cultivations he should give his cotton. This loose surface soil may be affected by light showers of rain. The crust which is then formed at the surface will destroy the mulching power of the soil blanket, and cultivation should therefore follow at once.

FERTILIZERS.

Our experience in experimenting with fertilizers has been limited. It was strictly confined to a very small part of the experimental cotton plats at College Station. We are fully convinced that acid phosphate is the all-important fertilizer under our conditions—the soil being about 2 feet in depth, of a sandy nature, and underlaid by an impermeable clay pan.

Summarizing what has been said, we come to the following conclusions, which must guide us in our work at the present time: First, that the cultural system is the only reliable procedure in the production of a cotton crop in Texas; second, that this system, in order to be effective, must be intelligently carried out in all of its important details; third, that the fall destruction of stalks is less generally practiced than other recommendations made, as embraced in the cultural system, and needs effective campaigning; fourth, that shallow cultivation on uplands should be more universally practiced, because it forms the most perfect mulch and saves labor and expense; fifth, that by thorough cultivation is meant such a number of cultivations as will insure the maintenance of a blanket of dry soil at the surface of the ground.

LABORATORY METHODS IN THE COTTON BOLL WEEVIL INVESTIGATIONS.

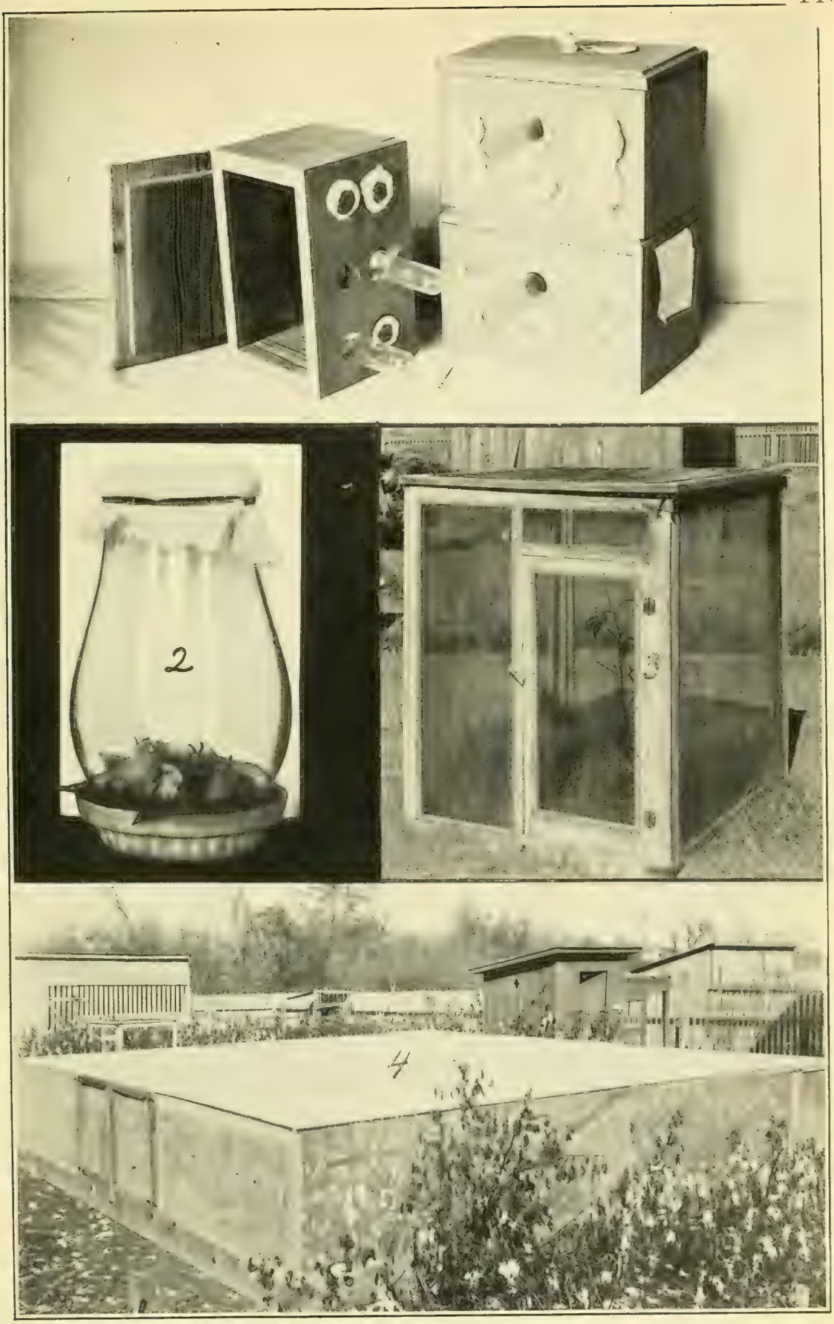
By W. E. Hinds, *Dallas, Tex.*[1]

By way of introduction, let me state that I shall interpret my subject as including not only the methods in the cotton boll weevil investigation which may be classed as strictly "laboratory," but also those field methods which have been employed in checking laboratory results and in determining under the most natural conditions many of the most important answers to questions regarding the life history, habits, enemies, etc., of the weevil. Though used in the field, these are, in a broad sense, "laboratory methods," and will be so considered. Unless indoor results are checked by observations made in the field, important points are sure to be overlooked and serious errors are apt to creep into conclusions drawn from the work. I shall touch briefly, as is necessary, upon methods employed in three divisions of the work—namely, research, record, and illustration. Though no claim for originality can be made for many of these methods, I shall endeavor to avoid taking up time with that which is the common practice of economic entomologists, and confine myself to those methods which contain some suggestion of newness either in theory, practice, or equipment.

As a foundation for the study of any insect pest from an economic standpoint, there must be a rather accurate study and knowledge of at least the main points in its life history. The same apparatus and methods are not likely to prove equally well adapted to the study of widely different species, and there must be therefore more or less of an adaptation in these respects to the specific study of each insect.

From the beginning of the boll-weevil investigation much attention has been given to obtaining "individual records." To obtain these, isolation of specimens was essential, and as the nature of the food supply was very perishable, requiring its frequent renewal, some form of breeding jar was required which would facilitate the work of daily examinations. After trying several forms of cage, we settled finally upon the following type as best suited to our needs (see Pl. II, fig. 2): The base was formed of a 4 or 5 inch flower-pot saucer, filled level full with earth. On this was placed an ordinary lantern globe, covered above with a single thickness of cheese cloth held in place by a rubber band around the top. In general practice it was found advantageous to place a cotton leaf large enough to cover the saucer upon the dirt before placing the food supply and covering with the globe. The principal advantage of this cage lay in the facility with which the specimens might be moved from place to place and the ease with which the top might be removed, giving free access to the squares or bolls within the bracts of which the weevils were, as a rule, hiding. The cloth cover rarely required removal, and if weevils had crawled to the top of the globe they were there safely inclosed while the necessary examination of the food supply was being made. These globe cages were found to be equally well adapted for work with from one to ten weevils. A larger number than this would require a larger cage.

An adaptation of the type of box used in capturing parasites of scale insects and described in the First Biennial Report of the Commissioner of Horticulture of the State of California has been found very useful in the breeding of parasites and also of the weevils themselves. The box (Pl. II, fig. 1) may be of any size desired, but must be tightly joined throughout. We have found a box about 6 or 8 inches deep and wide by 10 or 12 inches long a convenient size for our work. In one side are two rows of holes cut to fit almost any size of glass tube at hand. The number of holes depends partly upon the number of insects to escape, but unused openings may be easily closed with cork stoppers. Small crevices around the tubes are closed with a few thicknesses of cheese cloth or cotton wound around the tube. The cover should fit tightly but be easily removable. The escaping insects naturally make their way to the light, and may be removed by exchanging tubes without danger of losing valuable specimens or the necessity of handling those that might be easily crushed. An



LABORATORY METHODS IN THE COTTON BOLL WEEVIL INVESTIGATIONS.

Fig. 1.—Boxes used in breeding parasites and weevils. Fig. 2.—Breeding jar used in life-history work. Fig. 3.—Folding cage used in field experiments. Fig. 4.—Wire-screened cage used in hibernation experiments. (Original.)

added improvement to this box as described, for some purposes, has been made by Mr. Wilmon Newell, secretary of the Louisiana crop pest commission, who has been cooperating with the Bureau of Entomology in the fight against the boll weevil. It consists of a plate of glass fitting smoothly upon a narrow projecting ledge formed by a wooden strip tacked around the box on the inner side and near the top. This allows the removal of the cover and facilitates inspection without the danger of allowing the escape of insects which have not entered the tubes.

Since its first advent into Texas there has been more or less speculation as to how far north the weevil might be expected to spread. The probable influence of the lower average temperatures encountered in more northern latitudes also became a question of much importance. To obtain a safe basis for forming conclusions upon many important questions of this kind, it became necessary to secure much data relative to temperature effects under conditions which could be kept uniform and under the absolute control of the investigator. For observations at temperatures ranging above the normal, a small-size incubator has been found to answer well; such questions as those of ventilation, humidity, etc., being carefully guarded. For temperatures ranging below the normal ready-made apparatus can not be so easily secured. Ordinary refrigerators may give temperatures as low as 40° F., but their construction is not such as to allow of approximate control of the temperatures intermediate between that of the ice box and that of the outside atmosphere. To meet this need it was found that a box must be built to order, and one was designed having three compartments below the ice box in which the temperature could be varied at will in each compartment without affecting the others. Two compartments were dark, while the third was lighted through double glass windows. When desired a thermograph could be placed in any one of the compartments and an accurate record obtained of the temperature prevailing for any desired period. The temperature above all compartments was kept uniform by the retention of the water from the melting ice. With the incubator and this ice box the development of the weevil could be tested for any temperature, and from the periods found the total effective temperature required to allow complete development at any mean temperature could be quite accurately determined. This work led to the prediction that around Dallas, Tex., there would be one less generation of the weevil than at Victoria, and such has since been found to be the case. One of the most important results of this work has been the demonstration that the number of generations, the period in each developmental stage, and, in a general way, the destructiveness of an insect, can be thus determined for any new locality where the Weather Bureau records make available the general facts as to temperature and rainfall.

Passing, now, from the indoor to some of the outdoor phases of the work, I would say that the field cages covered with 14-mesh wire netting have been of great value. These cages (Pl. II, fig. 3) are about $3\frac{1}{2}$ feet square by about 4 feet high. The latest type is so constructed that the top may be removed and the four sides folded flat. This is quite essential where the cages may need to be shipped or moved from one place to another. All fastening to set up the cages and fix the top in place is accomplished by screw hooks and eyes. In one side of the cage is a door about $1\frac{1}{2}$ by 3 feet in size and opening outward. Within there is ample room for the investigator to work. The field cages have been found useful not only in life-history work, but also in remedial work as well. As an illustration of one way in which the outdoor work in the cages proved of great value as supplementing the observations made in the laboratory, I would describe very briefly the experiment made to determine the average number of eggs deposited daily by the average weevil. The first laboratory records obtained indicated that between two and three eggs were deposited daily by the average weevil. Five females which had begun laying were confined in one of the field cages placed over a plant which had not been attacked by the weevil. The daily observations extending over several weeks showed that these weevils were depositing an average of between 5 and 6 eggs a day. This difference in results led to a further investigation, which showed that the rate of egg deposition depended in a considerable measure upon the abundance of squares which had not been attacked, and also that during a period which may be spoken of as the "prime of life" the rate is considerably higher than it is when nearer the end of life.

Much larger cages than those described have been built at various times for special use in the boll-weevil work. The largest of these is the cage constructed according to plans of Mr. Newell by the Louisiana crop pest commission at Keatchie, La., for the use of Capt. B. W. Marston in making tests of Paris green as a practical insecticide for the control of the weevil. This cage covers one-fourteenth of an acre and was originally divided into three sections of equal size by partitions running through the length of the cage. The height of this cage is about 8 feet, and the cost of building it was somewhat over $350. This is probably the largest cage that has ever been constructed for economic entomological work, and for that reason its size and cost are of especial interest.

For the purpose of allowing a larger number of hibernation experiments this cage has been further divided by cross partitions in each of the original sections into 18 rooms, and here in the various experiments have been placed about 35,000 weevils. Each compartment presents varying conditions, with proper checks for testing the most favorable and the most unfavorable conditions for the successful hibernation of the weevil.

At Dallas, Tex., a cage 20 feet square by 4 feet high (Pl. II, fig. 4), having 4 sections, has been built at a cost of slightly over $20, for additional hibernation tests and also to serve as a check upon the experiments at Keatchie, La. In the Dallas cage have been placed more than 10,000 weevils, and as many more have been distributed in smaller cages at various points in Texas. From the large number of conditions represented and the more than 50,000 weevils under test, it is hoped that valuable data may be obtained upon the hibernation of the boll weevil.

In the work done in the field cages it was found that whenever possible each individual in a lot should be so marked as to be easily recognizable. The definiteness of the record work was also largely increased by the practice of attaching a tag to each square or boll as it was attacked by a weevil. Upon the tag was recorded all data as to date and nature of attack. Daily examinations were then made of all these tagged squares or bolls and additional data recorded as it developed. In this way the full data for thousands of cases have been obtained and from it many important conclusions have been drawn. The tags in any series of records are numbered consecutively, that it may be possible to know when the series is complete and to give at any time an approximate idea of the number of records already obtained. If a number of experiments with varying conditions are to be made, each portion of the experiment is described and given a serial number by which it may be designated upon the tags. After the experiment is completed the data from the tags is transferred to permanent record cards for incorporation in the card catalogue system. Wherever possible the data is recorded in tabular form and the tables followed by cards giving a full summary of the results obtained.

The record cards for general note work are 4 by 6 inches in size. The sheets are arranged in books of 50 leaves each, making the convenient pocket size of 4 by 7 inches. Perforations across the bases of the sheets make it easy to remove them as desired. Across the left-hand end of the sheet is space for the name of the writer of the notes. At the top of the sheet are spaces for "Subject," "Date," and "Locality." The body of the page is cross ruled, giving 12 by 22 lines for the records. These cards have been found adaptable for practically all the permanent record work of the investigation. The cards have been arranged by subject and alphabetically, but it is our purpose to arrange the entire catalogue upon a decimal system during the present winter.

Quite extensive use has been made of photography as a supplement to the records made in the note work of the investigation. Many things can be easily shown which can only with difficulty be described, and a photograph, together with the notes, will undoubtedly convey a clearer idea to any person not making the actual observation than can be given in any other way. Methods in photography may be briefly considered later, but it will not be out of place here to say that our photographic file now shows over 900 negatives as the result of three seasons' work. These are kept in a card catalogue cabinet designed for commercial reports, thus accommodating both 4 by 5 and 5 by 7 negatives. All negatives are numbered and arranged consecutively. A card catalogue of the negatives with abundant cross references refers readily to the numbers of negatives illustrating any subject photographed, and a series of albums is kept in which is a sample print from each negative taken. In this way it is possible to know at any time exactly what negatives can be of use in making any desired illustrations. While very many of these negatives can never be of use for publication, few of them are thrown away, as the photographer may learn as much from a failure as from a success in the making of a desired negative. Careful record is kept of the particular brand and speed of plate used in each exposure, also of the lens, the light conditions, the stop used, the length of exposure given, the developer employed, and a general criticism of the result obtained. These records give the operator a clear idea of the conditions under which he has secured the best results and frequently enable him to correct mistakes, thus raising materially the standard of the results obtained.

During the past season, following the suggestion of Mr. Wilmon Newell, we have made photography do the work of the printer in the preparation of labels for a large part of the specimens collected by members of the boll-weevil investigating force. When a series of labels for a new locality, food plant, or collector is desired the typewriter is used to write in columns each desired label a proportionate number of times. A black ribbon is used with a clear white paper. If possible each column should be composed throughout its length of the same number of spaces, and a single space is sufficient to separate the columns. Attention to these points facilitates the cutting up of the labels. Prints are made upon special portrait paper, and if the work of negative making and printing has been well done a very good and durable label may thus be obtained. One of the chief advantages of this photographic system in the preparation of labels is that the delay involved in printing may be largely avoided. The entire process from the typewriting to the finished label may be completed, if desired, in a few hours. Each series of labels is kept in an envelope by itself, and all are arranged alphabetically in a drawer of the card-catalogue cabinet.

It may be needless to say that insect photography stands in a class quite apart from any other branch of the art. The methods of either the ordinary "kodaker" or the professional portrait maker will not produce good illustrations of insects. Right here allow me to express my appreciation of the valuable address given by Prof. M. V. Slingerland at the meeting of this association in St. Louis in 1903. I shall not presume to add much of value to the advice and suggestions of one who has done much more work than I have in this field, but even the novice may be allowed to mention some of the things he has found helpful in his work.

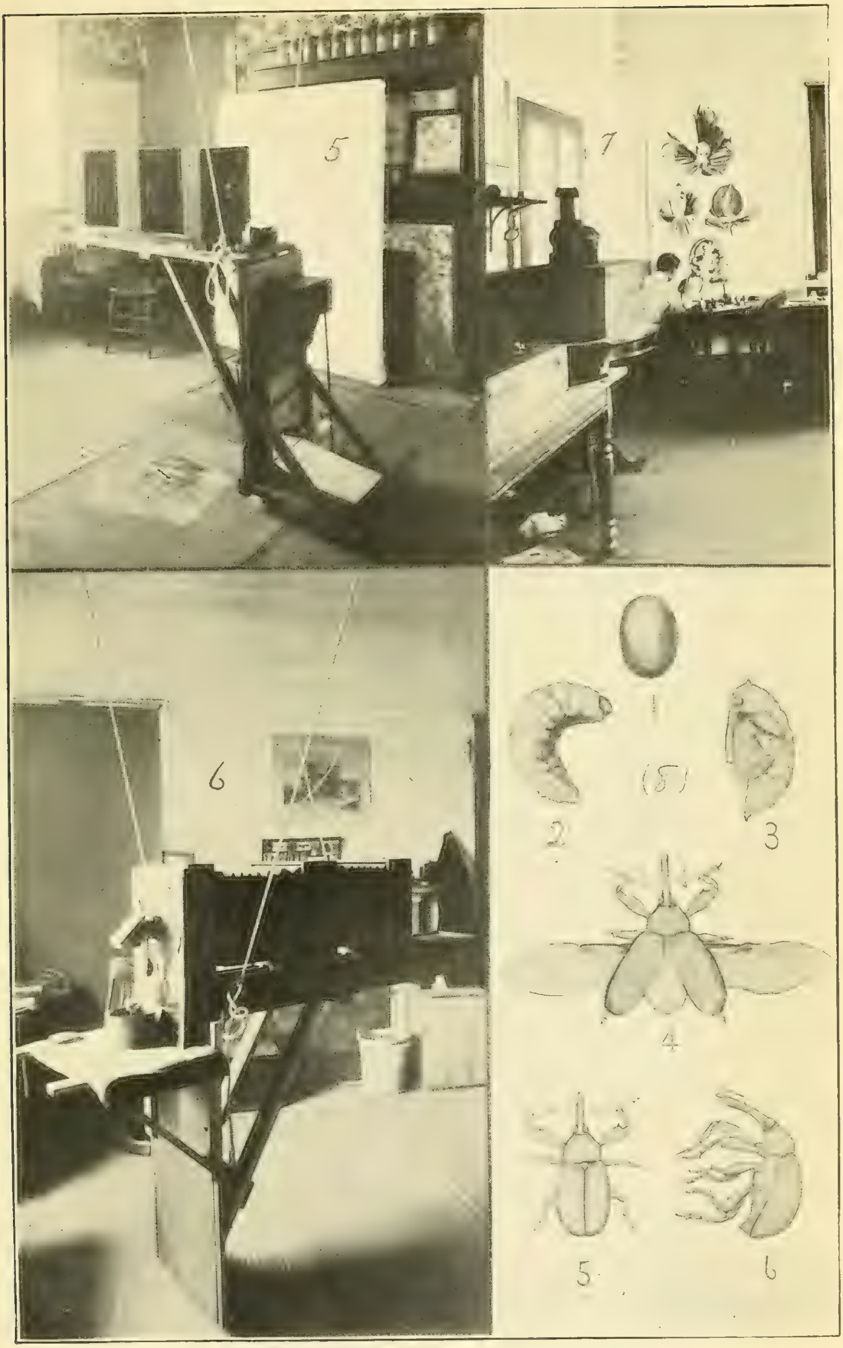
Owing to the small amount of room which could be set aside for photographic work and the constant necessity of working where others were more or less continually moving around the room, I have been forced to devise a camera stand that would accommodate at the same time both the copying and enlarging camera and the 5 by 7 hand camera, with which most of our views have been taken. This stand (Pl. III, fig. 5) consists essentially of a horizontal baseboard 18 inches wide, 1 inch thick, and 6 feet long, strongly braced so as to prevent warping. To one end of this board is hinged another, 3 feet long, of equal width and thickness, so that it can be dropped and fastened in a vertical position, or at right angles to the baseboard. In order to prevent the bad effects of floor vibration, the stand is suspended in a horizontal position from the ceiling by four ropes hooking into screw eyes at the four corners. On each side of the drop front, 1 inch in from the outer edge, is cut a half-inch wide slit, along which may pass the thumbscrew holding an adjustable right-angular bracket. Along the middle line of the drop front is cut another slit for the screw holding the hand camera when that is to be used. Both camera and object table are thus adjustable independently of each other, and either camera may be used as desired. If it is desired to use the copying camera with the object in a vertical position, the drop front may be raised to the plane of the base board and firmly secured in that position. This brings the brackets into such a position that they serve well as a vertical background, the distance of which from the front of the camera can easily be varied from a few inches to several feet. If the nature of the subject is such that it may be better taken in a horizontal position, the front is dropped and a right-angular prism is used, allowing the camera to remain also in a horizontal position. (See Pl. III, fig. 6.) The distance from the center of the lens to the plane of the object is still as easily adjustable by the sliding side brackets supporting the object table.

If an enlargement of less than four diameters is desired, I generally use the hand camera, owing to its easier manipulation and more accurate adjustments. This is adjustably placed upon the middle of the vertical front board and secured by the usual tripod screw. The height of the entire apparatus from the floor may be easily regulated to suit the convenience of the operator. The vertical position of the camera allows convenient focusing, while the horizontal position of the object table makes it easy to place the object upon glass, as may be done over a white background to obviate shadows, or to so arrange the background as to make it absolutely black. I have found greater difficulty in securing the black background with a properly lighted subject than in getting a shadowless background. The following method has been gradually developed: Upon the board resting on the side arms I first place a sheet of thick cork. Over this I spread a piece of heavy black velvet. The object is elevated a few inches above the velvet ground upon a dissection needle held in the cork, and the background below the object may then be shaded from the light in such a way as to render it absolutely black. (See Pl. III, fig. 6.) I have found that mirrors may be used in illuminating an object with this arrangement without having difficulty with the background. Medium isochromatic plates have proved to be the best for general use, and the double-coated plates of this brand are also an improvement upon the single coated. For label work or any subject consisting of black and white the contrast plates have given best results.

While I have found little use for photomicrography, the stand described serves very well for the combination of the camera with the microscope.

Frequently in the experience of the economic entomologist there arises the necessity for making enlarged views or charts for illustrative work under conditions when lantern slides can not be used. As I do not know that the process which we have used in making such charts has ever been used elsewhere, I will give an outline of our method.

The essential idea is to transmit a strong light through a negative of which an enlargement is desired, projecting the image directly upon the chart surface in a darkened room. The arrangement for securing the projection (see Pl. III, fig. 7) may consist of a stereopticon lantern, or if only a cheap stereopticon is available, it will do better to use only the portion of the stereopticon necessary for lighting the negative and then use the camera lens in front of the negative for the projection of the image. An arrangement such as is often used in making lantern slides may be adapted to this work, the negative-holding end of the camera being exposed to daylight at a window which is entirely darkened around the camera box, and the image projected upon the chart surface instead of upon the lantern slide. The great advantage lies in the fact that all outlines and



LABORATORY METHODS IN THE COTTON BOLL WEEVIL INVESTIGATIONS.

Fig. 5.—Camera stand designed for both horizontal and vertical work. Fig. 6.—Arrangement used in securing black backgrounds with camera horizontal. Fig. 7.—Chart making with stereopticon for projecting image. Fig. 8.—Chart made from negative image projected by electric light through copying camera. (Original.)

details are shown in their correct position upon the chart, and the worker has simply to ink them in as he sees them. No other apparatus is positively required beside the ordinary hand camera. Either daylight or strong artificial light may be used. Of course, in this work a positive image such as is used in a lantern slide is desirable, but if not at hand the negative will serve to give all outlines, and the positive image may be filled in much more easily and accurately than the average worker could do by making a freehand enlargement from a print or object. (See Pl. III, fig. 8.) With some such arrangement as I have outlined a man does not need to be an artist to secure a fairly good chart of any subject that he can photograph.

THE WORK OF THE STATE CROP PEST COMMISSION OF LOUISIANA ON THE COTTON BOLL WEEVIL.

By Wilmon Newell, *Shreveport, La.*

The work of the State Crop Pest Commission of Louisiana, in the campaign against the cotton boll weevil, is being conducted along three rather distinct lines: (1) Preventing, so far as possible, the spread of the boll weevil to new territory; (2) reducing the weevil damage in the area already infested, by disseminating information regarding the cultural methods to be employed in producing profitable crops of cotton in defiance of the weevil, and by experimental and demonstration work with the cultural methods upon different soils and under different conditions; (3) investigating and disseminating information regarding insects other than the boll weevil, in order that the production of crops other than cotton may be rendered more profitable than heretofore and the adoption of a diversified system of farming be encouraged among the farmers in the weevil-infested territory.

Before proceeding with a discussion of any one of these three lines of work, a brief résumé of the boll weevil's progress through the State of Louisiana up to the present time will be advisable in order that the problems with which the Commission has had to deal may be more clearly understood.

The boll weevil first reached Louisiana in 1903. In all probability the 1903 infestation was by a migratory flight, although some little evidence that the insect was introduced in other ways is not entirely wanting. The territory which was known to be infested in the fall of 1903 is shown upon the map in figure 3, the infested district comprising a comparatively small area in the western portion of Sabine Parish.

No diminution of the infested area was noticeable as the result of the climatic conditions prevailing during the winter of 1903–1904.

Acting upon the knowledge of the weevil's habits available at that time, the Commission undertook the complete extermination of the weevil in this limited area and undertook to prevent the spread of the insect by a rigid quarantine upon cotton seed, hulls, and seed-cotton, as well as upon household goods, hay, grain, forage, cotton sacks, baled cotton, etc., from the weevil-infested sections.

The extermination of the Sabine Parish colony was undertaken in the spring of 1904, by prohibiting the farmers in the affected terri-

FIG. 3.—Area in Louisiana infested by *Anthonomus grandis* in December, 1903, and in December, 1904.

tory from planting cotton, the landowners and tenants being paid a cash rental by the commission and in addition being permitted to grow any crop, other than cotton, that they desired. The elimination of cotton from this area of course resulted in eradication of the weevils therefrom during 1904.

Near Logansport an infestation covering a few acres was found in the early summer of 1904, having evidently been there the autumn previous, but undetected. Extermination of this colony was accomplished by destruction of the cotton plants in the area involved and by systematic hand picking of adult weevils and infested squares from trap plants.

Early in August of 1904, the special field agents of the Bureau of Entomology who were employed in Louisiana under the immediate personal supervision of Prof. H. A. Morgan, then entomologist of the crop pest commission, discovered boll weevils generally distributed in cotton fields where a few days before careful inspections had revealed none at all. Their numbers, as well as their occurrence in cotton fields several miles distant from the two original colonies, precluded all possibility of their being individuals which had escaped destruction at the time of extermination of these colonies. In all of the infested fields Professor Morgan and his assistants found only adult weevils, eggs, and very young larvæ, showing that the arrival of the adult weevils in fields many miles apart had been practically simultaneous.

Only one explanation of this phenomenon presented itself, and that was that these weevils had migrated from the infested cotton fields of Texas. Further examinations of cotton fields during the summer and autumn months of 1904, by Professor Morgan and the special field agents of the Bureau of Entomology, established the existence of a marked and clearly defined migratory movement of the weevil into new territory. This migratory habit of the weevil, which had previously been unknown and evidently unsuspected—as it is not mentioned in any of the writings upon this insect prior to that time—entirely revolutionized the methods to be employed in retarding its progress into new territory. The attempt to eradicate infestations within the territory covered by the yearly migrations became not only impracticable but impossible, as fields in which the cotton might be destroyed in the work of exterminating the insect would become reinfested from surrounding territory immediately upon cotton being again planted therein.

The migratory movement of 1904, while most marked and extensive during the latter part of August, continued with greater or less volume until frost, the weevil's movements during the latter part of the season being more or less continuous and hardly distinguishable as distinct migrations. The territory gained by the weevil during the month of August more than equaled in area all of the territory gained by it during September, October, and November. The area infested by the weevil in December, 1904, is seen in figure 3.

The winter of 1904–5 was one of the most severe that Louisiana has seen for many years, the temperature being much lower than usual and the rainfall much in excess of normal for the winter months.

Careful examinations in cotton fields aggregating several thousand acres, between May 1 and August 1, 1905, showed that the weevil had not survived the winter in the eastern portion of the territory infested the previous autumn. In other words, the weevils were exterminated by meteorological conditions in that area which they did not occupy until after about the middle of September, 1904, and in which therefore they did not have opportunity to breed up to considerable numbers before the arrival of frost. The territory

FIG. 4.—Area in Louisiana infested by *Anthonomus grandis* in July, 1905 (see shaded portion of map).

infested in July, 1905, is shown by figure 4, and by comparison with the eastern limit of infestation in December, 1904 (fig. 3), an idea will be had of the amount of territory actually lost by the insect. It is, of course, conceivable that an occasional weevil may have survived the winter in this territory, but the examinations of so many cotton fields in different localities, and with different surroundings, by men thoroughly skilled and practiced in detecting even the lightest infestations, and each of whom was in ignorance of the findings of the rest, seems to reduce the chance of any survivals in this area to one in several thousand.

Perhaps the most interesting point noticed in connection with this extermination of the weevil by meteorogical conditions was the fact that it was exterminated in Caddo, the northernmost parish of the State, and also at Cameron, the southernmost point at which the weevil has been found in Louisiana. As Cameron has about the highest average winter temperature of any locality in Louisiana, and as Caddo Parish has very nearly the lowest average winter temperature of any locality, it appears that the excessive moisture, rather than low temperatures, was responsible for this heavy mortality.

A similar loss of territory by the weevil in northern Texas has been noted by Mr. Hunter and his assistants the present season (1905); and so far as the writer is aware the winter of 1904–5 was the first in which meteorological conditions brought about anywhere near so great a decrease in the territory infested by this insect.

In 1905 the migratory movement of the weevil commenced about the middle of August and continued with more or less continuity until about November 20. The existence of certain quarantines throughout the State during August, September, and early October, on account of yellow fever, prevented the extensive field observations necessary to determine the exact time and extent of the migratory movements. Field work could not be resumed until the middle of October, and after that date an accurate survey was made to determine the eastern limit of the territory invaded.

The migrations of 1905 gained for the boll weevil practically all of the territory it lost during the winter, and a very considerable area in addition. Cameron, La., a community practically isolated from other cotton-growing sections by many miles of marsh, was the only locality not reinfested by the 1905 migrations, careful field examinations in this locality during December failing to reveal any indication of infestation.

In the eastern part of the area at present infested (fig. 5) the infestation is of course exceedingly light, maximum infestation and consequent severe injury not occurring before the second season of infestation and occasionally not before the third. In those portions of the State reached by the weevil in the fall of 1903, or the very early summer of 1904, the injury during the season just passed has been considerable. Roughly outlined the area suffering severest weevil injury during 1905 is embraced in western Vernon and Sabine parishes and southwestern De Soto Parish. In western Sabine Parish the weevils are doubtless now as abundant as they ever will be, and it is interesting to note, incidentally, that the farmers in this section who have followed, even in a crude way, the cultural measures advocated by the Bureau of Entomology and the crop pest commission have made approximately 90 per cent more cotton per acre than those who adhered to the use of big-boll, late-maturing varieties and to indifferent and insufficient cultivation.

THE QUARANTINE MAINTAINED BY THE CROP PEST COMMISSION.

By virtue of the provisions of act No. 6 of the extra session of the Louisiana legislature of 1903, the crop pest commission is vested

FIG. 5.—Area in Louisiana infested by *Anthonomus grandis* in December, 1905 (see shaded portion of map).

with authority to make and enforce quarantine regulations governing the movement of any material likely to disseminate the boll weevil or other seriously injurious insect.

The quarantine regulations at present maintained by the commission, in connection with the boll-weevil campaign, prohibit the movement of cotton seed, seed cotton, cotton-seed hulls, cotton-seed sacks (used), and seed-cotton sacks (used) from the infested territory of Texas and Louisiana to any point in the noninfested sections of Louisiana.

The materials mentioned are those which experience has shown to be such as are most likely to contain living boll weevils, and the shipment of which to uninfested sections might therefore result in new infestations many miles ahead of the gradually advancing line of weevil infestation. Of the materials named, only one, cotton-seed hulls, is ever permitted to be shipped into the uninfested territory under any circumstances. The commission has perfected a method by which cotton-seed oil mills can so arrange their machinery as to handle the hulls after they leave the huller in a manner that will effectually prevent the dissemination of boll weevils with them; and to mills having a satisfactory arrangement of their machinery, as required by the commission, permits are given for the shipment of cotton-seed hulls to any point in the noninfested sections.

The commission is frequently confronted with the question: "So long as the boll weevil's progress by migratory flights can not be controlled, what is the use of trying to maintain a quarantine upon shipments likely to disseminate the weevil?" To any thinking man who will note the progress made by the weevil each year in its migrations and the loss of territory which the pest experienced last winter, the answer must be evident. Even though the insect is each year gaining additional territory, and even though ultimate infestation of the major portion of the cotton belt appears inevitable, much is to be gained by preventing the pest from obtaining a foothold many miles ahead of the gradually advancing frontier of infestation. For example, if infestations now occurred in the north central portion of Louisiana and at points along the Mississippi River, as well as in that portion of the State east of the river, it is evident that the entire State would become infested much sooner than if all such outbreaks were prevented and the weevil forced to limit its progress into new territory to actual bodily movement. Even if the advance of the pest can not be permanently prevented, there is certainly no justification for permitting it to be accelerated. To abandon quarantine measures simply because the weevil gains new territory each year by flight, would be analogous to the case of a large city in which a conflagration occurs, spreading gradually, and in which on that account the authorities permit other fires to be started in other portions of the city, each of which in turn would itself become a conflagration involving a large area.

It is pleasing to note that not a single case of infestation by the boll weevil is known to occur at any point east of the territory which has been occupied by the weevil in its migrations, the eastern limit of which is virtually coincident with the quarantine line established by the commission, and we have therefore every reason to believe that this quarantine has been entirely successful, and has thereby saved not only eastern Louisiana but States east of us from infestation through shipments of the articles referred to above. There is at least no evidence to indicate that the enforcement of these regulations by the commission has not accomplished as much in restricting the spread of the boll weevil as could be accomplished by any agency subject to human control.

THE CAMPAIGN AGAINST THE BOLL WEEVIL IN THE TERRITORY ALREADY INFESTED.

In the territory which is already infested by the boll weevil the commission has exerted every effort to furnish all planters and farmers with accurate and detailed information regarding those farming methods which must be employed to produce profitable crops of cotton in spite of the weevil. The commission advocates, essentially, the remedial cultural methods perfected by Dr. L. O. Howard and Mr. W. D. Hunter, of the Bureau of Entomology. The dissemination of this information has been through the press, by means of bulletins and circulars, by addresses at farmers' meetings, by the cooperation of local business men in the distribution of literature, and by actual field demonstrations in growing cotton in the heavily infested sections under the direction of the assistant entomologists in the employ of the commission. In addition to this work, the commission has conducted rather elaborate experiments in determining the value of the different steps involved in the "cultural remedy," as well as along kindred lines.

As Paris green has at times been enthusiastically advocated as a sovereign boll-weevil remedy, the commission undertook during the season just passed exhaustive experiments in determining the value of this agent in the campaign against the weevil. The results were somewhat surprising, as they showed that not only was the boll weevil not affected by applications as heavy as could be made without destroying the foliage of the cotton plants, but that the application of Paris green in late summer, by destroying the cotton worm (*Alabama argillacea* Hbn.), indirectly increased the food supply of the weevil, facilitating breeding and furnishing an abundance of food, in the form of squares and young bolls, right up to the time of entering hibernation, thereby greatly increasing the weevils' chances for successful survival of the rigors of winter.

A "hibernation experiment" with the boll weevil, at present under way, is perhaps the largest experiment that has ever been undertaken in "breeding cages." In the neighborhood of 35,000 adult boll weevils are being used in the experiment, distributed among 18 cages, each of which occupies 160 square feet of ground and has a height of about 8 feet. These cages contain hibernating quarters offering varying degrees of protection from rain and cold, simulating as nearly as possible the different conditions which obtain upon the average Louisiana plantation.

The object of the experiment is, of course, to determine the per cent of weevils which survive under different conditions for hibernation and when forced to subsist for varying intervals without food before entering hibernating quarters in the fall. In addition to this we expect to determine next spring the date and temperature at which the first hibernating adults emerge from winter quarters, the time at which the bulk of hibernated weevils emerge, and the date at which the last individuals leave hibernation. An accurate knowledge of all the points involved is of the utmost importance in securing the maximum results in employing the cultural remedy.

THE INDIRECT METHOD OF REDUCING DAMAGE BY THE BOLL WEEVIL.

That the boll weevil has no food plant other than cotton has become almost an axiom. The farmer who produces crops other than cotton has nothing to fear from boll-weevil ravages, but unfortunately he finds other insect enemies threatening his success regardless of what crops he may undertake to substitute for cotton. The crop-pest commission does not overlook the fact that we are to continue in the future, as in the past, to produce cotton, but under the present labor and credit systems which prevail in Louisiana and adjacent States the profitable production of cotton, upon as large a scale as formerly, with the weevil present, will be impossible, and the growing of cotton to the practical exclusion of other crops must be succeeded by a diversified system of agriculture. By the control of insects seriously injurious to crops other than cotton and by devising and disseminating information concerning methods of successfully combating them, the profits derived from producing such crops are materially increased and the advent of a properly diversified system of farming is accordingly hastened.

In this connection it is sufficient to direct attention to the fact that as the territory infested by the boll weevil increases and as the present infested area approaches a state of maximum infestation, the warfare against other insects will become of much greater moment to the agriculture of the State than it is at present.

Mr. Marlatt, referring to the recommendation made in some of the papers for the encouragement of the cotton leaf-worm as a means of controlling the boll weevil, remarked that it should not be forgotten that the leaf-worm itself has proven in the past a very serious cotton pest, and that in the early years of its presence, before means of control were discovered or generally practiced, it caused a loss in single seasons quite as great as that now occasioned by the boll weevil. He felt, therefore, that the encouragement of the abundance of the leaf-worm was open to some question, and that such encouragement from official sources might lead planters to ignore the presence of this pest and omit the customary prompt treatment, with resulting great losses to the cotton crop.

Mr. Newell said that it was quite true that the cotton worm was at one time a most serious pest, and did great damage, but since then the planters have learned how to control it with certainty, and without the necessity of consulting an entomologist. It is doubtful whether there is any other single injurious insect which is subject to as full and certain control as is the cotton caterpillar.

In sections heavily infested by the boll weevil, the production of a so-called "top crop" is impossible, and it is rarely that the caterpillar ever destroys more than the top crop. In weevil-infested sections the top crop must be sacrificed, and in view of this fact, it is preferable to allow the caterpillars to take it and thereby decrease the food supply and breeding places of the boll weevil.

The boll-weevil problem is most serious upon our alluvial lands, where the cotton grows high and rank. If caterpillars are permitted to "rag" the foliage of such cotton in the latter part of summer, sunlight is permitted to reach the unopened bolls on the lower limbs, and the maturity of these bolls is accordingly hastened. Any factor which tends toward early maturity of the crop is of the utmost importance in the weevil sections.

It is not proposed to substitute one injurious insect for another, in attempting to utilize the caterpillar in the warfare against the weevil, but merely to let one injurious insect destroy the food-supply of the other, after all possibility of making additional fruitage is gone. When the caterpillar appears early in the season, it must be controlled, but the application of Paris green to the cotton never secures total extermination of the caterpillar, so that in such years the caterpillars will become abundant enough to defoliate the plants in from three to four weeks after poisoning ceases. It is merely proposed to utilize the work of the caterpillar in those years when it is sufficiently abundant to completely defoliate the cotton three or four weeks before frost, such complete defoliation answering practically the same purpose as the fall destruction of the cotton plants by the planter, and at a much less cost.

Mr. Hunter said that it was true, as had been stated, that the leaf-worm was a dangerous insect many years ago, but the conditions have so changed that this is no longer true. One of the factors in this has been the cutting up of the larger plantations. Even before the boll weevil came, planters had come to regard a late visitation of the leaf-worm as beneficial. This is especially true in the alluvial soils, where the foliage is excessive in amount. Here, anything that will let in the light late in the season assists in the ripening of the cotton, and is therefore beneficial.

Mr. Morgan said that there was another aspect of the relation between these two insects that seemed of importance. The leaf-worm, by stripping the plants of foliage, deprives the boll weevil of food, and thus causes it to migrate farther. In this way, the spread of the insect was undoubtedly extended last year. If we let the leaf-worm come into our fields early, we hasten the spread of the weevil towards the more important cotton regions farther east. If, however, the caterpillar recommendation prevails, it seems important to emphasize the possible value of the caterpillar in connection with weevil suppression only when it (the caterpillar) appears late in the season; otherwise careless planters might accept this recommendation as an excuse for neglect when caterpillar damage came too early and threatened the cotton crop.

Mr. Hinds called attention to the fact that when the leaf-worm is ahead of the weevil it actually delays the spread of the latter by rendering the conditions for its survival so precarious that few of those migrating live.

Mr. Newell said that we had commonly supposed that the existence of a defoliated area would tend to make the weevil go farther in its migratory flight in search of suitable food, and that, vice versa, an area in which the cotton was rank and luxuriant and not defoliated would have the effect of discouraging the weevil from extending its flight farther. With this in mind, it seemed not improbable that the migratory flight of 1905 would be limited by the Red River Valley. In reality, however, the weevils crossed the Red River Valley into the hills to the eastward, and the area covered by the 1905 migrations was as great as that covered by those of 1904.

Mr. Hunter said that he had in mind especially, in discussing the probable spread of the boll weevil, the work of Professor Webster on the chinch bug. He could not see why the two insects were not likely to follow the same route.

Mr. Webster stated that he could see no good reason why the boll weevil should not follow the same trend of diffusion as had other insects that had spread from eastern Mexico into the United States, as, for illustration, the chinch bug. He thought that the trend of diffusion would be more rapid to the eastward than to the northward, but there were several facts to be taken into consideration. At present the spread was with the trend of commerce in cotton; after the Mississippi River had been crossed, the spread of the pest would be against this trend of commerce, which would be presumably toward the greatest cotton mart, New Orleans. Unless the winter weather prevented the pest from doing so, he saw no reason why the boll weevil should not spread eastward along the Gulf coast until it had passed the lower extremity of the Appalachian mountain system, and then go northward, possibly reaching Virginia before it did Missouri or extreme northern Arkansas, but in either case stopping only with the limit of cotton culture. This was the case with the harlequin cabbage bug, which had spread at one time as far north as Chicago, Ill., and had almost reached the shore of Lake Erie, in Ohio. A very severe winter, however, had killed it off to southern Illinois and Ohio, and it had not yet recovered this lost ground, and might not again in years.

Mr. Newell believed that climatic conditions are an important factor in determining the rate of spread of the boll weevil. It is certainly spreading much faster eastward than northward, and at the present rate will probably reach the eastern end of the cotton belt before it does the northern limit of cotton culture in the Mississippi Valley.

Mr. Sanderson stated that he was particularly interested in Mr. Hunter's remarks upon the relation of the boll weevil to the cotton crop of 1904. Since the last meeting of the Association he had revised the paper presented at Philadelphia concerning the injury done the cotton crop by the boll weevil, bringing the report up to include 1904, and the article has finally been published as a bulletin of the Texas department of agriculture. He stated that from a careful statistical study of the acreage and crop produced by the counties of the State he felt that in 9 counties in central Texas a better than normal crop had been produced, very largely due to following the directions of the entomologist. The following was quoted from the bulletin cited:

The injury in 1904 was quite different in many respects from that of any previous years. The total acreage injured showed a decrease from that of 1903, due to the fact that 9 counties in central Texas, 5 of Central Group A, including Austin, Brazos, Burleson, Comal, and Fort Bend, and Bell, Hays, Limestone, and Williamson, having a total acreage of 8 per cent of that of the State, and producing nearly 10 per cent of the total crop, produced better than a normal crop compared with the uninjured counties, though in 1903 they had all shown serious injury. In contrast to this encouraging feature, the 12 counties of Southern Group A, owing to a very mild winter, early spring, and allowing stubble cotton to remain over winter upon which the weevils commenced to multiply early, produced but half a normal crop, for the first time showing serious injury since 1899. In addition to the injured area of 1903 were 7 counties in eastern Texas and 10 southwestern counties, the outer limits of the area injured in 1904 being almost exactly those infested in 1902, except for the 10 counties of Central Group E, Blanco, Bosque, Burnet, Coryell, Ellis, Hamilton, Hill, Randall, Lampasas, McLennan, which showed a better than normal crop, though many of them had been well infested in 1903, and all more or less in 1902. Together the 69 injured counties showed an "apparent" decrease of 0.14 bale per acre, which, with the increase of 0.08 bale per acre for the balance of the State, gave 0.22 bale per acre total loss, practically the same as in 1903, making 586,478 bales decrease, slightly larger than for 1903. In 1904 there was comparatively little injury from the bollworm and loss from flood, so that 550,000 bales may safely be charged to the boll weevil. Had the 9 counties which previously had shown a loss, but in 1904 made better than a normal crop, showed as much injury as those surrounding them, the total loss would have approximated 700,000 bales. Had the 10 counties of Central Group E been injured as much as the 7 eastern counties after two years of infestation, there would have been 175,000 bales further decrease. In other words, had the weevil been as injurious in the territory infested two years or over as previously, there would have been a loss of 875,000 bales of cotton due to the weevil in 1904. That this was not the case, and that a phenomenal crop was made, was undoubtedly due to the extremely favorable season, an early spring hot summer, and a late growing season. These favorable weather conditions made possible the best possible results from the "cultural methods" of preventing injury by the weevil, consisting of early planting, early varieties, and thorough continued cultivation. These methods were widely practiced by progressive planters and undoubtedly were a large factor in producing a crop above the average for the uninjured counties, including 9 of the largest counties which had previously shown serious loss, as well as lessening the loss in other counties. It should be borne in mind, however, that in spite of the large total crop the loss to over one-third the acreage of the State was as severe as in 1903 and was fully one-half the crop of those counties. Had there been no loss by the boll weevil in 1904 Texas would probably have produced 3,750,000 bales of cotton.

He believed, however, that the large crop was due, as a whole, to the very favorable weather conditions.

He commended the remarks of the paper of Mr. Conradi in showing that the control of the boll weevil had come to be largely a matter of agricultural methods, and expressed his belief that the advent of the boll weevil had really been a very great blessing to the farmers of Texas. Mr. Sanderson warmly commended the laboratory work and methods of Doctor Hinds, which he had carefully studied. The photographic prism mentioned by Doctor Hinds he believed he had mentioned to the Association before, since he was the first to use it, so far as is known, in Delaware in 1900, and has since found it exceedingly useful, especially for photographing larvæ and material in alcohol or liquid. The vertical attachment to the photographic stand described by Doctor Hinds had originated in Texas, and he had suggested the construction to Professor Quaintance, and since constructed one along the same lines for his use in New Hampshire. With larger laboratory room, however, he prefers the spring stand, which rests on the floor and may be moved about the room for photographing objects at a distance. He suggested that one of the most useful devices in photography is a universal arm lens holder made with several ball joints. In the clips may be inserted a bit of cork covered with white or black paper, upon which the insect is pinned, or a small glass plate, and the object may then be put to any desired angle or position with a touch. He expressed his opinion that enlargements should be used more in insect photography for publication. The great temptation was to attempt too great an enlargement immediately from the object. A clear, sharp negative, natural size, is much preferred, as it can then be enlarged as desired by making an enlargement from the negative. Mr. Sanderson stated that the effect of the cotton leaf-worm, as shown to Mr. Newell, had been frequently published in southern Texas by publishers there, and that they found the weevil much less abundant the following spring after a fall in which the caterpillar had attacked the foliage. He believed the leaf-worm to be a most valuable ally, and pointed out the fact that usually the use of the leaf-worm did not occur until late in the season, so that with the growth of early cotton for the boll weevil the leaf-worm would rarely do any real injury. He deprecated, however, the tendency to place much emphasis upon the work of the leaf-worm as having a tendency to encourage the planters in their failure to destroy the cotton stalks in the fall by burning. Although the work of the leaf-worm should be encouraged by stopping the use of Paris green on the foliage for its destruction, it would be unfortunate if the planters should come to depend upon it.

He believed that the elementary solution of the control of the boll weevil depends upon the destruction of the stalks in the fall, and stated that so far as he was aware no experiments had demonstrated the value of this procedure upon individual farms if not adopted by neighboring farms, and that this seemed to be a most important matter. The value of the fall destruction of the stalks had been realized by entomologists and recommended by them from the first, but had been practically neglected by planters in general. He stated that observations made by him at Texas College showed the undoubted value of the destruction, even upon one farm, but that the records, though convincing to an entomologist, would not prove the matter to the average planter.

He suggested the great desirability of an experiment on a large scale, taking in several square miles, where the stalks might be destroyed in the fall, so that the value of this method could be demonstrated on a large scale. The success of the growing of early cotton with thorough culture in Texas is due to the fact that farmers had seen an actual demonstration of the method on a large scale, and he believed that the burning of the stalks required a similar demonstration. He suggested the possibilities of such an experiment to the Louisiana crop-pest commission, who, he understood, had conditions under which they could prosecute such an experiment. Had the State of Texas furnished funds for such work, he should have made the experiment previously, and believed that it would be worth several thousand dollars.

Mr. Newell said that on a small farm, practically continuous with surrounding cotton areas, the destruction of the cotton plants in the fall is not likely to result in a great amount of good, unless the plants on adjacent farms are destroyed as well.

Upon large plantations of several hundred acres or more, and upon small farms which are isolated from neighboring cotton fields by a mile or more of fields not in cotton, or a half mile or more of forest, fall destruction of the plants will undoubtedly pay, even if other farmers in the community do not adopt the plan. In observations carried on in 1905 in an area in Sabine Parish, La., where no cotton was grown in 1904, it was found that the weevils did not reach the center of the area—a distance of 3 or 4 miles—until three to four weeks after they had appeared in the cotton fields outside this area where they hibernated. Delay in reaching any given cotton field in the spring means, of course, a corresponding postponement of the date at which maximum infestation will occur in that field, and opportunity for the plants to mature additional fruitage is afforded.

There is, of course, no doubt that full cooperation on the part of all farmers, in this autumn destruction of cotton plants, is necessary to secure the maximum benefit therefrom. An experiment or demonstration over a large area, for the purpose of showing the public just what can be accomplished by the fall destruction of plants, is most desirable, but owing to the fact that the farmers in this area would have to be compensated at a rate satisfactory to them rather than at a rate really commensurate with the labor required, the experiment would doubtless cost several thousand dollars. It is also doubtful if all of the farmers in an area, as large as a township, for example, could be induced to cooperate in a demonstration of this kind. Without full cooperation of all the farmers in such an area the experiment would fall far short of giving satisfactory results.

Mr. Flynn said that one of the main reasons why the destruction of the stalks is not practiced in Louisiana is that not more than one-half of the cotton on the large plantations is picked by November 15. This condition is due principally to the scarcity of cotton pickers at that season.

Mr. Webster stated that in 1904 he had predicted the advancement of the boll weevil into Louisiana, and these predictions had proven approximately correct, though he was inclined to believe that but for the influence of the Galveston hurricane the lines shown by Mr. Newell might have been slightly modified, as this certainly drove the insect to the northward in Texas.

AFTERNOON SESSION, WEDNESDAY, JANUARY 3, 1906.

On motion, it was decided that the next annual meeting should be held in New York City in conjunction with the American Association for the Advancement of Science.

Mr. W. D. Hunter, chairman, presented the following report:

REPORT OF COMMITTEE ON NATIONAL CONTROL OF INTRODUCED INSECT PESTS.

Your committee is impressed with the great advisability of some definite action, and considers that the time for the beginning of such action has arrived.

The Government has delegated to certain bureaus full authority in the control of diseases of live stock that are likely to spread to such an extent as to cause great public loss. The committee believes in the wisdom of the general policy established thereby. Inasmuch as similar cases have occurred in this country and are likely to occur again, in which the subject comes within the domain of the Bureau of Entomology of the Department of Agriculture, your committee recommends the following plan of action:

(1) That this Association, by nomination, select a committee of five members to consider the matter carefully and report at the next meeting.

(2) That this committee be instructed to confer with the Chief of the Bureau of Entomology in the preparation of its report.

(3) That the committee be instructed to confer with a committee charged with the formulation of plans for obtaining uniform nursery inspection regulations, selected at the last meeting of the National Association of Horticultural Inspectors.

(4) Your committee recommends the consideration of the following scheme:

(A) The granting to the Bureau of Entomology of full authority to inspect at the ports of entry all commodities likely to carry injurious insects.

(B) The granting of authority for the Bureau to take whatever action may be necessary in the eradication or control of species that have been or may be introduced accidentally, wherever, in the judgment of the chief of that Bureau, such action is practicable.

(C) That an effort be made toward the obtaining of uniformity in regulations relating to nursery inspection by either the passage of a Federal law or the charging of the Bureau of Entomology with the duty of inducing cooperative uniformity in the laws of the several States.

W. D. Hunter, *Chairman.*
L. O. Howard.
W. E. Hinds.
E. D. Sanderson.
H. A. Morgan.

On motion, the report of the committee was adopted. The chair called for nominations for the five members of the committe provided for in the above resolution. The following were nominated. and on motion the nominations were declared closed and the secretary was instructed to cast the ballot of the society for the members named: Messrs. A. L. Quaintance, W. E. Hinds, W. D. Hunter, C. L. Marlatt, and H. Osborn.

The committee on membership, consisting of H. E. Summers, chairman, W. D. Hunter, and A. F. Burgess, reported as follows:

The committee recommends that in the future the Society exercise greater care as to the qualifications of candidates for election to membership, and that as regards active members particularly a considerably more conservative policy than has prevailed in the past should be adopted. In general, only those who are already associate members should be elected to active membership, and this should occur only after they have published a considerable amount of original matter on economic entomology based on their own independent investigations. The privileges of associate membership, however, may well be extended as a means of encouragement to young men who are expecting to pursue economic entomology as a profession, but who have not yet had time to show their capabilities by publication or otherwise.

In the case of active members who seem to have abandoned economic entomology permanently, as indicated by their adopting some other profession, they should be transferred to the associate list either permanently or until such time as they may reengage in work in economic entomology.

In accordance with these principles the committee recommends the following list for membership and for transfer:

For foreign membership: A. L. Herrera, Mexico City, Mexico.

For transfer from associate to active membership: R. I. Smith, Atlanta, Ga.; H. J. Quayle, Ames, Iowa.

For associate membership: C. F. Adams, Fayetteville, Ark.; C. E. Bartholomew, Ames, Iowa; James H. Beattie, Washington, D. C.; R. W. Braucher, Chicago, Ill.; Edwin C. Cotton, Columbus, Ohio; Alexander Craw, Honolulu, H. I.; C. W. Flynn, Baton Rouge, La.; A. B. Gahan, College Park, Md.; J. B. Garrett, Baton Rouge, La.; E. S. Hardy, Shreveport, La.; J. S. Houser, Wooster, Ohio; Fred Johnson, Washington, D. C.; Charles R. Jones, Dallas, Tex.; Albert Koebele, Alameda, Cal.; G. W. Kirkaldy, Honolulu, H. I.; W. O. Martin, Shreveport, La.; R. S. Mackintosh, Auburn, Ala.; John F. Nicholson, Stillwater, Okla.; R. C. L. Perkins, Honolulu, H. I.; J. L. Randall, Durham, N. H.; E. R. Sasscer, Washington, D. C.; W. W. Yothers, Dallas, Tex.

For transfer from active to associate membership: E. E. Bogue, C. T. Brues, R. S. Clifton, Carroll Fowler, C. W. Hargitt, Gerald McCarthy, George W. Martin, C. V. Piper, W. M. Scott.

On motion, the report of the committee was adopted.

On motion by Mr. Osborn, it was

Resolved, That the secretary be requested to arrange, if practicable, in the next annual programme for a symposium on "Insect Legislation," and for one on "The Use of the Insectary in Entomological Research and Education."

It was moved by Mr. Marlatt and carried that a committee of three, with the secretary as chairman, be appointed to prepare the programme for the next meeting and to formulate suggestions relative to the method of presentation of papers and the discussion thereon. The chair appointed as such committee the secretary to be elected, Mr. Marlatt, and Mr. Summers.

The following papers on insecticides were presented, the discussion being postponed until the entire series was read:

TESTS OF LIME-SULPHUR WASHES IN CONNECTICUT IN 1905.

By W. E. Britton, *New Haven, Conn.*

In our experiments, 6,000 peach, apple, and pear trees in five different orchards, situated in Westville, West Haven, Westport, Southington, and Middletown, were sprayed in March and April, 1905. The spray mixtures were chiefly lime-sulphur washes, which were prepared after five different formulas, as follows:

BOILED WASHES.

No. 1.—Twenty pounds lime, 14 pounds sulphur, 40 gallons water. The sulphur was added to the slaking lime and boiled 45 minutes. The mixture was then strained into the pump barrel, diluted, and applied.

No. 2.—Twenty pounds lime, 14 pounds sulphur, 10 pounds salt, 40 gallons water. Prepared as in the preceding, the salt being added with the sulphur.

"SELF-BOILED" WASHES.

No. 3.—Twenty pounds lime, 10 pounds sulphur, 10 pounds sodium sulphide, 40 gallons water. The lime was started slaking, and sulphur added. When at greatest heat, the sodium sulphide was added, with constant stirring.

No. 4.—Twenty pounds lime, 14 pounds sulphur, 5 pounds caustic soda, 40 gallons water. Prepared like No. 3, caustic soda being used instead of sulphide.

No. 5.—Twenty pounds lime, 14 pounds sulphur, 10 pounds sal soda, 40 gallons water. Made like Nos. 3 and 4, except that hot water was used and sal soda was employed instead of caustic and sulphide.

In each of these "self-boiled" washes the materials were allowed to stand for about thirty minutes after the violent boiling had ceased before diluting and applying.

In comparison with these lime-sulphur washes the following kerosene-limoid mixture, containing about 25 per cent of kerosene, was employed:

No. 6.—Forty pounds limoid, 10 gallons kerosene, 30 gallons water. The kerosene was absorbed by the limoid, then by violent stirring and forcing through the pump this was mixed with the water.

Mixtures 1 and 2 were boiled; mixtures 3, 4, and 5 are called "self-boiled" because no heat is used in preparing them except that evolved by the slaking lime.

The cost of materials in making these mixtures varies from $0.54 to $0.84 in the lime-sulphur washes for enough to make a barrel of 40 gallons. Materials for the same quantity of mixture No. 6 (kerosene limoid) cost $1.66. These are all retail prices. Mixture No. 1 cost $0.54 for materials, exclusive of boiling, which can probably be done in large quantities for $0.15 to $0.25 per barrel, according to equipment and conveniences.

Following our usual custom, twigs from a number of each kind of tree in each locality were examined before treatment. About 35 per cent of the wintering female scales had been killed by the winter. Late in June, just before the appearance of the young, twigs were again cut from the same trees and examined. This record showed the kerosene-limoid mixture to have killed about 88 per cent of the scales alive at the time of treatment, while the lime-sulphur washes killed from 91 to 95 per cent. These figures, though not marked, indicate the greater effectiveness of the latter, and observations made late in the season not only confirmed the indications, but showed a much greater difference in favor of the lime-sulphur washes. Large peach trees at Southington were sprayed, a portion with the kerosene-limoid mixture and another portion with the boiled lime-sulphur wash, the trees being well covered in each case, and all were badly infested with scale. In October I was greatly disappointed to find plenty of living scales on the trees sprayed with the kerosene-limoid mixture; some were as badly infested as before spraying.

Trees in adjoining rows sprayed with the lime-sulphur wash, though showing some living scales, were comparatively free from them, although there were plenty of dead ones. The evidence seems to show that though the kerosene-limoid mixture had in June killed nearly as great a proportion of the scales as the lime-sulphur washes, it apparently left the bark in a condition much more favorable to the presence of the scale, and therefore to reinfestation, than the latter. I have noticed that where lime-sulphur washes are applied the bark does not readily become again covered with scales; it is also possible that the scales counted as alive in June were injured to such an extent by the lime-sulphur wash that they failed to reproduce. Other experimenters have reported similar results.

Strange to say, the self-boiled wash of lime, sulphur, and sodium sulphide gave slightly better results than the boiled wash. The presence of salt in the boiled wash could not be detected by its effect on the scales nor by its adhesive qualities.

EXPERIMENTS WITH INSECTICIDES ON THE SAN JOSE SCALE.

By E. P. Felt, *Albany, N. Y.*

The insecticide campaign of recent years has been continued with gratifying results, so far as confirmation of earlier work is concerned. The tests have been limited largely to lime-sulphur washes, boiled and unboiled, and 20 and 25 per cent of the so-called limoid or K–L mixtures. The lime-sulphur washes called for 20 pounds of lime and 15 pounds of sulphur, 25 pounds of lime and 20 pounds of sulphur, and 15 pounds each of lime and sulphur, to 50 gallons of water, the mixture in each case being actively boiled for about thirty minutes. Unboiled washes, using 20 pounds of lime, 15 pounds of sulphur, and 10 pounds of sal soda; 25 pounds of lime, 20 pounds of sulphur, and 12½ pounds of sal soda, and one composed only of 30 pounds of lime and 15 pounds of sulphur, were tested. Applications of these washes were made at Washingtonville, in the Hudson Valley, and also at Oyster Bay, on Long Island, for the purpose of observing their behavior under different conditions. The general results may be briefly summarized as follows:

There was very little difference between the behavior of the three boiled washes mentioned above. We still recommend the formula 20 pounds of lime, 15 pounds of sulphur, and 50 gallons of water, with at least thirty minutes active boiling, because this wash proved thoroughly efficient and calls for a minimum amount of material, except in the case of the one where equal quantities of lime and sulphur are employed. There seems to be a practical advantage in having some excess of lime, and as the cost of the additional 5 pounds is very slight we prefer the formula given above.

The unboiled washes—those depending on chemical activity to effect a combination—gave nearly, if not equally, as satisfactory results as those where fire was employed. The wash composed of 30 pounds of lime and 15 pounds of sulphur presents mechanical disadvantages, and as the one calling for 20 pounds of lime, 15 pounds of sulphur, and 10 pounds of sal soda is just as efficient an insecticide and gives a much more satisfactory mechanical and chemical combination, we do not hesitate to recommend it wherever small lots of wash are desired. Experience last season has shown that while this latter preparation can be made without adding any hot water, the mechanical condition is immensely superior when the reaction is started with a few pails of hot water, as described last year, and the chemical combination appears to be considerably better.

A very fine amorphous grade of sulphur, carefully mixed with lime which had been previously slaked and allowed to cool, was applied to a few trees and proved of no value in destroying the scale. Twenty and 25 per cent limoid or K–L mixtures were tested, and, generally speaking, the results were not equal to those obtained with lime-sulphur washes, though we went to the trouble of securing the best grade of limoid with which to prepare them. There is no doubt that a certain amount of the scale was destroyed by the application. Nevertheless, the general results were disappointing, even in the hands of other parties, where the treatment was said to have been exceptionally thorough.

SULPHUR DIOXIDE AS AN INSECTICIDE.

By C. L. Marlatt, *Washington, D. C.*

The fumes of burning sulphur, namely, sulphur dioxide with some sulphur trioxide, have long been one of the standard insecticide gases for the disinfection of rooms or dwellings of certain insect pests. Brimstone fumigation was urged by Dr. J. A. Lintner as a means of controlling the bedbug (*Cimex lectularius* L.) where liquid applications were inadvisable, and within the last few years Dr. Ch. Wardell Stiles, of the Bureau of Public Health and Marine-Hospital Service, has very successfully fumigated and disinfected frame cottages at a seaside resort for bedbug infestation by the sulphur treatment, burning the sulphur at the rate of 2 pounds of stick sulphur for each 1,000 cubic feet of space. Sulphur candles for such fumigation and for disinfection are a standard supply material to be purchased anywhere.

Sulphur has long been also one of the standard means of disinfection of premises or goods from disease germs, and in the later work against the *Stegomyia calopus* conducted by the Yellow Fever Institute of the United States Public Health and Marine-Hospital Service various experiments with sulphur as a means of destroying mosquitoes in houses were tried and the following conclusions reached: "From the limited number of experiments made and from previous experiments, we consider sulphur dioxide the best of the gaseous insecticides for this purpose." The other means tested included the fumes of tobacco, pyrethrum, and formaldehyde gas.

The chief objection to sulphur fumigation for insecticide or other work is the strong bleaching action of these fumes in the presence of moisture and their powerfully destructive action on vegetation. This latter effect has been exhibited very emphatically in the last few years in the large devastated areas surrounding the works of various smelting companies, where a great deal of sulphur is given off from the reduction of sulphide ores. As shown by the investigation of this sort of damage by Mr. J. K. Haywood, of the Bureau of Chemistry (see Bulletin 89 of that Bureau), the sulphur fumes given off from such reducing works are the same as those generated in the burning of stick sulphur, and their action is so powerful as to practically exterminate forests and other vegetation to a distance of from 2 to 9 miles about the smelting plants. Referring to the form in which the sulphur is given off, Mr. Haywood says:

For each pound of sulphur burned 2 pounds of sulphur dioxide are formed and given off into the atmosphere, a part of which acts directly on the foliage of the trees. Sooner or later, however, all of the sulphur dioxide is changed by the action of the oxygen of the air into sulphur trioxide, and it is in this form that we may expect to find it in the foliage of trees. The moisture present in the air unites with this sulphur trioxide to form the highly corrosive compound, sulphuric acid, which in its turn acts upon the delicate foliage.

This same action may occur in the use of sulphur gas for disinfection of dwellings, and for all such uses the important consideration is to have a state of as complete dryness as possible to prevent the formation of sulphuric acid and the consequent bleaching of fabrics and wall papers and the corroding of metallic surfaces.

Opportunity offered during the past summer and autumn to very thoroughly test the availability of sulphur dioxide and trioxide for various insecticide uses. Many of you probably have heard of Clayton gas. This gas is nothing more than the sulphur dioxide and trioxide referred to above, and is the same mixture which is obtained by burning ordinary stick sulphur or sulphur candles. It was originally employed as a means of extinguishing fires, particularly on shipboard, as in cargoes of cotton or of coal, and the recognition of its value against insects and rodents and other vermin by the company is an outcome merely of its use as a fire extinguisher. This method of disinfection has been very widely exploited by the Clayton Company, and has been adopted by the North German Lloyd Steamship Company for use on vessels transporting grain from South America and North American ports to Europe. It is used not only to destroy insects in cereals, but also to rid steamers of rats and other vermin, and, further, to disinfect vessels in which disease has broken out. The method has received such wide acceptance commercially that it seemed advisable to give it a thorough experimental test. The Clayton Company, furthermore, was anxious to have us make such a test, and was willing to furnish every assistance and meet whatever expense might be entailed. It being impracticable to conduct a long series of tests in New York, the company sent to Washington an expert in charge of a complete apparatus, which was made the subject of a good many experiments, covering a period of two months. These experiments are given in detail below. In explanation of the experiments with plants it may be stated that Doctor Galloway, of the Bureau of Plant Industry, was consulted, and he deemed it advisable to attempt to use the gas in as nearly a dry condition as possible on plants to determine its value, if any, for disinfecting living plant material. The violent destructive action of this gas on plants is very fully emphasized by these experiments, and it is shown conclusively that probably under no conditions of ordinary practical application can it be used as a means of disinfecting living plants.

With the Clayton apparatus the gas is prepared by the combustion of common roll brimstone in an oven or generator, and the principal features are large production of gas, the reduction of its temperature to nearly normal, and its control under pressure. The sulphur is burned on a grate and also on the floor of the oven as it melts and falls through, and a temperature is developed of from 700° to 1,000° F. To prevent the carrying over of flowers of sulphur the gas generated passes over two "baffle" plates before it reaches the outlet pipe. Through this outlet pipe the gas is carried to a cooler arranged like an ordinary steam boiler tank with numerous pipes around which water is kept constantly circulating. By this means the gas is cooled down to from 70° to 100° F., and is carried thence to the apartment or building or ship to be disinfected. The gas is forced through this apparatus and into the building to be fumigated by means of a blower operated by a small electric motor or by a gasoline engine. There are double grates to the furnace so that the supply of air can be either drawn from out of doors or from the building to be fumigated. In the latter case there is a circulation of air and gas between the apparatus and the building, the gas percentage becoming stronger all the time, but without pressure. When the supply of air for the apparatus is taken from without, the air and gas in the building or vessel is under heavy pressure and the penetration of the gas is much increased. The gas is tested from time to time by submitting it to water observation in a pipette, and any percentage of gas can be maintained, from a fraction of 1 per cent to 16 per cent or more.

The special claims made for the gas thus generated are its strong toxic effect on insects, and great penetrating power. The penetration of the gas is both normal to it and very much increased by its being forced into the building under heavy pressure, so that every crevice and crack of the building is filled, and the gas escapes forcibly through every aperture. This apparatus has been tested by a committee of supervising inspectors of steam vessels acting under the authority of the Treasury Department and favorably reported on as a fire extinguisher. The apparatus has also been tested in a limited way by the Public Health and Marine-Hospital Service, and certain of the quarantine officers have been authorized to employ the apparatus for the fumigation of vessels under proper conditions. It has also been tested by foreign shipping companies and hygienic laboratories.

In the practical carrying out of the details of the experiments, and particularly the supplying of insect material, Messrs. Chittenden and Sanders rendered valuable assistance. The grain and various seeds were furnished by the Office of Seed and Plant Introduction and Distribution of the Bureau of Plant Industry.

RECORD OF EXPERIMENTS WITH SULPHUR DIOXIDE.

Experiments 1 and 2 were conducted in the glass fumigating house of the Bureau of Plant Industry.

Experiment No. 1.

Four per cent gas pumped into house for 10 minutes. Subjects of experiment, various plants. Palms and pineapples were uninjured; all the other plants were killed.

In the course of this and the following experiment the escaping gas blown by the winds over and more or less into adjoining greenhouses killed a great many delicate plants, doing much damage, the tests showing conclusively the absolute impossibility of using this gas for the fumigation of growing plants. Where also the gas flowed for a few minutes over grass the latter was burned as though scorched by fire, and killed to the ground.

Experiment No. 2.

One hour treatment of several bushels of various kinds of seeds, including Kafir corn, rice, rye, barley, and cowpeas. Beginning with a strength of 6 per cent, the gas was increased to 12 per cent at the end of half an hour, and to 16 per cent at the conclusion of the experiment, the forcing of the gas into the building being continuous and under pressure. The results of the germination tests of these seeds by Mr. E. Brown, botanist in charge of the Seed Laboratory, indicated that Kafir corn and rice were killed, the cowpeas were injured to the amount of 10 per cent, and the rye and barley were substantially uninjured, 95 per cent germinating.

Tests with insects were also made in jars very tightly plugged with cotton. The Bruchus in cowpeas died in 40 to 45 minutes. All free Calandras were killed; some still inclosed in the grain afterwards emerged. In bags of grain all free insects were killed, but some of the Calandras and Bruchus inclosed in grain and peas afterwards emerged.

Experiment No. 3.[a]

Two hours at 10 per cent, machine running 5 minutes. Jars containing insects were all tightly plugged with cotton, and none of the insects were killed.

Experiment No. 4.

Treatment for 3 hours at 5 per cent, the machine running 5 minutes. (The lid of the box in the meantime had been made more nearly air-tight by rubber packing.)

[a] Experiments 3 to 12 were conducted at the Department insectary: Nos. 3 to 8 in a small, zinc-lined fumigating box, and 9 to 12 in a building 10 by 10 by 10 feet, especially constructed for the purpose.

Results on insects.—Of insects at bottom of jars merely covered with cloth 2 out of 10 mealworms (Tenebrio) killed; in small sack made of ordinary grain sacking or heavy drilling everything was killed. The capacity of the sack was about half a peck.

Experiment No. 5.

Treatment for 1 hour with 7 to 8 per cent gas, machine running 30 minutes. Test at the end of the hour showed that the box contained full per cent gas. Insect tests made with four jars, two of which were covered with cloth and two lightly plugged with cotton, merely sufficiently to retain the insects. In the cloth-covered jars the insects were alive at the end of the hour, but the cotton was sufficient to retain more or less of the gas over night, and the insects were all dead the next day, indicating the value of the longer time gassing at a low percentage.

Experiment No. 6.

Two and one-half to 3 per cent of gas for 16 hours, the machine running for 5 minutes. At the end of the 16 hours less than 0.5 per cent of gas was found in the box. The free insects on the exterior of the bags were killed, and those deeper down in the bags were uninjured. This test was made with three bags of rye infested with Calandra—ordinary grain bags, capacity of each about 2 bushels. It is probable that the machine, running but 5 minutes, had not at the end of this time caused the gas to penetrate these large bags, and the subsequent partial penetration of these bags would reduce the percentage of the gas considerably.

Experiment No. 7.

Five per cent gas, machine running 15 minutes, and then left for a total of 22 hours. At the end of 4 hours a sample of the gas taken from the fumigating box indicated a strength of over 2 per cent gas remaining. Some of this gas had doubtless escaped from the box, but probably a good deal of it had been absorbed by the grain in the large bags. The following morning the box was opened, and an examination of the contents showed the apparent destruction of all insect life. The bags of infested grain placed in the center and at the bottom of the large sacks with many living insects (Calandras) showed no living material. The same was true of Bruchus in cowpeas. All of this material was held for later examination, and there were no revivals. When the box was opened the gas was still very strong in the box, probably exceeding 1 per cent. This test seems to indicate that a low percentage of gas, say from 5 to 1 per cent, continued for a long time, will destroy insects in grain and seeds, and has considerable penetrating power.

NOTE.—In the case of all these tests 10 to 15 packages of various seeds were included to be tested for effect on germination. The reports on these tests are appended to this article.

EXPERIMENT NO. 8.

An experiment to determine the effect of the gas on miscellaneous insects, household pests, grain pests, and the powder-post beetle (Lyctus) in manufactured wood products—furnished by Doctor Hopkins. The insects submitted to the test (except those in the wood material) were in cloth-covered glass jars or in glass cylinders cloth-covered at either end, containing grain. These were placed in the house, opposite the windows, so that the effect of the gas and the exact time of the death of the insects could be noted. The wood material was placed in the building, but of course the action of the gas on this material could not be followed. The experiment began at 2.15 p. m. and continued until 10 o'clock the next morning, a total of nearly 20 hours. In charging the building, necessarily the beginning was with a low percentage of gas, which worked up to the full amount of 6 per cent in 30 minutes. After 15 minutes' pumping a test of the gas in the house indicated 2 per cent and after 25 minutes 5 per cent. Five minutes under pressure brought the gas up to 6 per cent in the building, 7 per cent at the machine, and further charging was discontinued. After 1 hour the gas in the building still indicated 6 per cent; after 2 hours, 5½ per cent; after 4 hours, something more than 3 per cent, and at the end of the experiment, about 1 per cent.

The immediate effect on the insects noted below was chiefly with a very low percentage of gas; in other words, all effect noted prior to the expiration of 15 minutes was with gas of less than 2 per cent strength, and at 7 minutes the gas was doubtless less than 1 per cent in the building.

SUBJECTS OF EXPERIMENT.

(1) Honey bees (*Apis mellifera* L.): Semiunconscious and fallen to bottom of jar in 7 minutes; all motion ceased at 10 minutes.

(2) German roaches (*Blattella germanica* L.): Down and apparently dead in 7 minutes.

(3) Bedbugs (*Cimex lectularius* L.): Down and motionless in 10 to 15 minutes.

(4) *Monilema* sp: Sluggish in 15 minutes; quiet in 20 minutes.

(5) Miscellaneous insects, several orders, including Orthoptera, Hymenoptera, Hemiptera, Diptera, and Arachnida (complete list be-

low):[a] Most of these insects went down and became motionless in between 5 and 10 minutes. The Orthoptera remained active and uninjured for 15 miutes, but soon thereafter became motionless and apparently asphyxiated.

(6) Clothes moths, adults: Down and quiet in 10 to 15 minutes.

(7) Dermestes larvæ: Down and quiet in 10 to 15 minutes.

(8) Ants in jar with earth: Actual time of asphyxiation could not be noted; probably within 10 minutes, judging from the Hymenoptera in other jars.

(9) Corn meal containing *Tribolium confusum* Duv. and *Silvanus surinamensis* L., also parasitic four-winged flies: The beetles mentioned were asphyxiated within 10 minutes; the parasite, protected more or less in the mass of meal, in 30 minutes.

(10) *Anthrenus verbasci* L.: Time of asphyxiation not noted, but within 30 minutes.

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[a] The list of the miscellaneous species subjected to this test, as determined by Mr. Titus, and in addition to those noted above, follows. It includes 122 specimens, representing at least 30 genera.

Diptera (24 specimens).

1 *Winthemia 4-pustulata* Fab.
1 *Lucilia cæsar* L.
1 *Musca domestica* L.
2 *Culex pipiens* L.
3 *Syrphus* sp.
5 *Sciara* sp.
2 *Drosophila punctulata* Loew.
1 *Drosophila busckei* Coq.
3 Ortalids.
5 Unidentified (minute).

Orthoptera (4 specimens).

4 *Melanoplus femur-rubrum* De G.

Neuroptera (1 specimen).

1 Dragon-fly.

Coleoptera (10 specimens).

3 Minute species.
5 *Epitrix parvula* Fab.
2 *Megilla maculata* De G.

Hymenoptera (3 specimens).

1 *Halictus* sp.
1 *Rhogas rileyi* Cress.
1 *Pimpla inquisitor* Say.

Hemiptera (80 specimens).

27 *Dræculacephala mollipes* Say.
2 *Deltocephalus inimicus* Say.
2 *Diedrocephala coccinea* Forst.
3 *Stobera* sp.
22 *Cicadula* sp.
1 *Cicadula* sp.
11 *Empoasca* (2 species).
1 *Geocoris bullatus* Say.
6 *Lygus pratensis* L.
1 *Nabis ferus* L.
3 *Macrosiphum* (?) sp.

(11) *Calandra oryza* L.: Asphyxiated within 30 minutes. In the same jar was *Silvanus surinamensis* and *Tribolium confusum*.

(12) Bean weevil (*Bruchus quadrimaculatus* Boh.): Asphyxiated within 30 minutes.

All of the material referred to above was left untouched for approximately 20 hours, at the end of which time no sign of life or evidence of possible resuscitation was manifested on exposure to air, and there were no later revivals. No signs of life were afterwards seen in the infested wood material, and a thorough examination made two months after treatment by Doctor Hopkins indicated that the insects had been reached in the wood and killed.

At the same time various objects were placed in the building to determine the bleaching effect of the gas—a good many colored papers and a good many fabrics, representing light-colored cotton linings and silk and cotton linings, black, and also men's tailoring goods of various colors and qualities. No bleaching effect was noted whatever in the heavier cloths. Some of the lining cottons showed slight bleaching. The papers were practically unbleached, except one of pink shade. The bookbinding cloths were very slightly bleached, not enough to be especially noticeable or to injure the appearance of the bindings. A highly polished bit of brass was completely darkened and tarnished.

Experiment No. 9.

This experiment was to determine the possibilities of penetration of a low percentage of gas, between 5 and 6 per cent, ending at the latter amount. Small bags of infested grain were placed at the bottom of an air-tight zinc-lined box having a depth of 18 inches and a capacity of 3 or 4 bushels. Similarly small bags of infested grain were placed at the bottom of earthenware crocks having an inside depth of 14 inches. The gas could only get at these insects by penetrating through the grain directly from the top, 18 inches in one case and 14 in the other. This was necessarily a pretty severe test, inasmuch as there was no possibility of circulation of air. The gas was kept under pressure for one-half hour after reaching 6 per cent to increase the possibilities of penetration. The apparatus was then disconnected and the building left closed overnight for a total of some 22 hours. The gas in the building was tested from time to time after stopping the generator. After one-half hour 6 per cent gas was still found, and the same was true after an hour's time. After 2 hours the percentage had fallen to 5 per cent, and at the time of the opening of the building in the morning of the following day there was still at least 1 per cent of gas present.

Results.—Neither in the case of the zinc-lined box nor the crockery jars had the gas penetrated very deeply into the grain, and the insects in the small bags at the bottom were unaffected. (See Experiment No. 11.)

EXPERIMENT No. 10.

Designed to test the possibility of using the gas for the fumigation of ships loaded with bananas. A bunch of green bananas was submitted to 6 per cent gas without pressure from 3 p. m. to 10 a. m., a total of some 19 hours. There was still 6 per cent gas found in the building an hour after disconnecting the apparatus, and practically the same amount 2 hours after. After 6 hours the percentage had fallen to 5 per cent, and at the end of the experiment there was apparently somewhat less than 1 per cent in the building.[a]

Results.—The bananas, which could be observed through the window, showed no bleaching effect for the first 5 or 6 hours, but the next morning were much bleached and yellowed and apparently somewhat softened, the fruit having in the meantime become moist from condensed moisture, which undoubtedly occasioned the bleaching noted. The indications are that, in view of the natural moisture which would be found in holds of banana-laden vessels, the use of this gas for fumigation would be rather disastrous to the appearance and quality of the fruit.

EXPERIMENT No. 11.

This experiment duplicated experiment No. 8, except for the strength of gas, and was designed to determine the penetration powers of a high percentage of gas rather than a low percentage, which had proven ineffective. The conditions were the same as in experiment No. 8. The generator was started at 4.10 p. m. By 4.30 a 5 per cent gas was being generated, and the gas was forced into the building under pressure at 4.40. By 5 p. m. 10 per cent gas was reached in the building, 12 per cent at the machine. By 5.45 p. m. 15 per cent of the gas was secured in the building, and this percentage was kept up under pressure until 6 p. m., when the generation of gas was stopped. The gas was therefore under pressure in the building about 1 hour and 20 minutes, and the total operation of the machine was 1 hour and 50 minutes. The gas in the building was tested at 7.50 p. m., and 10 per cent found at that time. At 9.50 in the morning, the following day, 5 per cent of the gas still remained in the building. The building was then opened and aired and the infested grain removed from the bottom of the jars and from the zinc-lined box. It was evident, from the odor, that the gas had penetrated to the bottom of both of these receptacles, and an examination of the infested grain showed the insects all apparently dead.

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[a] The retaining capacity of the building for the gas varied slightly with the condition of the external air, falling more quickly in windy weather than in still weather.

The bags of infested grain used in this test were kept free from a chance of reinfestation, and two months later were carefully examined with the following results: The infested grain buried in the middle of the zinc-lined box, namely, at a depth of about 9 inches, contained only dead insects, the penetration and destruction of insect life being perfect in this case. The insects represented were principally *Calandra oryza* and *Ateleopterus tarsalis* Ashm., a parasite of *Silvanus surinamensis*. The sack at the bottom of this chest, namely, at a depth of 18 inches, exhibited the same results, and contained, in addition to the above, *Meraporus calandræ* How., a parasite of *C. oryza*, and one beetle of *Tenebroides mauritanicus L.*

The sacks of infested grain placed at the bottom of the earthenware jars, namely, at a depth of 14 inches, exhibited, after two months' standing, living insects. (All were dead, apparently, at the conclusion of the experiment.) The insects represented are *Calandra oryza* and its parasite, *M. calandræ*, and of these only about 50 per cent had been killed. There was also found one living larva of *T. mauritanicus*. The test in this latter case was a very severe one, for the reason that the jars were narrow and the surface exposed at the top for direct penetration was only 5 or 6 inches in diameter. In the case of the zinc-lined chest there was a superficial area for direct penetration of 4 or 5 square feet.

Experiment No. 12.

To test the effect of the gas on wall paper and lacquered brass and nickel.

The material was subjected to 5 per cent of the gas for 3½ hours, with occasional pressure of a few minutes at a time to test the strength of the gas in the building. Some 12 samples of wall papers of different color and quality were submitted to the test, and also lacquered brass and a nickel-plated object. The fumigation chamber was unheated and was somewhat moistened from rains, and hence the air in the room was at a fairly high degree of saturation, which undoubtedly very much increased the bleaching power of the gas. Practically all the wall papers were considerably altered in color, either by notable bleaching or by an actual change in the tone of color, in one case becoming considerably darker than the original. The dark reds were least affected—almost none—and the pinks and greens were most affected. These tests indicated that the use of this gas would be very apt to bleach wall papers in rooms or houses at all damp. With houses subjected to regular heating, as in early fall or winter, the bleaching probably would be reduced to a minimum. The lacquered brass was unaffected. The nickel-plated object was badly rusted. It was noted that in the damp weather which occurred at the time of this experiment the wall papers retained an odor of the gas for a long time after being removed from the fumigating chamber, indicating the formation of sulphuric acid by condensation.

SUMMARY OF RESULTS.

(1) Sulphur dioxide is very destructive to most growing plants and almost instantly deadly to succulent plants and grasses, even at low percentages. Palms and pineapples can, however, stand a moderate fumigation. This gas, therefore, has probably no value whatever as a means of disinfecting living plants, except perhaps for the very hardiest of dormant nursery stock and palms.

(2) The germinating power of grass, grain, and common garden seeds is quickly destroyed with even weak applications of the gas, and its employment is therefore impracticable for all seeds for planting. It does not, however, injure the feeding value or cooking quality of cereals, and the odor of the gas passes away fairly quickly and is not retained except where the grain or seeds are moist.

(3) A comparatively low percentage of the gas will kill practically all free insects after an exposure of from a few minutes to half an hour, but a much longer exposure is necessary to kill insects inclosed in grain or seeds, as Bruchus and Calandra. The best results are obtained by submitting such grains or seeds to a low percentage of the gas (from 1 to 5 per cent) for a period of 12 to 24 hours. Employed in this way the gas is a very effective means of disinfecting stored grain or similar products, and has the additional advantage of entirely eliminating the danger of explosion and fire.

(4) The bleaching quality of the gas on fabrics and wall papers is largely determined by the moisture in the air. In comparatively dry air such bleaching is inconsiderable, and in a heated house can probably be ignored. Its effects on metal surfaces, however, is more marked, and these are likely to be tarnished if the air be at all moist, and the protection of such surfaces during the treatment is therefore necessary. Under conditions of considerable or excessive moisture wall papers and the lighter fabrics are much bleached and all metal surfaces corroded.

(5) The penetration of a low percentage of gas (5 or 6 per cent) without pressure from above into exposed surfaces of grain is not very great; but a strong percentage (15 per cent) under high pressure for an hour or more has strong penetration to a depth of from 14 to 18 inches even where a comparatively small area for penetration is allowed. It should be noted here also that in the ordinary method of fumigating grains with the Clayton apparatus the gas is liberated through a perforated iron tube thrust into the bottom of the bin, and the gas forced in under pressure is made to permeate much more quickly and thoroughly the entire mass of grain.

(6) The test made with the fumigation of a bunch of bananas was, in a measure, unsatisfactory, as it was done in a very rainy, damp

season, and the air in the building was the same as the exterior air and heavily charged with moisture. Under these conditions, however, the bananas were much bleached and softened. Nevertheless, it must be remembered that there will always be a great deal of moisture in the holds of vessels stored with bananas, and its use for the disinfection of such cargoes is therefore most questionable.

The general results of these experiments as indicated above seem to show that this gas has a very great value for the uses in which it is now employed, namely, the disinfection of vessels and cargoes of grain. Here all conditions are exceptionally favorable. The vessel furnishes a comparatively air-tight fumigating receptacle, and the gas is forced into it by circulation at first, and finally under pressure, and made to reach every portion of the vessel. The grain thus disinfected is practically always for consumption and not for planting; hence the effect on germination is comparatively immaterial. It seems probable also that it may be very useful in a similar way in elevators and flouring mills, eliminating the risk of fire and explosion. It is possible, further, that it may have distinct utility as a means of control of such diseases as yellow fever, where it is necessary to fumigate house after house over large areas in cities. It would be possible for this apparatus to move from house to house, thoroughly filling and fumigating each individual house in a comparatively short space of time, with no danger of overheating or fire from burning sulphur directly in the rooms or houses to be fumigated. These points of utility for the gas are in addition to its value as a fire extinguisher and as a general germicide. The Clayton apparatus is undoubtedly a most efficient means of quickly generating the gas. The process, however, is very simple and elementary. The danger in the use of the gas is in its corrosive action on metallic surfaces, and its strong bleaching power by its condensation in the presence of moisture and the formation of sulphuric acid, and its violent and destructive action on all plant life.

While having no lasting effects of serious nature, the odor of burning sulphur is very objectionable, and it is advisable in employing this means of disinfection to avoid breathing it as much as possible. The ill effects, however, are very temporary, and amount in the case of one not accustomed to the gas to a slight headache or sometimes to a slight effect on the stomach. It is apparently possible to get accustomed to the gas, and the expert who ran the apparatus paid little if any attention to it, and seemed to breathe it for indefinite periods and daily without injury.

There has been added, as an appendix, the detailed report furnished by Mr. Edgar Brown, botanist in charge of Seed Laboratory, of the germination tests made with different grains and seeds submitted to various strengths of the gas.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
BOTANICAL INVESTIGATIONS AND EXPERIMENTS, SEED LABORATORY,
Washington, D. C., October 3, 1905.

Final report of germination test of seed received September 22, 1905.

Test number.	Sender's mark.	Name of seed.	Duration of test in days.	Germination, per cent.
34573	12001	Wheat, nonfumigated	4	91
34574	1	Wheat, 1 hour at $7\frac{1}{2}$ per cent	6	0
34575	2	Wheat, 2 hours at 10 per cent	6	0
34576	3	Wheat, 3 hours at 5 per cent	6	0
34577	11760	Rye, nonfumigated	6	69.5
34578	1	Rye, 1 hour at $7\frac{1}{2}$ per cent	2	0
34579	2	Rye, 2 hours at 10 per cent	6	0
34580	3	Rye, 3 hours at 5 per cent	6	0
34581	11215	Timothy, nonfumigated	6	88.5
34582	1	Timothy, 1 hour at $7\frac{1}{2}$ per cent	6	0
34583	2	Timothy, 2 hours at 10 per cent	6	0
34584	2A	Cotton, 2 hours at 10 per cent	4	0
34585	....	Garden pea, nonfumigated	6	99.5
34586	1	Garden pea, 1 hour at $7\frac{1}{2}$ per cent	6	89.5
34587	2	Garden pea, 2 hours at 10 per cent	6	86.5
34588	3	Garden pea, 3 hours at 5 per cent	6	86.5

The actual value is the percentage of pure seed that will germinate. This is obtained by multiplying the percentage of pure seed by the percentage of total germination.

REMARKS.—Exposed to SO_2 gas as above.

E. BROWN,
Botanist in Charge of Seed Laboratory.

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BOTANICAL INVESTIGATIONS AND EXPERIMENTS, SEED LABORATORY,
Washington, D. C., October 3, 1905.

Final report of germination test of seed received September 22, 1905.

Test number.	Sender's mark.	Name of seed.	Duration of test in days.	Germination, per cent.
34589	12862	Rice, nonfumigated	3	96
34590	1	Rice, 1 hour, at $7\frac{1}{2}$ per cent	6	0
34591	2	Rice, 2 hours, at 10 per cent	6	0
34592	3	Rice, 3 hours, at 5 per cent	6	0
34593	11722	Oats, nonfumigated	6	52
34594	1	Oats, 1 hour, at $7\frac{1}{2}$ per cent	6	0
34595	2	Oats, 2 hours, at 10 per cent	6	0
34596	3	Oats, 3 hours, at 5 per cent	6	0
34597	12023	Barley, nonfumigated	3	99.5
34598	1	Barley, 1 hour, at $7\frac{1}{2}$ per cent	6	76.5
34599	2	Barley, 2 hours, at 10 per cent	6	70
34600	3	Barley, 3 hours, at 5 per cent	6	6
34601	11267	Flax, nonfumigated	6	82
34602	1	Flax, 1 hour, at $7\frac{1}{2}$ per cent	6	22.5
34603	2	Flax, 2 hours, at 10 per cent	6	25
34604	3	Flax, 3 hours, at 5 per cent	6	2

The actual value is the percentage of pure seed that will germinate. This is obtained by multiplying the percentage of pure seed by the percentage of total germination.

REMARKS.—Exposed to SO_2 gas as above.

E. BROWN,
Botanist in Charge of Seed Laboratory.

United States Department of Agriculture,
Bureau of Plant Industry,
Botanical Investigations and Experiments, Seed Laboratory,
Washington, D. C., October 3, 1905.

Final report of germination test of seed received September 22, 1905.

Test number.	Sender's mark.	Name of seed.	Duration of test in days.	Germination, per cent.
34605	....	Sweet corn, nonfumigated	4	94.5
34606	2	Sweet corn, 2 hours, at 10 per cent	4	.5
34607	3	Sweet corn, 3 hours, at 5 per cent	4	0
34608	13316	Sorghum, nonfumigated	6	75
34609	1	Sorghum, 1 hour, at 7½ per cent	5	0
34610	3	Sorghum, 3 hours, at 5 per cent	6	0
34611	....	Beans, nonfumigated	6	80.
34612	1	Beans, 1 hour, at 7½ per cent	4	12.5
34613	2	Beans, 2 hours, at 10 per cent	4	7
34614	3	Beans, 3 hours, at 5 per cent	4	3.5
34615	5939	Cotton, nonfumigated	6	85
34616	1	Cotton, 1 hour, at 7½ per cent	4	0
34617	2	Cotton, 2 hours, at 10 per cent	4	.5
34618	3	Cotton, 3 hours, at 5 per cent	4	0

The actual value is the percentage of pure seed that will germinate. This is obtained by multiplying the percentage of pure seed by the percentage of total germination.

Remarks.—Exposed to SO_2 gas as above.

E. Brown,
Botanist in Charge of Seed Laboratory.

United States Department of Agriculture,
Bureau of Plant Industry,
Botanical Investigations and Experiments, Seed Laboratory,
Washington, D. C., October 7, 1905.

Report of germination test of beet seed received September 22, 1905.

Test number.	Sender's mark.	Name of variety.	Duration of test in days.	Sprouts from 100 balls.	Per cent of balls giving sprouts.
28149	....	Beet, nonfumigated	10	164.5	79
28150	1	Beet, 1 hour, at 7½ per cent	6	0	0
28151	2	Beet, 2 hours, at 10 per cent	6	0	0

Remarks.—Exposed to SO_2 gas as above noted.

E. Brown,
Botanist in Charge of Seed Laboratory.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
BOTANICAL INVESTIGATIONS AND EXPERIMENTS, SEED LABORATORY,
Washington, D. C., October 6, 1905.

Final report of germination test of seed received September 26, 1905.

Test Number.	Sender's mark.	Name of seed.	Duration of test in days.	Germination, per cent.
34630	....	Rye, untreated	5	21
34631	....	Rye, 2 to 5 per cent, 22 hours	5	0
34632	....	Beans, untreated	5	66
34633	....	Beans, 2 to 5 per cent, 22 hours	5	0
34634	....	Garden pea, untreated	5	66
34635	....	Garden pea, 2 to 5 per cent, 22 hours	5	7
34636	13316	Sorghum, untreated	5	73.5
34637	13316	Sorghum, 2 to 5 per cent, 22 hours	5	0
34638	....	Timothy, untreated	8	52
34639	112.5	Timothy, 2 to 5 per cent, 22 hours	5	0
34640	....	Oats, untreated	5	9[illegible]
34641	11722	Oats, 2 to 5 per cent, 22 hours	5	0
34642	11268	Flax, untreated	5	81
34643	11268	Flax, 2 to 5 per cent, 22 hours	5	17
34644	....	Cotton, untreated	5	50
34645	....	Cotton, 2 to 5 per cent, 22 hours	5	0

The actual value is the percentage of pure seed that will germinate. This is obtained by multiplying the percentage of pure seed by the percentage of total germination.

REMARKS.—Treated with SO_2, as above noted.

E. BROWN,
Botanist in Charge of Seed Laboratory.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
BOTANICAL INVESTIGATIONS AND EXPERIMENTS, SEED LABORATORY,
Washington, D. C., October 6, 1905.

Final report of germination test of seed received September 26, 1905.

Test number.	Sender's mark.	Name of seed.	Duration of test in days.	Germination, per cent.
34646	11780	Barley, untreated	5	94.5
34647	....	Barley, 2 to 5 per cent, 22 hours	5	9.5
34648	....	Wheat, untreated	3	94
34649	12061	Wheat, 2 to 5 per cent, 22 hours	5	0
34650	....	Rice, untreated	8	42.5
34651	....	Rice, 2 to 5 per cent, 22 hours	8	0
34652	....	Corn, untreated	5	94
34653	....	Corn, 2 to 5 per cent, 22 hours	5	0
34654	....	Sweet corn, untreated	5	97.5
34655	....	Sweet corn, 2 to 5 per cent, 22 hours	5	0

The actual value is the percentage of pure seed that will germinate. This is obtained by multiplying the percentage of pure seed by the percentage of total germination.

REMARKS.—Treated with SO_2, as above noted.

E. BROWN,
Botanist in Charge of Seed Laboratory.

NOTES ON INSECTICIDES.

By A. F. Burgess, *Columbus, Ohio.*

[Withdrawn for publication elsewhere.]

Mr. Britton said that he had used hydrocyanic-acid gas for bags of grain infested with the larvæ of *Plodia interpunctella* Hbn. The silk spun by the larvæ formed a dense coating on the outside of the bags. One ounce of cyanide to 100 cubic feet was used, but after thirty-six hours the gas had failed to penetrate to the interior of the bags sufficiently to kill the Plodia larvæ, although those on the outside were all destroyed. Some live Tenebrio larvæ were also found in the bags.

Mr. Washburn asked if there were any data on the use of sulphur dioxide in flour mills.

Mr. Marlatt replied that he had not had any experience in actual mill work, but had tested it with sacks of flour and that it penetrated these rapidly.

Mr. Quaintance said that experiments had shown that penetration of hydrocyanic-acid gas into the soil is so slow that it is entirely impracticable to use it for soil fumigation in greenhouses. He also referred to a series of experiments in progress with the lime-sulphur-salt wash by the Bureau of Entomology. Twenty-three or 24 formulas were tested during 1905 in western New York, in Maryland, and in Georgia, the work thus being extended over a considerable range and likely to bring out differences due to climatic conditions. Mr. Quaintance further stated that washes containing less than 15 pounds of sulphur to 50 gallons of water in all cases proved inefficient in destroying the scale, and best results were secured from the use of washes containing considerably more sulphur, as 20 or 25 pounds to 50 gallons of wash.

Mr. Smith said that his experience in Georgia showed that instead of the ordinary method of mixing the sulphur with the lime after the water has been added to the latter, and while it is in the process of slaking, it is better to mix the sulphur with the water first while the latter is being heated by steam and then afterwards add the lime to the hot mixture.

Mr. Mackintosh asked for an opinion as to the difference between the so-called "flour of sulphur" and "flowers of sulphur." He said that he found difficulty in getting "flowers of sulphur" in Alabama. The former is used almost exclusively by the fruit growers and seems to give good results.

Mr. Quaintance said that in portions of the South, notably in Georgia, orchardists were using in the preparation of the lime-sulphur-salt wash a sulphur there known as "crystallized sulphur," which is practically the crude product as it comes from the mines.

The following papers were then read:

SOME OBSERVATIONS ON THE SPINED SOLDIER BUG.

(*Podisus maculiventris* Say.)

By A. W. Morrill, *Washington, D. C.*

The observations recorded in this paper, unless otherwise stated, are based on two specimens of *Podisus maculiventris* taken by the writer July 9, 1902, on a Camperdown elm tree at Amherst, Mass. The specimens were on that date in the fourth nymphal instar, and one of them had a nearly full-grown elm leaf-beetle larva impaled on its beak. They were taken to the laboratory, and until their death, which took place in each case over one and a half months later, were under daily observation, being caged in a lantern globe, covered at the top with cheese cloth.

The insects upon which my observations were made were kindly examined by both Mr. E. P. Van Duzee and Mr. O. Heidemann, who independently determined them as *Podisus maculiventris* Say, a name which has recently taken the place of the better known *Podisus spinosus* Dall.

As a beneficial insect this species has long held a high place in the esteem of economic entomologists, and consequently in entomological literature the references to it are very numerous. It has been noted as being especially useful as an enemy of the larvæ of the Colorado potato beetle (*Leptinotarsa decemlineata* Say), the elm leaf-beetle (*Galerucella luteola* Müll.), the tent caterpillar, the cotton bollworm (*Heliothis obsoleta* Fab.), and the cotton leaf-worm (*Alabama argillacea* Hbn.). Undoubtedly some accounts of the destruction of injurious insects by *Podisus maculiventris* have been under the name *P. serieventris* Uhl., a species with which it is frequently confused. Van Duzee, in his Annotated List of the Pentatomidæ,[a] indicates his suspicion that the form treated of by Kirkland[b] as *P. serieventris* is the same as the one he (Van Duzee) has called *P. maculiventris*. Whether or not the form known to some as *P. serieventris* be ultimately considered as a species distinct from *P. maculiventris*, its habits appear to be the same as those of the latter, and for a more general account than I shall give one should refer to the papers by Kirkland, which also contain an extended bibliography of the species of the genus.

[a] Annotated List of the Pentatomidæ Recorded from America North of Mexico, with descriptions of some new species. By Edward P. Van Duzee. Trans. Am. Ent. Soc., Vol. XXX, p. 71, March, 1904.

[b] Mass. Bd. Agric., Report on Gypsy Moth, 1896, pp. 392–403. Same, 1898, pp. 129–131.

INDIVIDUAL VARIATION IN ADULTS.

The color of adults shows considerable variation even between parents and offspring. Nine specimens, including the two of the first and seven of the second generation, vary in ground color of the dorsum from a grayish to a reddish brown, and are marked with varying amounts of black. The variation in the form and size in the same series (see fig. 6) is more striking. The humeral angles are more acutely produced in the male parent than in any of the other specimens in the series. The males average smaller and show a greater range of variation in size and form than the females. The abundance of food during the nymphal stages is the principal factor which determines the size attained by the adult. Certain measurements have been made of each individual of the nine specimens, and are here given in tabular form:

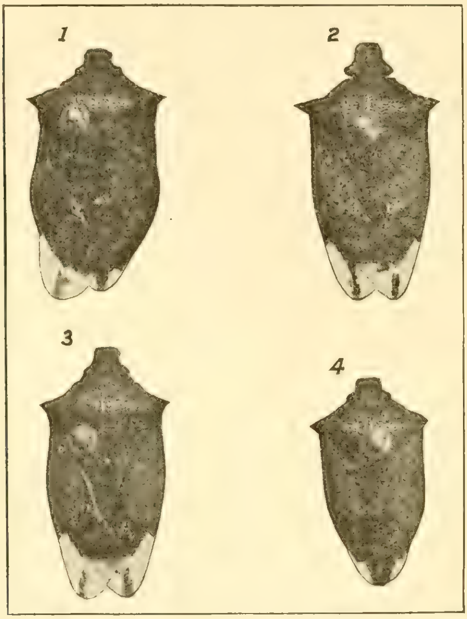

FIG. 6.—*Podisus maculiventris*, variation in form and size of parents and progeny: No. 1, female parent; No. 2, male parent; No. 3, largest specimen of seven of second generation, female; No. 4, smallest specimen of seven of second generation, male. Enlarged (original).

Variation in form and size of parents and offspring.

	Female parent (No. 1) and female offspring.							Male parent (No. 1) and male offspring.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	Average.	Range.	No. 1.	No. 2.	No. 3.	No. 4.	Average.	Range.
Length, in millimeters, tip of head to apex of wings	12	12	12	12	12.5	12.1	0.5	12	10.5	10.5	11	11	1.5
Width of body, in millimeters, from points opposite anterior margin of scutellum	5.6	5.4	5.4	5.6	5.6	5.52	.2	5.5	5	4.8	5.1	5.1	.7
Width of body, in millimeters, from tips of humeral angles	6.6	6.2	6	6.2	6.4	6.28	.4	7	5.4	5.4	5.6	5.85	1.6
Length of scutellum, in millimeters	4	4	4	4.2	4	4.04	.2	4	3.4	3.6	3.8	3.75	.6

OBSERVATIONS ON EGG LAYING AND DURATION OF INCUBATION.

The female became adult on July 16 and deposited her first batch of eggs on the ninth day thereafter. The following table gives the data relating to eggs laid by this insect:

Data on egg laying and incubation.

Arrangement according to time of deposition of egg batches.									Arrangement according to mean temperature of intervening days.		
Egg batch number.	Recorded as deposited.	Number of eggs deposited.	Number of eggs hatched.	Recorded as hatched.	Number of intervening days.	Recorded fractions of day and corrections.[a]	Approximate incubation period.	Average daily mean temperature of intervening days.[b]	Egg batch number.	Average daily mean temperature.	Approximate incubation period.
	July.			August.			*Days.*	° *F.*		° *F.*	*Days.*
1	25 p. m ...	33	33	2 a. m....	7	½	7½	69.3	13	61.3	9½
2	26 p. m ...	23	23	.....do	6	½	6½	70.3	17	62.7	8½
3	29 p. m ...	19	15	4 a. m....	5	½	5½	72.3	12	62.9	8
4	30 p. m ...	22	[c] 11	5 a. m....	5	½	5½	72.9	16	63	7
	August.										
5	1 a. m....	29	29	6 a. m....	4	1	5	73.1	11	65.5	8
6	2 a. m....	32	32	8 a. m....	5	1	6	70.8	10	65.5	8½
7	4 a. m....	21	20	9 p. m ...	4	1½	5½	68.4	14	66.2	8½
8	4 p. m ...	31	31	11 a. m ...	6	½	6½	67.9	9	67.8	7
9	5 p. m ...	26	26	12 p. m ...	6	1	7	67.8	15	67.8	6½
10	6 a. m....	14	14	14 a. m....	7	1	8	65.5	8	67.9	6½
11	.....do	14	14	14 p. m ...	7	1½	8½	65.5	7	68.4	5½
12	10 a. m....	38	34	18 a. m....	7	1	8	62.9	1	69.3	7½
13	15 p. m ...	56	[d] 26	25 a. m....	9	½	9½	61.3	2	70.3	6½
14	21 p. m ...	20	17	30 a. m....	8	½	8½	66.2	6	70.8	6
15	25 a. m....	44	40	31 p. m ...	5	1½	6½	67.8	3	72.3	5½
				September.							
16	30 a. m....	38	28	7 a. m....	6	1	7	63	4	72.9	5½
	September.										
17	1 p. m ...	23	[e] 9	10 a. m....	8	½	8½	62.7	5	73.1	5
18	....	9	9	11 a. m....	....	......	......	......	....	......	......
Total	....	492	411	....	....	......	......	......	Average.	°67.5	7d 1h

[a] The "recorded fraction" of a day is obtained as follows: For an egg batch recorded as deposited in the forenoon, one-half day (noon to midnight) has been added to the intervening days; if recorded as deposited in the afternoon, one-fourth day (6 p. m. to midnight) has been added to the intervening days; if recorded as hatching in the forenoon, one-fourth day (midnight to 6 a. m.) has been added to the intervening days; if recorded as hatching in the afternoon, one-half day (midnight to noon) has been added to the intervening days. "Corrections" are based on one-half of the sum of the period preceding the record of deposition and the period preceding the record of hatching during which no observations were made. While in general the incubation periods without doubt were made more nearly correct by the method of correction adopted, in some cases it resulted in slight discrepancies in the ratio of the incubation periods to the mean temperatures of the intervening days.

[b] The temperature records are from the Bulletins of the Meteorological Observatory of the Massachusetts Agricultural College. The insects under observation were kept close to a north window which was open daily from 8 a. m. to 6 p. m. Under the conditions the daily mean temperature was probably very close to that recorded at the observatory.

[c] Unhatched eggs fed upon by nymphs of batch No. 3.

[d] Fourteen infertile; 16 fertile, but failed to hatch.

[e] Nine infertile; 5 fertile, but failed to hatch.

From the above table can be deduced the approximate effect within the limits of these observations of a single degree of daily mean temperature on the period of incubation. If we consider only the three batches of eggs which matured with the lowest average daily mean temperature and the three batches which matured with the highest average daily mean temperature, we find that the former average was 62.3° F. and the latter 72.7° F., while the period of incubation is shortened with the increase in temperature from 8.6 to 5.3 days. In other words the decrease of 10.4° F. represents an increase of 3.3 days in the incubation period or 0.32 day for each degree of temperature.

The average number of eggs deposited per day by the female during the entire adult life was 9.3. Omitting the first eight days during which no eggs were laid, the number of eggs after the beginning of the egg-laying period averaged 11.2 per day. The rate of production of eggs as well as the length of incubation period was affected in a marked degree by the daily temperatures. The last fifteen days of the month of August were cooler than the first 15; the 5 warmest days of the month occurred consecutively from August 1 to 5, inclusive, and the 5 coolest days occurred consecutively from August 16 to 20, inclusive. The relation of temperature to the production of eggs is shown in the following table, although allowance should be made for the influence of minor factors, the experience with one insect being too limited for anything more than general conclusions.

Relation of temperature to production of eggs.

Period, August, 1902.	Average daily mean temperature.	Number of egg batches.	Total number of eggs.	Per cent of total number of eggs per month.	Average number of eggs per day.
	° F.				
1–15	67.9	9	271	73	18.6
16–30	63.9	3	102	27	6.8
1–5	73	5	139	37	27.8
16–20	59.3				

It is worthy of note that the longest incubation period of the 17 records included the 5 coldest days of the month, while the shortest incubation period included 4½ of the 5 warmest days.

OBSERVATIONS ON DURATION OF NYMPH STAGES AND LENGTH OF ADULT LIFE.

The duration of the nymph stages depends for the most part on the temperature and perhaps more or less on food supply. Of the 18 batches of eggs obtained from the female under observation, the nymphs from only 1—No. 12—were bred to maturity in the laboratory. Thirty-four nymphs hatched on August 18 from egg batch No.

12, but, their number being reduced by insufficient food supply and by cannibalism, 7 only reached maturity. The first of these to become adult molted its fifth nymphal skin on September 23, and the last one of the seven to become adult molted its last nymphal skin on September 27, making a range of from 36 to 40 days for the nymphal stages and from 44 to 48 days for all immature stages, including the egg. The average duration of the immature stages of the seven specimens was approximately 46 days, with an average daily mean temperature of 61.5° F. The approximate total positive temperatures (above 32° F.) during the developmental period in this case was 1,357° F.; to which, if we add the approximate total positive temperature required by the female after reaching maturity, before any eggs are deposited, we get 1,708° F. for the approximate total positive temperature of the life cycle in the instances here recorded. The total positive temperatures at Amherst, Mass., from the 1st of May to the 15th of October, inclusive, would make a maximum of 3 annual generations possible at this rate, considering that earlier than the month of May and later than the 15th of October the development is practically nil. Of the two specimens under observation, the adult life of the female extended from July 16 to September 6 and that of the male from July 17 to August 29. The total number of days in the case of the female being 53 and the male 44, the average of the pair was 48½ days. Death took place very slowly in each case and was apparently due to natural causes.

OBSERVATIONS ON THE FEEDING HABITS.

Desiring to obtain a definite idea of the value of this species as an enemy of the elm leaf-beetle, the two specimens, from the time they were taken on July 9, were fed exclusively on the larvæ of this beetle as long as it was possible to obtain them in sufficient numbers. Before molting the fourth nymphal skin the two bugs ate four full-grown elm leaf-beetle larvæ. Their food during the six days of their fifth nymphal or "pupal" stage and during their entire adult life is shown in the following tables:

Feeding record of two bugs in fifth nymphal instar.

Food: Elm leaf-beetle larvæ (*Galerucella luteola* Müll.).

Date, July, 1902.	Full grown.		Three-fourths grown.		One-half grown.		One-fourth grown.		All stages, total destroyed.
	Eaten.	Partly eaten.	Eaten.	Partly eaten.	Eaten.	Partly eaten.	Eaten.	Partly eaten.	
11	2								2
12	2		3		2		2		9
13-16	9	2	1	1	1	1			15
Total, 6 days	13	2	4	1	3	1	2		26

Feeding record of two adults—male and female.

[Food: Elm leaf-beetle larvæ.]

Date.	Full grown.		Three-fourths grown.		Half grown.		One-fourth grown.		All stages, destroyed.
	Eaten.	Partly eaten.	Eaten.	Partly eaten.	Eaten.	Partly eaten.	Eaten.	Partly eaten.	
1902.									
July 16–18	6								6
July 18–20			6						6
July 21	6		4		1				11
July 22	4				7				11
July 23	7		2						9
July 24–28	12		6		1	1			20
July 29–30	8	2	2	1	1			1	15
July 31	8	1				1			10
August 1			5		3				8
August 2					3				3
August 3	15				4				19
August 4	8	1							9
August 5–6	5								5
August 7	5		2						7
August 8	6								6
August 9–10	6	3							9
August 11–12	4	1	3						8
August 13–17	15		3						18
August 18–22	11								11
August 22–26	9								9
August 26–29	10								10
August 29[a]									
September 4	10								10
Total	155	8	33	1	20	2	0	1	220

[a] Female only.

In addition to the elm leaf-beetle larvæ, the two adults destroyed an unknown lepidopterous larva about an inch in length on July 16, and between August 26 and 29 they destroyed and partially ate six full-grown rosy-striped oak worms (*Anisota virginiensis* Dru.).

The tables given above show 246 as the total number of elm leaf-beetle larvæ destroyed by the two bugs in the fifth nymphal and adult stages. The total number of days covered by the life of the female in these two stages being 59 and by the male 50, the average number of beetle larvæ destroyed by each bug per day is 2.3. In the adult stage alone the daily average is practically the same.

SUMMARY.

The more important observations recorded in the foregoing paragraphs may be summarized as follows:

(1) Parents and progeny of *Podisus maculiventris* exhibit striking variations in form and color which might readily be mistaken for specific characters.

(2) Egg laying began on the ninth day after the female became adult and extended over a period of forty days, the rate of production apparently depending largely on the prevailing temperature. Eighteen batches, with a total of 492 eggs, were deposited by a single female.

(3) With 67.5° F. as the average daily mean temperature, the average period of incubation was seven days and one hour. The extremes in duration of incubation period of five days as the minimum and nine and a half days as the maximum corresponded with extremes in average daily mean temperature of 73.1° and 61.3°, respectively. Within this range 1° F. decrease corresponded with 0.32 day's increase in the incubation period.

(4) The average duration of the immature stages of seven specimens, with an average daily mean temperature of 61.5° F., was forty-six days. The average adult life of a male and a female specimen was forty-eight days.

(5) The two specimens of spined soldier bug under observation destroyed, during their last nymphal instar of six days, 26 elm leaf-beetle larvæ. During their adult life the same bugs destroyed 220 elm leaf-beetle larvæ and 7 large caterpillars.

DESTROYING THE WOOLLY MAPLE-LEAF SCALE BY SPRAYING.

By W. E. BRITTON, *New Haven, Conn.*

The woolly maple-leaf scale, *Phenacoccus acericola* King (formerly *Pseudococcus aceris* Geoff.) has become quite a serious pest of the sugar-maple street trees in New Haven, Hartford, Bridgeport, and other Connecticut towns and cities.

On August 2 a New Haven seed firm sent me some maple leaves, brought in by one of their customers, which were infested with *Phenacoccus acericola*. I immediately visited the place. A sugar maple of 10 or 12 inches in trunk diameter was thoroughly infested, and many leaves had already dropped. Scarcely a leaf was free from the white waxy mass containing female and eggs, which are formed on the under surface. The upper portion of the trunk was completely covered with the larvæ. Two other small trees near by were infested, though less seriously. The owner was afraid that the trees would die, and wished to save them. As very little has been published about remedies, and as I had not then noticed Professor Cooley's paper[a] giving his experience with remedial treatment in Massachusetts, I advised that the tree be sprayed with ordinary kerosene emulsion. This was done on August 4, the mixture used containing 2 gallons of kerosene, ½ pound of common hard soap, and 1 gallon of water as a stock solution, which was diluted nine times before using. On going to examine the trees a few days later, the owner informed me that the spraying did no good, and I almost

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[a] Notes on some Massachusetts Coccidæ. By R. A. Cooley. Bul. 17, n. s., Div. of Ent., U. S. Dept. Agric., p. 61, 1898.

agreed with him. A few of the scales were killed, but most of them seemed to be uninjured by the spray.

On August 17 we again sprayed the trees, using this time an emulsion made with a soft naphtha soap and without hot water. Two gallons of kerosene, 1 pound of soap, and 1 gallon of water were the quantities used, and the whole diluted five times. At this spraying the trees were very thoroughly drenched, the spray being directed especially against the under side of the leaves and against the bark of the trunk, where the larvæ had gathered in the crevices. Even with this emulsion we found it somewhat difficult to moisten the egg masses, owing to the wax. The first spray striking a leaf usually rolls off in small drops, but if the nozzle is held in one place long enough the mass finally becomes soaked with the emulsion.

On examining the trees a few days later nearly all of the insects appeared to be dead. Some of the leaves showed a little injury, as if from the emulsion, but it is often difficult to determine how much to attribute to the spray and how much to the insects.

I am satisfied that this insect is a difficult one to combat, and that if we use kerosene emulsion against it the spray should contain not less than 15 per cent of kerosene.

THE RELATION OF DESCRIPTIONS TO ECONOMICAL METHODS OF ERADICATION IN THE FAMILY APHIDIDÆ.

By CHAS. E. SANBORN, *College Station, Tex.*

The description of any species of Aphididæ should contain that of the different apterous and migratory forms, the male, the true or sexual female, the egg, and in addition the scientific names of the host plant or plants with inclusive dates of infestation.

There has originated and continues to be a great deal of confusion concerning the specific names in the family Aphididæ. It seems that early investigators supposed that every species of aphide colonized but one species of plant. Furthermore, the descriptions given by these authors are limited mainly to the general color of the insects at the time of their capture, and a common name of the host plant with no date of infestation.

Now it is necessary to know the scientific names of the plants on which specimens are captured, partly as a ready reference key to species. It must be borne in mind, however, that the name of the host plant is not always a true index for any species. Some species are quite cosmopolitan in their feeding habits and migrate from one host plant to another during the season and are changed sometimes in form, sometimes in color, and sometimes in both color and form.

Take for instance the common grape leaf-aphis. Soon after it first colonizes the grape its honey tubes elongate and its form partakes of the genus Macrosiphum. This same aphis when it colonizes the plum in early spring appears like the genus Myzus. Thus we see that a change of host plant affects not only the characteristics of a species but also those of the genus.

Now, if we depend upon the early system of description we may have one species described as many species and contained in more than one genus. One remedy is to follow a single species through its entire seasonal history and obtain the specific names of all its host plants, with descriptions of it containing all its changes in color and form. By doing this one-form method will be discarded with several troublesome synonyms.

Another remedy will be found in a "host plant catalogue," which should contain all the scientific names of the plants, each followed by the species affecting it. The former is not only a list of beneficial or injurious plants which are affected by these insects, but it is also a good index key for identifying them. For instance, if a colony is found infesting okra (*Hibiscus esculentus*) there may be but little difficulty in identifying the species, because by looking into a late host plant catalogue for *Hibiscus esculentus* there will be found *Aphis gossypii* Glov. and *Rhopalosiphum dianthi* Schrank. Then by comparing the descriptions of these species with the one in question an identification is sure to follow unless it is a new species to the plant in question. If the latter is true, a record of it should be made.

Another item of importance in this connection is the date or dates when a certain species is found to colonize a particular host plant. This is essential, since we might get several species from one form like *Callipterus walshii* Monell. The latter in July is frequently found with a mottled pulverulence on its body. In October it can be found with an entirely different coloration, consisting of no pulverulence, but with a background of brown color marked with dark spots and transverse bars. If the dates for these colorations or characteristics are given, the possibility of giving this species other names than its own can be eliminated.

Now, what is the bearing of an incomplete description upon methods of eradication? A conspicuous example in Texas is the "green bug" (*Toxoptera graminum* Rond). Whenever the natural conditions permit this aphis to flourish it can devastate all the wheat and oats that may be planted in its latitude of infestation. The financial losses are almost inconceivable. With the present incomplete life-history knowledge of this pest no artificial method of eradication seems possible. The only thing that can be depended on with any degree of success until the life history is known will be the inimical insects which prey upon it.

As long as the life histories of these insects remain incompletely known no thoroughly practical method of extermination can be used. It is true that the aphides can be profitably combated, but they can be combated with a great deal more profit when that stage which contains the least number of individuals is known. This stage is that in which the true sexual forms occur, or when the first generation occurs, which is from the egg. At these times the common methods of spraying or fumigating can be used to eradicate instead of to combat, as they are now used on unfavorable stages of the insect.

In conclusion, some valuable aids in the study and description of species of this family may be obtained from the following outlines whenever a form is to be described. It will not only help to eliminate mistakes by including all the main characteristics, but it will also bring about an easy method of comparison of the same or different species. Since it is not easy to completely describe a specimen before it has been treated with clearing mixtures, it is necessary to keep two kinds of notes, the one bearing on field notes and colorations, the other on measurements and minute details. The investigator should have about 200 of these keys for a season's work. The "color key" should be printed on one side of a leaf and the "measure key" on the other side. The "keys" may then be arranged in the form of a pad, 6 by 9 inches or other convenient size.

Description Theme.

[This key is followed when a final description is taken from the color and measure keys.]

- Head
  - Color.
  - Antennæ
    - Color and covering.
    - Length of segments.
    - Total length.
    - Length in relation to the body.
    - Sensoria
      - Shape.
      - Number per segment.
  - Eyes
    - Color.
    - Ocular tubercles.
    - Ocelli.
  - Beak
    - Color.
    - Length.
    - Length in proportion to the body.
- Thorax
  - Prothorax
    - Color.
    - Lateral tubercles.
  - Meso-and Meta-thorax
    - Color.
    - Wings
      - Color.
      - Venation
        - Color.
        - Normality.
      - Stigma
        - Length.
        - Breadth.
      - Total expansion.
    - Legs
      - Color.
      - Covering.
      - Normality.

- Abdomen
  - Color.
  - Tubercles.
  - Honey-tubes
    - Color.
    - Shape.
    - Length.
    - Length in relation to the body.
  - Style
    - Color.
    - Covering.
    - Shape.
    - Length.
  - Total length of body.
- Œcology
  - When found.
  - Host-plants
    - Number.
    - Position on.
    - Inclusive dates of infestation.
  - Habitat.

COLOR KEY.

[Underscore terms used. Blanks are to be used for qualifying terms and comments.]

Locality	Date ....
Acc. No	Name ....
Head—black, green, brown	Stigma—black, gray, brown ....
Antennæ—concolorous	Femora—black, green ....
Eyes—black, red	Tibia—black, green ....
Beak—concolorous	Tarsi—black ....
Prothorax—black, green, brown	Abdomen—bare, pulverulent, cottony ..
Thorax—black, green, brown	Abdomen—green, black, brown ....
Wings—deflexed, reposed	Abdomen—other markings ....
Wings—clouded, banded	Honey-tubes—black, green, brown ......
Veins—black, brown	Style—black, green, brown ....

Host-plant: Common name .... Genus .... Sp ....

Parts affected—leaves, dorsal, ventral, marginal, petiole, twigs, fruit, distal, proximal, trunk, roots, gall, pseudogall ....

Habits—aerial, subterranean, sporadic, gregarious, viviparous, oviparous ....

Comments ....

MEASURE KEY.

[Underscore terms used and fill out blanks.]

Acc. No .... Name ....

- Head
  - Antennæ
    - Hirsute .... glabrous ....
    - Length
      - Apparent, mm. I..II..III..IV..V..VI..VII..
      - Real, mm. I..II..III..IV..V..VI..VII..
      - Total length
        - Apparent, mm ....
        - Real, mm ....
      - Extends ....
    - Sensoria
      - Circular, transverse.
      - Number, III.... IV.... V.... VI....
  - Eyes
    - Ocular tubercles ....
    - Ocelli ....
  - Beak, length
    - Apparent, mm ....
    - Real, mm ....

Prothoracic tubercles: Present, absent.

- Wings
  - Venation ....
  - Stigma
    - Length
      - Apparent, mm......
      - Real, mm ....
    - Breadth
      - Apparent, mm.....
      - Real, mm ....
  - Total expansion
    - Apparent, mm.....
    - Real, mm ....
- Tubercles ....
- Honey-tubes
  - Cylindrical, incrassate, clavate, tuberculate.
  - Extent, base of style, distal end............
  - Length
    - Apparent, mm........
    - Real, mm ....
- Style
  - Glabrous, hirsute.....................
  - Ensiform, conical, globular, subglobular, obsolete.
  - Length
    - Apparent, mm ....
    - Real, mm ....
- Total length of body
  - Apparent, mm ....
  - Real, mm.............
- Width of abdomen
  - Apparent, mm ....
  - Real, mm...............

Mr. Osborn said that he wished to call especial attention to the fact that in this family the nymphs were of much value as a means of specific distinction.

In the absence of their authors the following papers were presented by the secretary.

THE CURRANT ROOT-APHIS.

(*Schizoneura fodiens* Buckton.)

By Fred V. Theobald, M. A. (Cantab.), *Wye, England.*

During the present autumn (1905) several notices have been sent me regarding the prevalence on the roots of currants of a woolly and mealy aphis. As such root forms are very easily distributed with young nursery stock, a few notes regarding this insect may serve a useful purpose to my fellow-workers in America and our colonies, should it be imported abroad.

The currant root-aphis, or currant woolly aphis, as it is sometimes called here, is undoubtedly the species described by Buckton in his Monograph of British Aphides[a] as *Schizoneura fodiens*. This insect is roughly figured on Plate CVI (figs. 6 to 12) of that work, but the details are not sufficient to enable certain determination should the insect appear elsewhere, and it is hoped that the additional structural details given here will fill some of the gaps in the original description.

The appearances on the roots to some extent resemble those of the woolly aphis (*Schizoneura lanigera* Hausm.), and in consequence

[a] Vol. III, p. 94, 1880.

the pest has been confused with the apple and pear species in this country. In 1894 a number of these insects were sent me as woolly aphis from soil beneath apple trees in Kent,[a] together with specimens of *Pemphigus lactularius* of Passerini. Some of these undoubtedly came from currant roots growing beneath the apple trees; others were free in cavities in the earth. At first I thought this must be a form of the well-known apple pest, but later winged forms came out of the ground and proved to be distinct. Many of these were found on the apple trunk. *S. fodiens* seems, therefore, to be able, under certain conditions, to live upon apple and other roots as well as on those of the currant, which was further recorded in

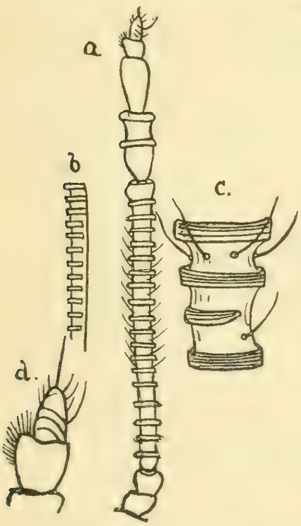

FIG. 7.—*Schizoneura fodiens*, antenna of winged viviparous female: *a*, dorsal view; *b*, lateral view of third segment; *c*, further enlarged rings of third segment; *d*, apical segment. *a*, much enlarged; *b*, *c*, *d*, more enlarged (original).

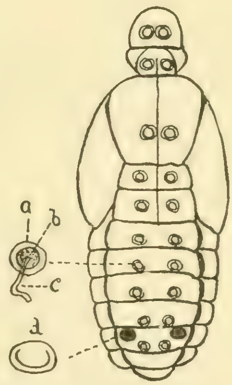

FIG. 8.—*Schizoneura fodiens*, pupal markings: *a*, ring of white meal; *b*, opening of gland; *c*, white fiber; *d*, cornicle area. Much enlarged (original).

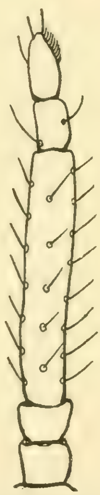

FIG. 9.—*Schizoneura fodiens*: Antenna of pupa, very greatly enlarged (original).

1897.[b] Since then I have several times seen real woolly aphis on the roots of apple, but the currant root-aphis occurs there now and again and may thus be confused with it by growers.

It is as a currant pest, however, that it is of such great importance. Buckton originally described the species from the roots of the black currant. No mention is made, however, of the variety attacked. During the present year I have observed it on the Black Naples and Baldwin varieties and on a cottage garden variety found in Kent, known as the Old Black Dutch. The worst attacks have, however, undoubtedly been on the red currant, all varieties seemingly be-

[a] Notes upon Insect Pests in 1894, p. 4, 1895.

[b] Notes on Injurious Insects, Journ. S. E. Agric. Coll., pp. 15 to 21.

coming infested. So far I have not seen it on the white currants, but it probably will attack them just as readily as it does the red.

The effect on young stock is very disastrous, not only checking growth, but in one instance, it was observed, killing the plants outright. A large number of year-old slips were found to have made such poor growth at Swanley Horticultural College that they were lifted, and all were found smothered with the aphis. Many of the cuttings had scarcely grown at all, and the best had not made more than a foot's growth during the summer. The effect on old-established bushes is not so marked, but I have seen them die now and again under the attack, and even when a few aphides only are present on the roots the fruit runs off just before ripening.

The aphides live in three ways below ground. The majority live on the main stem, and there by the punctures of their proboscides they cause the rind to split and peel off and the wood to crack. Those that feed close to where the lateral roots come off cause large rounded, swollen, gall-like growths. Others may be seen feeding on the fine rootlets, and yet others in nest-like cavities in the soil. Buckton found them from 4 to 6 inches underground. Those observed this season have been found a foot or more down.

The wingless forms appear to live in small colonies composed of from ten to fifty individuals. These colonies probably represent the progeny of one parent. As many as seventy colonies have been found on one small bush. Those that live in earth cavities, through which a small root runs, line the nests with a mass of dull grayish white wool. Those that occur on the main roots do not produce so many fibers, but, nevertheless, a sufficient number to give the plant a distinct mealy appearance, which sometimes assumes a dull, almost gray, shade. The wingless females may be found on the roots all the year round.

During November many change to pupæ and winged viviparous females occur. These wander about in the soil and many make their way into the air and crawl onto the stems. After remaining there a short time they fly off to other bushes, where they deposit young close to the stem, often working their way into the soil. The production of these winged females goes on into December. Buckton says (p. 95): "In October the larvæ became very scarce, all the young passing into pupæ and winged insects." He also says that the wingless forms were taken plentifully up to the middle of November.

From what I have observed, the insects will go on breeding all the year underground, every now and then in November and December giving rise to winged forms. I have been unable to find out if these winged females fly elsewhere than to neighboring currant bushes. That they fly to the latter and there give rise to living young I have found to be the case during the present season.

Buckton figures what he describes as "a vermiform young insect fifteen minutes after birth," and says it is in all probability a sexual form. The figure looks just like an immature form of the asexual generation produced by the winged females I observed.

I have never found centipedes affecting the nests of this aphide as did Buckton. They were observed by him not to molest the schizoneuras.

The only record previous to Buckton's that I can find is in an old work entitled "A Treatise on the Insects Most Prevalent on Fruit Trees and Garden Produce," by Joshua Major, 1829, page 153. As this work is now very rare I reproduce what is said of this currant root-aphis:

The roots of the currant bush, particularly the small fibrous roots, are sometimes infested by a small species of the aphides. It is smaller in size than any of the preceding ones described. The body is of a buff or flesh color, produces a cotton-like envelopment similar to the *Aphis lanigera* on apples, and which probably might have been mistaken by Salisbury for the Eriosoma, or apple bug, on the root of the apple tree, as I am almost persuaded that the Eriosoma, or, as it is now called, *Aphis lanigera*, never feeds upon the roots, or at least after many investigations I never found any feeding, or the least symptoms of their having fed there. The attacks of the root-aphis are generally from the middle of July to the latter end of September. At the last period they arrive at their perfect or winged state. They prevail principally in dry weather. Tokens of the visitations of these depredators are exhibited in the languishing or drooping of the foliage, occasioned by the loss of the ascending sap, which they draw out for their support.

No mention is made of this pest by Kaltenbach, Taschenberg, or more recent European writers, and I am not aware of its record outside the British Islands. Neither Ormerod nor Whitehead has referred to it, yet it is well known to many growers and gardeners. Recently it has been recorded from Ireland, and I have observed it in the northern part of Wales.

The *winged viviparous female* varies in length from 1.70 to 1.80 mm., with antennæ 0.70 to 0.80 mm., and a wing expanse of 5.50 mm. The general color is dusky blackish-brown; head and thorax rather shiny black; abdomen deep blackish-gray. The legs and also the antennæ are shiny brownish-black. The eyes are dull reddish and prominent. The antennæ (fig. 7) are composed of seven segments, the two basal ones quite small, the second a little smaller than the first and rounded apically, the third segment very long with 18 prominent rings projecting around the central stalk; the base contracted; the apex normal, rather swollen, a few scattered hairs in whorls between the rings; fourth segment small, narrowed basally, with two rings, the one apical; fifth segment rather smaller than the fourth, narrowed basally, swollen apically, with a few hairs; the sixth closely applied to the fifth, about one-third the size; the seventh much narrower than the sixth, about the same length (with traces of three rings), and with numerous fine hairs. The rings apparently are only on one side of the long segment, not completely encircling it (fig. 7, *b*). The proboscis reaches halfway between the prothoracic and the mesothoracic legs. Wings normal, the stigma ochreous-brown; cubital vein stopping short about the middle of the wing, forked once. Ungues large, expanded basally.

The *pupa* (fig. 8) varies from 1.40 to 1.80 mm. in length, with antennæ 0.30 to

0.40 mm. Head mealy with two dark spots; pronotum mealy with two dark spots; rest of the thorax ochreous with two spots and with a median line; venter fawn colored. Abdomen mealy-gray to dusky-brown, densely clothed with white meal, two dusky spots on each segment except at the apex (=8 pairs); a dusky line shows on each side owing to the conformation of the segments. At the base of the seventh segment are the two large round black areas, the position of the cornicles. When denuded of its mealy coat the abdomen varies from slaty gray to plum color or brownish ochreous. In a few cases I have seen them almost flesh colored, especially when first coming from the larval skin. The meal especially forms a ridge around each dusky spot, which is the opening of a gland from which the flattish white waxen threads are passed out. The rostrum is dark and short, reaching just beyond the base of the prothoracic legs. Antennæ (fig. 9) dark, with ocherous bands, short and thick, composed of five segments, the two basal ones small and of about equal size, the third long with a few prominent thick hairs of moderate length, ringed ventrally when about to hatch into the winged female; last two segments small, the apical one longer than the penultimate and bluntly pointed, with small fine pilosity and some longer hairs. The legs are dark brown and thick and short; tibiæ spinose, and a few spine-like hairs also on the tarsi. Coxæ very dark brown. The pupal legs are so short that the insect can not right itself if placed on its back.

The *wingless viviparous female* is more uniformly fawn colored, varying to ochreous and covered also with a mealy coat. The head is dusky brown. The dark spots are much as in the pupa. Legs deep brown. Antennæ grayish-brown. Eyes very small or absent. Rostrum long, reaching to beyond the base of the third pair of legs. Fatter and more globose than the pupa. Length, 1.35 to 1.70 mm.; of antennæ, 0.38 to 0.45 mm.

Buckton describes the antennal segments as being more cup-shaped than in other stages. Unfortunately I have made no notes on their structure and allowed them all to enter the pupal stage.

In all the stages the body is more or less mealy, thus hiding the true color, which is very variable according to my observations. The waxy threads can be easily watched proceeding from the dorsal glands and are most pronounced in the wingless viviparous female. The waxy excretion remains on the currant stems long after the aphides have disappeared and after the specimen showing damage has been dried.

It has been found that the rootage is easily cleaned by first moving it through a tub of plain water and then for a couple of minutes in strong soft-soap solution, slightly warm. This should always be done where young stock is moved if any traces of the woolly aphis are observed.

When older bushes are attacked treatment of the soil with bisulphid of carbon is found most successful. Dry weather was found the best time to employ this remedy.

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THE PLAGUE LOCUST OF NATAL.

(*Acridium purpuriferum* Walk.)

By CLAUDE FULLER, *Pietermaritzburg, Natal.*

So far as economic entomology is concerned the most important and interesting work done in this colony is the annual campaign against the invading plague locust (*Acridium purpuriferum*). Briefly, this locust invaded Natal about thirty-six years ago; the exact date is somewhat legendary, for we are still a very young colony, and our official records were all burned some seven years ago. The invading swarms did very little damage, laid no eggs, and disappeared. Then, in 1894 there was an invasion again, and in 1895 and 1896 further and devastating invasions occurred, the locusts swarming over the whole colony and depositing their eggs from the littoral to the high veldt (5,000 feet altitude). The damage they did was enormous, and the farmers and planters were in a hopeless position. The rapidly undulating nature of this country, where plains are absent and comparatively level areas seldom more than 50 to 100 acres in extent, and exceptional at that, precluded the use of your well-known hopperdozers and rollers. The government of the day paid out vast sums for eggs, bands of natives were organized, and the young locusts were thrashed with wire flails, made up like the old pedagogue's birch. No outside advice or help, so far as I can ascertain, was sought, and the people worked in the dark and unavailingly. I am told that a dead locust was sent to an eminent naturalist of Europe with a request that he should say how such insects could be readily killed. He seriously replied, it is said, that such a desired effect might be most easily procured by pulling off their heads. For the veracity of the story I can not vouch.

The next move forward was the discovery (I use the word advisedly) of the efficiency of arsenic solution sweetened with treacle as a destructive agent, by Messrs. Anthony and Gilbert Wilkinson, sugar-cane planters. By this time the locust trouble had become rather a coast than an upland question, and the arsenic-soda solution was immediately brought into use from north to south of the littoral. This innovation of the Messrs. Wilkinson was recognized by Parliament, and the colony presented them with a handsome piece of plate inscribed with the people's appreciation of their services. A material consequence of the general application of arsenic solution was a greatly increased demand for arsenic. Planters' orders for the poison in one season amounted to 50 tons; and, curiously enough, the increased demand from Natal, for a time, put up the price on the London market.

Late in 1899 I arrived in Natal, and was, as you may well imagine, rapidly involved in what is known here as "the locust question." I was quickly forced to recognize the efficiency and local applicability of the arsenic solution. I found that it was applied in the following ways: In the cane fields gangs of "Indians" (chiefly women) were kept constantly at work laying down between the rows baits made by dipping begasse in the solution. In the grass lands gangs of Kaffirs, each with a paraffin (kerosene) tin full of solution, stalked about placing the poison upon grass and herbage about the swarms, applying it crudely by switches made by bundling together a few twigs.

I brought with me an American knapsack pump fitted with a cyclone nozzle, and had the liquid sprayed on instead of switched. It was even more efficacious, and in actual practice we found that one man could get as far in an hour with 1 gallon of solution as 70 men could get with 70 gallons in seventy hours by the other method. That spray pump was the first of its sort in Natal. Nowadays several hundred are imported annually for the destruction of locusts. Owing to the rough handling the machines are subjected to by the Kafirs, we find now that it pays us best to use the bucket pump instead of the knapsack pump, the loss in labor, time, etc., with this machine not being equal to the damage sustained by the copper tanks.

You will gather that we deal only with immature locusts. Nothing is attempted with the winged individuals. This is so for two excellent reasons:

(1) Such work is impracticable (until the days of aerial navigation, when we can perhaps try net fishing).

(2) We sustain no damage from the flying locusts.

The latter statement requires some qualification, and to explain it I must digress a little.

Acridium purpuriferum deposits its eggs regularly each year between the first part of December and the middle of January in Natal. The majority of eggs are laid just before mid-December; earlier and later deposits are, in a sense, abnormal. These eggs hatch in thirty days; therefore, about the middle of January the infested areas (the littoral, as a rule) are swarming with young locusts. These locusts will acquire wings when about 90 days old. During this interval we wage war against them, wherever they may be, upon Crown lands or in native locations (areas of country set aside for occupation by natives only); and at the same time our locust officers, in the course of their duties, inspect private lands to see that owners and occupiers are destroying the hopping locusts upon their properties, as provided by law.

The cost of this work to the State depends mainly, of course, upon the area infested. The season of 1901–2 cost us £494; that of 1902–3, £8,000, and that of 1903–4, £4,500. For this year's campaign Parliament has voted £4,600. The appreciation of the value of this work—for the money is saved over and over again in crops and in the prevention of famine among the natives—is strongly evidenced at this present moment. Despite a falling revenue and severe retrenchment in every branch of administration, the locust vote stands intact.

Now, what we do is simply this: We destroy all the progeny of the locusts which come into the country. By attacking them at this season we prevent the destruction of young crops throughout the growing season, and we have no winged locust swarms feeding about the country for nine months in the year. Occasional swarms of invading locusts will appear in Natal as early as August—they come, I believe, from the native territories to the south of us—but their mischief is very slight. November and December see the main invasion. Hordes of locusts fly in clouds from north to south across the county. These insects, however, do not feed, and simply migrate southward to oviposit.

Just one word in conclusion with regard to the "locust poison." Our old formula used to be:

	Pounds.
White arsenic	1
Washing soda	½
Treacle or treacle sugar	6

Boil in 2 gallons of water for one-fourth of an hour, then add sufficient water to make 16 gallons of solution.

For the past three years, however, we have adopted arsenite of soda with equally efficient results:

Arsenite of soda	pound	1
Treacle or treacle sugar	pounds	4–5
Water	gallons	15

Treacle is used only when mills are convenient. Treacle sugar is just as efficacious. To-day I have just made payment for 8 tons of this commodity, 5 of which will be used in our work in the wilds of Zululand. The young locusts are passionately fond of the sirup, and you can see them lapping up the drops of liquid on the grass stems. The treacle aroma entices them to their death, when otherwise they might pass by the poison.

To you the amount of poison used will appear enormous, and so it is; but what we want is rapid work. To see the locusts dead before passing to a new camp is the most satisfactory way of knowing that the work is well done, and, further, in the last molt we find that the poison is none too strong.

The effect of the arsenic upon grass lands is purely temporary. Cattle feeding over the land afterwards have suffered no deleterious effects, but the farmers think them always the better for a little locust poison, arsenic being a much-used drug in farm veterinary work.

Let me say definitely that I never use the locust fungus. I say unhesitatingly that, if the unknown conditions suitable to its development arise, it breaks out—in the ordinary acceptance of the term—spontaneously. Further, I feel certain that if those conditions were to prevail for from four to six weeks during the summer we would have no work to do until the following season.

The use of Paris green for locusts is not practicable; contact insecticides, i. e., soap solutions and kerosene emulsion, are occasionally employed for the insects in the first larval stage, but in practice the same results are never obtained as with the arsenic solution.

Begasse baits are still largely used in the cane fields, but nowadays many planters leave the trash on the older leaves and spray that. In many cases, however, advantage is taken of the habit displayed by the young locusts of leaving the cane lands to moult in the grass of the headlands or veld in their proximity.

I have not listed the plants which these locusts do not attack, but it is curious to note that while they feed readily on the foliage of the orange, they never touch that of the mandarin orange. Tea plantations are also exempt from them.

DOES THE SILVER-FISH (LEPISMA SACCHARINA L.) FEED ON STARCH AND SUGAR?

By H. Garman, *Lexington*, Ky.

In all the accounts of the food habits of the silver-fish with which I am familiar no doubt is expressed as to the food being starch, sugar, or both. Observations made by the writer a few years ago convinced him that the silver-fish common in dwellings in Kentucky, and presumably the same as that found everywhere in the country, feeds freely upon substances of animal origin.

My attention was first drawn to the habit by the scored condition of some velox photographic prints hanging on a wall in a dwelling, the film having been removed in irregular patches (see fig. 10) while the starch used in mounting them remained untouched. The injury was traced to silver-fish. They were found to be exceptionally common about a shingled balcony opening into the room. It was decided to set a bait for them, and with the statements of writers as to their fondness for starch and sugar in mind these substances were at first used. But the insects paid not the slightest attention to them in any condition in which they were employed, moist or dry. I was surprised at this, but in the course of my experiments noticed that killed or disabled silver-fish were fed upon by the others, often three or four gathering about a dead individual while I was engaged in placing bait at night. This, of course, suggested an animal bait, and at the same time a suspicion entered my mind that the injury to the binding of books with which they are charged might be the result of eating glue instead of starch. They were then tried with bits of white glue, which they ate readily, alone and also when dusted with Paris green.

In the light of this observation, statements in some of the earlier accounts of the insect are suggestive of a fondness for animal food. The surface of calendered paper is said sometimes to have been abraded by the jaws of silver-fish. Sizings used on such papers contain animal matter (leather), and it seems very probable that it was

FIG. 10.—Photographic print injured by silver-fish (*Lepisma saccharina*). (Original.)

the sizing alone and not the fiber—which could not furnish nutriment anyway—that they were after. Mr. P. R. Uhler, of the Peabody Library, of Baltimore, is said to have observed that the gnawings of silver-fish cause the white labels on the backs of books to become detached. Here plainly the glue used to stick the labels to the books is the attraction. Again, gilt lettering has been observed to be removed from the backs of books. In this case the insect might be attracted either by sizing used in securing the gold leaf to the books or by that used on the binding. It happens that we have in the Kentucky experiment station library some volumes that were at one time stored in a basement. A good deal of the lettering is removed from several of them, but they are cloth-bound volumes, and the surface is scored freely everywhere, the evident purpose of the gnawing having been to secure the dried glue used as sizing in the cloth. No food could be obtained from the gold leaf itself, and the perfect condition in which the fibers of the cloth are left in the gnawed regions leaves no ground for supposing that the insects were after anything but the glue with which the cloth is impregnated. Silk is sometimes attacked, but silk is a nitrogenous gluey product.

Does the silver-fish feed on sugar and starch?

Both Messrs. Washburn and Sanderson said that they felt convinced that, despite the observations recorded in the paper, Lepisma would feed upon starch. The former described one observation in support of this.

The committee on resolutions presented the following report:

Resolved, That we hereby express our appreciation and thanks to the local committee of arrangements, the citizens of New Orleans, and officials of Tulane University for courtesies extended to this Association during its meetings.

Resolved, That we hereby express our appreciation to the Secretary of Agriculture for his courtesies in publishing the proceedings of previous meetings, and we would respectfully ask him to publish the proceedings of this meeting.

Resolved, That the Association express to the officers of the Association its thanks for the efficient and painstaking manner in which they have executed their official duties during the past year.

Resolved, That the Association hereby express to the retiring president, Prof. H. Garman, its hearty thanks for his admirable presidential address, and extend to him the compliments of the season with wishes for his speedy recovery, and that the secretary be hereby instructed to forward to Professor Garman a copy of this resolution.

Resolved, That we commend to the careful consideration of our members the following important features and suggestions, which we consider of greatest moment, contained in the president's admirable address:

First. That the economic entomologist should be offered sufficient opportunity for investigation in order that he may put before the people the greatest number of facts gained through investigation, and thereby be less obliged to resort to more or less compilation.

Second. That while a certain amount of Latin and Greek work is recognized as necessarily supplemental in the study of the biological sciences, it is nevertheless evident that a proper study of entomology, or a closely related science, would offer equally as good mental training for students, and would in addition prove of much greater practical value, and that therefore the teaching of entomology should have a more prominent place in the curriculum of our high schools, colleges, and universities, especially those institutions receiving the benefits of the Morrill Act.

Third. That more attention should be given to entomology in relation to human diseases, to the relation of insects and plant diseases, and to the relation existing between insects and flowers.

Fourth. That more attention should be given to apiculture and sericulture, not only because of their importance in the arts, but also because of their instructional value.

Your committee respectfully suggests the desirability of a careful revision of both the membership and the qualifications therefor, to comply with the standard required by the American Association for the Advancement of Science, and that the following be substituted for section 2, Article II, of the by-laws:

"The annual dues of active members shall be one dollar and the dues of associate members fifty cents. The funds derived from the annual dues shall be used in the employment of a stenographer at the annual meetings, compensation for the secretary for his services, and for other necessary expenses. The secretary shall render an account of this fund at each annual meeting."

Your committee recommends that hereafter, on the death of a member of this Association, the president shall appoint a committee of three to prepare for the Proceedings an obituary notice, to be properly illustrated when possible to do so.

WILMON NEWELL.
F. M. WEBSTER.
T. B. SYMONS.

On motion, the report was adopted.

The committee on nominations, consisting of Messrs. Quaintance, Conradi, and Osborn, nominated the following as officers for the ensuing year:

For president, A. H. Kirkland, Malden, Mass.

For first vice-president, W. E. Britton, New Haven, Conn.

For second vice-president, H. A. Morgan, Knoxville, Tenn.

For secretary-treasurer, A. F. Burgess, Columbus, Ohio.

For member of the committee on nomenclature, to serve three years, Herbert Osborn, Columbus, Ohio.

For members of the council, American Association for the Advancement of Science, H. E. Summers, Ames, Iowa; E. A. Schwarz, Washington, D. C.

The secretary was, on motion, directed to cast the ballot of the Association for the persons nominated, and they were declared elected.

The meeting was then adjourned.

H. E. SUMMERS, *Secretary*.

31024—No. 60—06 M——12

LIST OF MEMBERS OF THE ASSOCIATION OF ECONOMIC ENTOMOLOGISTS.

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Aldrich, J. M., Agricultural Experiment Station, Moscow, Idaho.
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INDEX.

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