and August 1st. After this appropriation for the year had been exhausted, this office received notification from the state apiary inspector of Massachusetts about some suspected apiaries near the boundary line, with a request that they be inspected. As the case seemed to be important, and as it seemed advisable to coöperate as far as possible with an adjoining state in controlling the disease, Mr. Yates was sent to make the inspections, and the costs thereof, amounting to $23.14, were borne by this office from the general funds. The entire cost of the printed matter, inspection blanks, correspondence, and maintenance of the card index and records open to public inspection, as required by the law, are also borne by this office from its general funds, so as to leave more money for the actual work of inspecting and treating the apiaries.

Messrs. H. W. Coley of Westport and A. W. Yates of Hartford have continued as inspectors, as in 1910. Mr. Coley has jurisdiction over the four southern counties (Fairfield, New Haven, Middlesex and New London), and Mr. Yates the four northern counties (Litchfield, Hartford, Tolland and Windham) of the state.

The number of apiaries and colonies examined, and the cost of the work, are shown below:

APIARIES INSPECTED IN 1911.

	Apiaries.	Colonies.
Number inspected	162	1571
Infested, European foul brood	84	431
Other troubles:		
Pickled Brood .... 8 cases		
Spring Dwindle .... 1 case		
Wax Moth .... 1 case		
Cost of Inspection, paid by state		$299.94
" " station		23.14
Total		$323.08
Average cost per apiary		$1.99
Average cost per colony		.21

RESULTS OF INSPECTION AND TREATMENT.

The foul brood found in Connecticut in 1910 and 1911 has all been the European species. During 1910, 76 per cent., or over three-fourths of the apiaries, and 49 per cent., or nearly one-half of the colonies, examined were found infested. The inspection

work of 1911 shows that only 51 per cent. of the apiaries and 27 per cent. of the colonies examined were infested. Moreover, of the colonies treated for the disease in 1910 and again examined in 1911, less than one per cent. (0.8) were found diseased.

These figures show the value of the inspection work and treatment. In all cases where the disease was found, the inspectors treated the colonies by shaking upon clean frames and foundation, or showed the owners how to do it, using, of course, the proper cautions and disinfectants. The old hives were disinfected, and a few of the worst infested colonies were destroyed, but there is no need of destroying any colonies or supplies if the disease is taken in time.

The state has not as yet been well covered, almost no complaints being received from Litchfield and New London counties, and inspection can be made only on complaint. Any beekeeper, however, may sign his own complaint. It is probable that on further examination the disease will be found in all parts of the state.

In order to make the work thoroughly effective, authority should be given this office to inspect apiaries on suspicion or without waiting for complaints, especially in and around those infested centers which without treatment may continue for a long time to be distributing points for the disease. An appropriation of at least five hundred dollars per annum is needed and should not be considered unreasonable.

PROGRESS IN CONTROLLING THE GYPSY MOTH IN CONNECTICUT IN 1911.

By W. E. BRITTON AND DONALD J. CAFFREY.

The gypsy moth, *Porthetria dispar* Linn., was first discovered at Stonington in March, 1906, and a colony was found at Wallingford in December, 1909. Brief accounts of progress in exterminating the insect in each infested area will be found in each of the previous reports of this station issued since the pest was discovered. Though most of the work done was paid for out of state funds appropriated for this purpose, we wish to acknowledge the coöperation of the Bureau of Entomology in sending trained scouts to examine not only the infested areas but also much territory outside of it. The accompanying map, figure 1 on page 280, shows the location of the gypsy moth colonies in Connecticut.

STONINGTON INFESTATION.

Mr. Caffrey, with two men, began scouting for egg-masses on January 9th, 1911. Mr. Rogers furnished one scout, Mr. Miller, who also went over the same ground working part of the time by himself and some of the time with Mr. Caffrey. Mr. Miller found three fragments of egg-clusters under the edge of the lower stones of a wall near the ground a short distance from Mr. Koelb's house. All three would hardly equal one good-sized egg-mass, and may have all been deposited by one moth, perhaps disturbed in the act. It is not known whether or not these eggs were fertilized, as they were at once treated with creosote.

The summer work began May 1st, in charge of Mr. Fred Hoadley, under direction of the writers. Mr. Caffrey spent several days in Stonington in June scouting for caterpillars and inspecting the work. Three thousand five hundred trees were banded with burlap and about 100 with tanglefoot. From one to four men were employed, as needed. A number of tin patches were applied to cover cavities. The burlap bands were all removed and the work for the summer ceased on August 16th.

Though this work was carried on as in former seasons, no caterpillars could be found, and it looks as if the pest had been exterminated from Stonington. Further scouting has been done there this winter, and no egg-masses found, but the region must be examined with care next season to make sure. The statistics of the Stonington work are as follows:

RECORD OF GYPSY MOTHS DESTROYED AT STONINGTON.

Year.	Egg-masses.	Caterpillars.	Cocoons.
1906	73	10,000	47
1907	118	2,936	200
1908	76	2,560	44
1909	6	98	0
1910	1	146	1
1911	3	0	0

WALLINGFORD INFESTATION.

Mr. Caffrey, with men, started scouting work at Wallingford on November 7th, 1910. The first egg-mass was found November 14th, high up in an apple tree on South Main street. On November 22d an unusually large egg-mass was found at No. 40 Williams street. In all 23 egg clusters were found at Wallingford and the scouting work was finished on January 7th, 1911.

Work was resumed April 20th, by pruning and replacing tin patches. Tanglefoot bands were applied commencing April 25th. The first caterpillars were found on May 12th in their first stage on North Whittlesey avenue.

Commenced banding trees with burlap May 14th. First caterpillar was found under bands June 6th. Commenced turning bands June 8th. First spraying done on May 22d. On the 29th one dead caterpillar was noticed, which had been killed by the spray. On June 20th Mr. Caffrey observed many dead caterpillars killed by the poison. At this time they were from one and one-half to two inches in length.

On June 27th the first pupa, a male, was found in the breeding cage. The next day about fifty caterpillars were found in some low cherry bushes near the Whittlesey avenue dump. The brush was cut and burned at once with oil. The first pupa was found out of doors on July 6th. On July 10th the first adult, a male, emerged in the breeding cage, and the first one outside, a female, was found on July 25th.

The work on trees and turning burlap was continued until the middle of August, and a total of 1,551 caterpillars, 15 cocoons and two adults were found and destroyed, in addition to the egg-masses already mentioned, and the very large number of caterpillars killed by the poison spray and the tanglefoot bands.

The burlap bands were all removed and the summer work closed on August 17th.

Mr. Caffrey, with three men, began scouting for egg-masses November 20th, and two federal scouts began work December 6th and finished December 23d. The entire infested area was thus carefully examined by both state and federal scouts, and altogether only five egg-masses could be found.

The statistics of the year's work at Wallingford are given below:

Egg-masses destroyed	23
Caterpillars destroyed	1551
Cocoons destroyed	15
Adults destroyed	2
Trees banded with burlap	8556
Trees banded with Tanglefoot	469
Trees sprayed (not including shrubs)	116
Trees infested	216

The following figures show the number of insects destroyed since the discovery of the infestation at Wallingford:

RECORD OF GYPSY MOTHS DESTROYED AT WALLINGFORD.

Year.	Egg-masses.	Caterpillars.	Cocoons.
1910	8234	8936	96
1911	23	1551	15

The following table shows the cost of all work in Connecticut in suppressing the gypsy and brown-tail moths:

COST OF GYPSY MOTH WORK IN CONNECTICUT.
Including both Stonington and Wallingford Infestations.

Year.	State Funds.	Federal Funds.	Total per Year.
1906	$1,500.00		$1,500.00
1907	4,550.00	$ 272.00	4,822.00
1908	2,550.00	77.00	2,627.00
1909	1,503.22	42.00	1,545.22
1910	4,560.22	1,411.36	5,971.58
1911	4,017.95	4,660.22	8,678.17
Total	$18,681.39	$6,462.58	$25,143.97

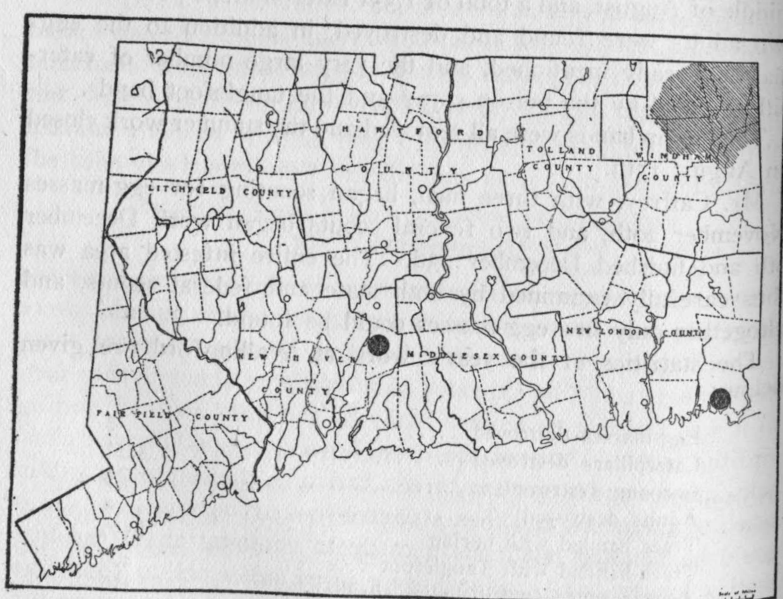

FIG. 1. Map of Connecticut. Shaded area denotes brown-tail moth infestation. Black dots show location of gypsy moth colonies.

CHECKING THE SPREAD OF THE BROWN-TAIL MOTH IN CONNECTICUT IN 1911.

BY W. E. BRITTON AND DONALD J. CAFFREY.

The discovery of the brown-tail moth, *Euproctis chrysorrhœa* Linn., at Putnam and Thompson in the spring of 1910 was recorded in the last report of this station (see Report for 1910, page 683). At that time the trees were covered with foliage, so it was very difficult to ascertain the extent of the territory infested. However, the work of the insect was apparent through a small area in Thompson and around the center of the city in Putnam.

During the winter and early spring of 1911, from February 6th to April 20th, the towns of Thompson, Woodstock, Putnam, Pomfret and part of Killingly were scouted for the winter nests, in order to determine the limit of infestation and also to cut off and burn the nests when found. Two men were taken from Wallingford who were familiar with the work, and the local authorities at Putnam helped us by removing many of the nests from the trees in that city.

Of course it was impossible to find and remove all nests from the thick woodlands, the oaks especially, with their dead and clinging leaves, making the nests very difficult of detection; but all the open country, the orchard land and the partially wooded areas adjoining the towns and villages were effectively covered.

METHODS OF WORK.

The nests, which are nearly always at the extremities of the twigs and may be readily seen during the winter months, were removed by means of long-handled tree pruners. One of these tree pruners could be extended to a length of about twenty feet, so it was possible to remove many of the nests without getting into the trees. Many of the trees, however, especially the elms, oaks, maples and larger fruit trees, had to be climbed to get within reach of the nests, and then a twelve-foot pruner was used, as it could be handled much more easily in climbing about the tree than a longer one. Ladders were often necessary to reach the lower branches of the large trees. The use of climbing irons for this purpose should be avoided as much as possible except on worthless trees or those with a very rough bark. When clipping off the nests, care was taken not to remove any more of the twig than necessary, and after being clipped, the nests were placed in a thick paper bag, which, with its contents, was burned at the close of each day's work. When only a few nests were found, they were wrapped in paper and burned in an ordinary stove, but generally a furnace was available when larger quantities of the nests were taken.

When examining orchards for nests, our practice was to have each man walk in the aisle between two rows of trees, looking through the branches to his left and right. The man in the next aisle does the same, and in this way each tree in every row is examined very quickly, as the nests are very easily discovered by a man familiar with his work. When the trees were in irregular clumps or standing alone, each man looked over the branches on one tree, going completely around it, and then passed on to the next tree. In all cases when looking over trees, the sky is used as a background if possible, which makes the nests more easily seen. The white silk connecting the nest with the branch is very conspicuous, and helps to distinguish the brown-tail moth nest from those of other insects.

The great majority of the nests were found on fruit trees, although some were found on elm, maple, oak, sycamore, cherry, hawthorn, birch and syringa. The extent of the area infested by the brown-tail moth is shown on the accompanying map, figure 1, page 280.

From July 4th to July 18th, when the adults were flying, Mr. D. M. Rogers stationed two men at Putnam to examine all trains headed westward or southward to remove the adult brown-tail moths, and 75 adults in trains and around the station were thus destroyed.

An account of the work in each town follows:

Thompson.

In the town of Thompson the nests were very scattering, being mostly confined to the western half of the town and along the Massachusetts state line. Along the Rhode Island state line but very few nests were found. The greatest number were in Thompson village and immediate vicinity, 47 nests being discovered at this point. During the previous May some spraying

had been done to control the pest on the N. B. Ream place in the village (see Report for 1910, page 684), and but for this fact the number of nests would have been larger. At Grosvenordale six nests were found; at North Grosvenordale, ten nests; in East Thompson, which is in the extreme northeastern corner of the town and of the state, only four nests; Wilsonville, three nests; Quinebaug and New Boston, eighteen nests, and West Thompson, five nests. Others were scattering between these villages, except in the eastern and southeastern part of the town, where only two scattered nests were found. A total of 112 nests were destroyed in the entire town.

Putnam.

The city of Putnam was quite badly infested, nearly every tree in the city having one or more nests. Some of the trees were badly defoliated the previous summer, and many of the inhabitants were afflicted with the "brown-tail rash" caused by the poisonous and irritating hairs which break off from the caterpillars and adults.

In the early part of the winter Mr. J. H. Osgood, the local tree warden, had removed about 4,000 nests from some of the worst infested trees in the center of the city, as far as his time and the funds at his command would permit. This saved us much labor.

The remaining trees in the township were examined, and it was found that the heaviest of the infestation was confined to the city limits, with a few nests outside. Some of the trees in the city yards were treated first, and at 139 Elm street five apple trees had 201 nests on them, while at 131 Elm street a pear tree had 64 and a syringa 27 nests. Just west from the railroad station, near the John O. Fox Lumber Company, four apple trees in one yard contained 431 nests, of which one large apple tree had 145 and another 125 nests. In this same yard 91 nests were taken from a large elm tree, which required much climbing, as they were on the tips of the highest branches. At East Putnam two nests were found, and at Putnam Heights three nests. In the eastern and southern parts of the town the nests were very scattering, one being taken a half-mile from the state line, and three others at a distance of about two miles from the line. In the western and southern parts they were found up to the town line. In the entire town of Putnam a total of 5,989 nests were destroyed, including those reported by Mr. Osgood.

Woodstock.

In Woodstock the infestation was largely confined to the apple orchards in the eastern and southern parts of the town, some of which were quite extensive, and much time was required to inspect them. In South Woodstock many of the orchards were badly infested, and 882 nests were found in this village and vicinity. The worst infestation in this region was on the property of Mr. Harrington, near the town line of Pomfret, where a total of 681 nests were cut from twenty-five apple trees, one large tree alone containing 166 nests. The trees surrounding this section, however, were only slightly infested. At Harrisville the nests were scattered over a large territory. At Woodstock Center 43 nests were found, at East Woodstock 27 were reported, and at North Woodstock only six were found in the village itself, but scattering nests were taken in the surrounding country. In the western half of the town the nests were few and far between, five being found in West Woodstock, with two others in surrounding territory. None were reported from Woodstock Valley or the extreme northwestern part of the town; but at Kenyonville, in the southwest corner of the town, one nest was found on an apple tree near the barn of a milkman who each day had been driving to and from South Woodstock. In the entire town of Woodstock 937 nests were destroyed.

Pomfret.

The nests were very scattering in Pomfret, with the exception of one or two orchards near Pomfret Center, where fifty of them were found, and in the northeastern corner, in territory adjoining Putnam. The nursery of J. H. Bowditch was given especial attention, but no nests were found there. At Pomfret Landing, in the southeastern part of the town, five nests were reported, at Pomfret Station two nests, at Utley Hill two nests, and one at Ragged Hill, in the extreme northwestern part of the town. Nothing was reported from Abington or Elliotts', or along the southern border of the town. In the town of Pomfret 89 nests were destroyed.

Killingly.

Only the northern half of Killingly, including the borough of Danielson, was examined for brown-tail nests. This territory appeared to be the edge of the infestation in Connecticut, only six nests being found in this town, of which one was taken at East Killingly, one at Killingly Center, one at Break Neck Hill, one near the northern town line of Putnam, and one at Mashentuck Hill. The entire borough of Danielson was given a very careful examination, and one nest was found in the northern part, near Elmville.

Colored Placards Issued.

A colored placard 11 x 14 inches in size and containing illustrations of the brown-tail moth and information regarding it was issued in September, 1911, as a special bulletin of the station, and printed in an edition of 3,000 copies. A copy was sent to each library, each grange hall and railroad station in Connecticut. The New York, New Haven and Hartford and the Central Vermont railroad companies kindly consented to coöperate with this office by not only allowing these placards to be placed in their stations, but by issuing orders to their agents to post them. A halftone reproduction of this placard may be seen on Plate II, *b*.

Summary.

The result of the work in this section shows that the brown-tail moth, in the course of its natural spread from the adjoining infested area in Massachusetts and Rhode Island, has established itself in the towns of Thompson, Woodstock, Putnam, Pomfret and part of Killingly in Connecticut. A total of 7,133 nests were found and destroyed in these infested towns, of which 112 were in Thompson, 937 in Woodstock, 5,989 in Putnam, 89 in Pomfret and six in Killingly.

Though it will be impossible to eradicate the brown-tail moth, as can be done with isolated colonies of the gypsy moth, the former can be more readily controlled, and by careful work prevented from doing any serious damage.

Colored placards were issued giving illustrations and information regarding the insect, and the cards were posted in public places such as libraries, railroad stations and grange halls throughout the state.

The previously infested towns will be scouted again this winter, and all nests found will be destroyed. It is also planned to examine the suroundring towns and those along the boundary lines of Massachusetts and Rhode Island, to determine any further spread of the insect.

THE ONION MAGGOT (*Phorbia ceparum* Meigen).

BY DONALD J. CAFFREY.

INTRODUCTION.

The name "onion maggot" is applied to the small white maggot or grub attacking the bulb or root of the onion plant and belonging to the genus *Phorbia* (*Pegomyia*) of the Dipterous family Anthomyidae. It is well named the onion maggot for it seems never to have been recorded on any other food plant.* Economically it is very important, ranking with the cabbage maggot and seed corn maggot as a destructive pest to the growers of vegetable root crops.

The onion maggot was first described by Meigen in 1830, but its ravages had been noticed and recorded in Europe long before that time, and it had been known and widely distributed as a serious pest of onions from time immemorial.

In the United States it has been present for many years, probably being introduced from Europe in some shipment of its food. Records are present showing the pest to be very destructive throughout the Eastern and Middle States in 1854 and again in 1863. Its distribution in this country is now widespread.

In Connecticut the onion maggot has frequently been reported as doing considerable damage, and many inquiries are sent to the station concerning it. At Greens Farms, Southport, and around New Haven in 1904 it was very abundant and caused much injury to the onion crop, killing from one-fourth to one-third of the plants in large fields.

CHARACTER OF THE DAMAGE.

The presence of the onion maggot is first shown by the plants changing to a yellowish color and finally wilting, while the lower or outer sheaf of the surrounding plants has also become affected in the same manner. The leaves of these plants have become soft and flaccid to the touch, and in general have a sickly appearance. Examination will show that the cylindrical root of the young plant has been nearly cut asunder, so that only the outer epidermal tissue or shell remains. Inside of this remaining tissue one or more maggots may be found feeding. If the plant is more advanced and the bulb partly formed, a hole may be found bored either in the side or on the bottom of the onion, and one maggot is present in the interior. More commonly, however, several maggots of different sizes are found in a large irregular cavity in the center, and the earth around the orifice is wet and slimy, forming a large muddy mass, into which the maggots crawl to rest when not feeding. If the onion bulb has been infested for a longer period, it may be found soft and putrid except the lower part, which, being nourished by the fibrous rootlets, remains sound. The larger worms looking for fresh food will crawl into this remaining part to feed, so that sometimes a thronged mass of worms may be found at this point. In the recent attacks recorded from Connecticut, the highest and dryest portions of the field seemed to be preferred by the pest, and in such places the first signs of infestation will probably be found.*

* Slingerland, N. Y. (Cornell) Agr. Expt. Sta., Bull. 78, p. 496, 1894.

LIFE HISTORY.

The adult fly passes the winter in the pupa stage in the ground, and emerges with the first warm days of spring, when the plants are usually just above ground. From two to six and sometimes more eggs are laid singly on particular plants here and there through the field. According to Fitch,† the adults seem to prefer certain plants to the exclusion of others. The eggs are loosely placed on the plant above the surface of the ground between the sheath or collar and in the crevices between the leaves, and are perceptible to the naked eye. The eggs hatch in a week or ten days, varying with the temperature.

After hatching, the young maggot or larva burrows its way down inside the sheath until it reaches the root, leaving a discolored streak to mark its progress, and begins feeding upon the interior of the root. Later, when the bulb is formed, the entrance

* Britton, Rept. Conn. Expt. Sta., p. 214, 1904.

† Fitch, Rept. on Noxious Insects of New York, XI, p. 487.

may be made from the side or bottom, and several maggots may be found in the interior of each. The maggot attains full growth in about two weeks, and pupates generally in the surrounding ground, although it has been known to pupate within the onion. The pupa stage lasts about a fortnight, and then the adult fly emerges to lay eggs for another brood.

There are several broods each season, varying with the locality and weather conditions. The last brood of larvæ pass the winter in the pupa stage, and adults emerge in the spring.

Description.

Eggs. Laid singly and are perceptible to naked eye. White and smooth in appearance and elongated-oval in form. Size, .04 inch long and .01 inch broad.

Larva or Maggot. Glossy, dull white and smooth in appearance, of an elongate-conical form, tapering to a point at its head or forward end. When crawling and elongated, nearly the whole length of the body becomes tapering. At the extreme forward end the jaws appear as two black hooks, and show through the skin as a short black stripe. Near the head are seen the breathing organs, and the alimentary vessel appears as a stripe along the middle of the back. Hinder end of body is cut off obliquely, and on its flat surface are two small elevated brown points or spiracles, and on the margin are eight small tooth-like projections, of which the lower two are larger, while slightly in advance of these are two small processes which aid the maggot in crawling.

Pupa. In pupation, as is the case in most dipterous families, the skin of the larva hardens and changes to a chestnut-brown color, with a stain of black at each end, to form the pupa-case or puparium, inside of which the true pupa is found. This true pupa is a short, white body, showing a jointed abdomen, and with the wings and legs of the future fly appressed to its surface.

Adult. Resembles the common house fly, though smaller and more distinctly gray in color. Male, ash-colored, with black bristles and hairs and a white face. Three dark lines run along the body between the wings, while particularly noticeable is a row of long black spots along the middle of the abdomen. Female, more ochreous or ashy gray in color, with a yellowish white face. The row of long black spots along the middle of abdomen is not as distinct as in the male. Shown on Plate VIII, *e*.

The sexes are recognized by the eyes, which in the male are close together and large enough to occupy nearly all of the head, while in the female the eyes are smaller and farther apart.

Natural Enemies.

One species of golden-eyed flies of the genus *Chrysopa** has been found in great numbers in infested fields destroying many eggs of the onion maggot.

Several species of predaceous beetles have been observed feeding upon maggots in the field, the most important being a small staphylinid beetle. Minute parasitic wasps and predatory mites have been found infesting eggs in great numbers.

None of these natural enemies, however, do enough to lessen the numbers of the pest from year to year, as they confine their operations largely to individuals, and cannot be relied upon to relieve the grower from active work against the maggot.

Control Methods.

The onion maggot has proved to be a very difficult pest to control after it has once gained a firm foothold. Therefore methods of prevention must be largely relied upon to forestall damage, and to this end the following practices are recommended.

By clean culture, prevent as many insects as possible from reaching maturity and multiplying. Clean out sheds and other outbuildings, and burn the rubbish out of doors. Remove previously infested plants carefully, and burn them, to destroy all maggots that may be feeding in the roots, this step being of great importance. All crop remnants, such as root cuttings, and all wild or volunteer plants about the place should also be burned. Having made the land as clean and free from infestation as possible, plant on ground not infested the previous season and as far as possible from any land that has been infested, as the flies are not known to migrate very far to lay their eggs. Then regulate the time of planting so that the adult, which emerges with the first warm days of spring, will have laid its eggs before the main crop of plants appear. When feasible, an earlier trap crop may be planted, which after becoming infested may be carefully

* Fitch, Rept. on Noxious Insects of New York, XI, p. 493.

removed and destroyed. Planting in hills seems to be of value, as the maggots find it difficult to work their way from one infested hill to another. Fertilize well with some quick acting mineral fertilizer, avoiding stable manure, rotted leaves, or other organic fertilizers, as they are apt to induce infestation. In addition, protect the plants and prevent the eggs from being laid about them or the maggots from getting to the roots, by applying some material or covering on the surface of the ground around the stem of the plant, for which purpose the following substances are used:

Preventives.

Sand and Kerosene. A cupful of kerosene to a bucket of sand applied to the base of the plants along the rows, to prevent the parent flies from depositing their eggs. This will also kill young maggots attempting to work through it.

Carbolized Lime. Three pints of lime slaked to a thin cream, in a gallon of water with a tablespoonful of *crude* carbolic acid, applied around the plant has proved very successful.

Glue and Bran. A mixture of 2 lbs. of glue, one gallon of water and ½ lb. of bran placed tightly around the plant prevents the young maggot from getting into the tissue beneath after it hatches.

Mineral Fertilizers. Kainit, nitrate of soda and sulphate or chloride of potash are useful as deterrents, especially when used just before or just after the ground has been wet. They may be used as a top dressing before planting, or applied afterwards as near as possible to the roots, the earth being turned away for this purpose. These fertilizers also stimulate plant growth, helping the plant to recover from maggot injury.

Other substances used frequently as repellents are powdered charcoal, powdered white hellebore, powdered tobacco, dry lime, dry unleached wood ashes, and pulverized gas lime. Salt between the rows has proven of value in some cases. Any of these preventives for best results must be applied early, and immediately after plants are set or have made their appearance above ground.

Remedies.

If the maggots succeed in getting a foothold, the infested plants should be taken up carefully, providing they are few in

number, and their maggot contents destroyed. If this fails to stop the infestation, other means may be tried.

Carbolic Acid Emulsion. Add to 1 lb. of soap boiled in 1 gallon of water, ½ gallon of *crude* carbolic acid, and dilute the whole with 50 parts of water. This is perhaps the best of the remedies for general use, as it is a strong killing agent and is also said to act as a preventive. It is used to best advantage a day or two after plants are started, and should be repeated every week or ten days until the last of May in the North.

Paraffine Oil and Sand. Spread broadcast among the onions and then water the plants. It has been found very efficient in many cases as a killing agent.

Lime and Liquid Manure. Five lbs. of fresh burned lime slaked in 100 gallons of liquid manure, stirred ten minutes and applied with a sprinkler is of value, although the use of organic manures generally is not recommended.

Carbon Disulphide. Injected around the roots this is efficient in some soils, but is not practicable on a large scale.

Hellebore Decoction. Applied as soon as eggs are noticed and continued at intervals of five or six days.

Kerosene Oil sprayed upon the soil is of some value.

Hen Manure which has been covered with soil to retain ammonia is reported to be useful.

Stress is laid upon the fact that differences in soil, condition and composition make a difference in the relative efficiency of any treatment, either remedial or preventive. It should also be borne in mind that the more maggots destroyed each year the less will remain to propagate for the coming year, so that if active measures are used for two or three years the infestation will be so reduced that keeping the pest in check becomes a comparatively easy task.

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THE PYRALID (*Omphalocera dentosa* Grote), A PEST OF BARBERRY HEDGES.*

On August 12th, 1908, Dr. F. P. Gulliver of Norwich, Conn., sent to the station some curious black and white caterpillars which were feeding upon the leaves of common barberry, *Berberis vulgaris* Linn. This plant, though introduced from Europe, has become naturalized in New England and is far more common in Connecticut than the native species *B. canadensis* Pursh. The writer was away on a vacation, and his assistant, Mr. Walden, who was in charge of the department, not recognizing the caterpillars, wrote to Dr. Gulliver asking him to send more material, which he kindly did. The writer examined the caterpillars on his return September 1st, but they were entirely unfamiliar to him. In his experience of fourteen years in the state he had not at that time ever seen the species before. A few specimens were inflated, and the others placed in the breeding cages for the purpose of rearing the adults, but none were obtained. The following season the insect was not observed by anyone connected with this office.

In 1910, however, this insect was more abundant than previously, and a number of caterpillars were found feeding not only upon the common barberry, *B. vulgaris* and its purple-leaved form, but also on the Japanese barberry, *B. Thunbergii* D. C., which is used rather extensively for hedges, though not as commonly as California privet, and on another species of barberry. Enough material was secured in 1910 to enable us to rear the adults, and both sexes were obtained. See note in last Report, page 711, 1910.

During the annual task of inspecting nurseries the work of this insect was observed in 1910, especially about New Haven, and in 1911 its work was again noticed.

* This paper was printed in the Journal of Economic Entomology, Vol. IV, page 521, December, 1911.

Habits and Injury.

The adults emerged in the insectary from April 10th to 20th, but they do not appear in the open until about the first of July. On July 3d, 1911, specimens were collected by the writer on the screen door of his house, the moths having been attracted by the light in the hall. As there is a low hedge of Japanese barberry in front of the house and only a few feet away, they were doubtless there for the purpose of ovipositing, and later a few caterpillars were found on this hedge.

The writer and his assistants hunted for the eggs, but could not find them. Presumably they are laid on the leaves of the food plant. The writer's hedge was slightly attacked in both 1910 and 1911. In one instance a tall hedge of *B. vulgaris* near the writer's home was almost entirely stripped of leaves at the top for a distance of two or three rods, leaving only the old webs containing the excrement, and rendering the hedge very unsightly. Spraying with lead arsenate would, of course, be the remedy.

The larva spins a web in which is collected the excrement, giving to the web a brown or dark grey color. This forms a case in which the larva lives and feeds. It is usually about two inches long and from three-eighths to one-half inch in thickness, though varying greatly in size and sometimes being several inches long. The case is attached to the leaves or twigs of the barberry and often includes both, as well as the fruit. As the eggs are laid about July 1st, it is usually a month later before larvæ or nests are noticed, and often two months later before they are conspicuous. After the leaves drop the old nests or webs disfigure the plants throughout the winter unless removed. The larvæ do not pupate in the nests, but go into the ground and transform in a tough cell, oval or oblong in shape and made of particles of soil held together by silk threads.

Identity and Literature.

On account of the appearance and characteristic position of this moth when at rest with wings folded, as well as the antennal tufts of the male, it was thought to be a Deltoid, and specimens were sent for identification to Professor J. B. Smith, who kindly replied as follows:

"Yours of the 5th inst. came duly to hand, and so did the box of specimens. The latter proved to be not Deltoids or Noctuids at all!—they belong to one of the Pyralid families, and the species is *Omphalocera dentosa.* I am under the impression that this species was described and figured in one of the Government publications, but have no note on the subject, and can't be sure at the present time. I know that nothing much has been written concerning the species."

In searching the more accessible works for the literature of the species, only two references could be found. One of these was the original description which is included in this article, and the other a brief note by Dr. H. G. Dyar in an article entitled, "A Review of the North American Pyralinae" (Proceedings Entomological Society of Washington, Vol. X, p. 101, 1908), giving records as follows:

"*Omphalocera dentosa* Grote.

"New Haven, Conn. (A. H. Verrill); Plummer's Island, Maryland, June 6, 1902 (H. S. Barber); Ames, Iowa, June 6, 1896 (C. P. Gillette); Black Jack Springs, Texas (Wm. Barnes); Dallas, Texas, May 31, 1896 (Dept. Agr., No. 6351), larvæ on *Berberis.* I have also a female from Durango, Colorado, that is less vinous in tone and more darkly colored, perhaps a distinct species, but with the present material I do not venture to separate it.

"Larvæ received from Mr. A. H. Verrill, which I think belong to this species, are black with many white dots, without the red lines of *cariosa.*"

Dr. H. T. Fernald has also kindly examined the card index in his office and consulted his father's catalogue, and assures me that no other references occur there.

As the literature seems to be scanty, this brief article is submitted for publication in the hope that it may be of help to other workers who may collect or observe the caterpillars on barberry.

Description.

Adult. The species was described from a female specimen by Grote, in Bull. U. S. Geological and Geographical Survey of the Territories, Vol. VI, No. 2, p. 272, as follows:

"*Omphalocera dentosa* n. s.

♀ A little larger than *cariosa,* with quite a different color, being dusty olive brown, without any reddish brown tinges. The median space is dark blackish brown. The pattern of ornamentation is the same, but the outer line is composed of well-defined and rather broad, open teeth. The line is double, filled in by a pale shade, and is brought a little nearer the margin over the median nervules than in *cariosa.* The interspaces beyond the t. p. line show dentiform shadings of the lighter and darker colors of the wing. The fringes are dark. The terminal dots do not contrast as much as in *cariosa.* The veins are darker marked. *O. dentosa* has the under surface fuscous with a common external double line near the border, which seems a little less strongly dentate than in *cariosa.* The abdomen is furnished with brown tufts on the dorsum in both forms. In place of the discal mark (?) there is a pale dot on the subcostal vein and one below it on median vein, quite distinct in *cariosa,* hardly evident in *dentosa,* which expands 40 mil."

I have not been able to find any description of the male, and take it to be undescribed, but in the specimens reared it closely resembles the female in color and markings. The median space is smaller and less well-defined, the markings are slightly less distinct, and it is smaller in size. Both sexes have the dark brown or black tufts on the dorsum of the abdomen, and the male has the brown antennal tufts and the longer anal tufts which are sexual characters.

The specimens reared are somewhat more of a reddish brown tint than one would expect from Grote's description, yet there is a distinct olive tint on the basal two-thirds of the secondaries.

Larva. Length, about one and one-half inches, thickness about three-sixteenths of an inch; somewhat flattened and thicker laterally than vertically. Ground color black dorsally, brown ventrally. Marked dorsally and laterally by small white irregular-shaped spots arranged rather irregularly as follows:—Two transverse rows on each segment as seen dorsally; three longitudinal rows as seen in lateral view, one nearly in line with the spiracles, one above and one below, these being in addition to the transverse dorsal rows of spots. Sometimes a fourth longitudinal row may be made out below the other three and at the base of the legs and pro-legs. Head dark brown or black, sculptured or pitted and shining; marked with white patches more or less irregular in shape, the arrangement not entirely symmetrical. Legs black and shining, with white patches on the first and second basal joints. Head and body sparsely covered with nearly straight light and dark hairs of medium length.

The larvæ, adults and nests are shown on Plate III. Credit is due to my assistants, Messrs. B. H. Walden and A. B. Champlain, to the former for making the photographs and to the latter for the drawing of the larva. Also to Professors J. B. Smith and H. T. Fernald for the courtesies already mentioned.

THE PERIODICAL CICADA OR SEVENTEEN-YEAR LOCUST IN CONNECTICUT IN 1911.

Brood No. II of the periodical cicada or seventeen-year locust, *Tibicen septendecim* Linn., was scheduled to appear in the central portion of Connecticut in 1911, so we were on the watch for it. The station collection contains examples of this brood collected in Branford in 1894, by Dr. W. C. Sturgis, then botanist of this station. But in 1894 no attempt was made to obtain records or to study the distribution of the insect in the state. In 1903, Brood XI was expected, and though we made many observations and inquiries, we did not obtain a single record.

Consequently, 1911 seemed to afford an excellent opportunity to collect data, and in addition to the observations made by the office force, much information was gathered from other sources. On June 1st, five hundred return postal cards were issued to fruit growers, entomologists, and others, particular care being taken to include at least two observers in every town in the state. The following request was sent out on the return postal cards:

OFFICE OF STATE ENTOMOLOGIST.
AGRICULTURAL EXPERIMENT STATION.
NEW HAVEN, CONN.

June 1, 1911.

Dear Sir:

In a few days the seventeen-year locust or periodical cicada (Brood II) is due to emerge from the ground in Connecticut, where it has appeared every seventeen years since 1724. Though not of great economic importance, on account of its peculiar life history this insect is of great interest, and this office seeks records of distribution in the state.

Will you therefore kindly fill out the attached return post card, giving any notes regarding the presence or absence of this insect in your locality this year? Please return this information on or before July 1st. Thanking you in advance, I remain,

Very truly yours,
W. E. BRITTON,
State Entomologist.

The results of the postal card canvass are as follows:

Return postal card requests issued	500
Cards returned	134
Failed to report	366
Reports of insects being present	47
Reports of insects not present	87
Number of counties infested	3
Number of towns infested	21
Number of towns not infested	58
Number of towns not reported	89

A number of additional reports were received from correspondents and acquaintances who had made observations at one or more points in the state. From all the data gathered, it is evident that Brood II of the periodical cicada appeared in 1911 in the same localities as in previous cicada years. It was present in the following counties and towns:

Hartford County: Avon, Berlin, Farmington, New Britain, Plainville, Rocky Hill, Southington, West Hartford.

New Haven County: Branford, Cheshire, East Haven, Guilford, Hamden, Meriden, New Haven, North Branford, North Haven, Wallingford.

Middlesex County: Cromwell, Durham, Killingworth, Middlefield, Middletown.

The area occupied by Brood II in Connecticut in 1911 is shown on the accompanying map, figure 2, on page 298.

ABUNDANCE IN PARTICULAR LOCALITIES.

Though the shaded portion of the map indicates the area where the adult cicadas were found, it should be understood that they by no means occupied the whole of this area. As a rule, they occupy high ground, and do not breed on the lower levels. They were especially abundant on some, though not all, of the dry wooded trap rock ridges, and here their song or rattling noise could be heard for a long distance. In some of the areas, intervening, however, the cicadas are seldom if ever seen. For instance, none were found on the station grounds and only a few were noticed on the station farm at Mount Carmel, but on the ridge west of the farm the noise at times was almost deafening. One observer described the noise as being "like a great many mowing machines going at once."

In the following localities they were particularly abundant: West Rock and the ridge toward the north; Mt. Carmel and

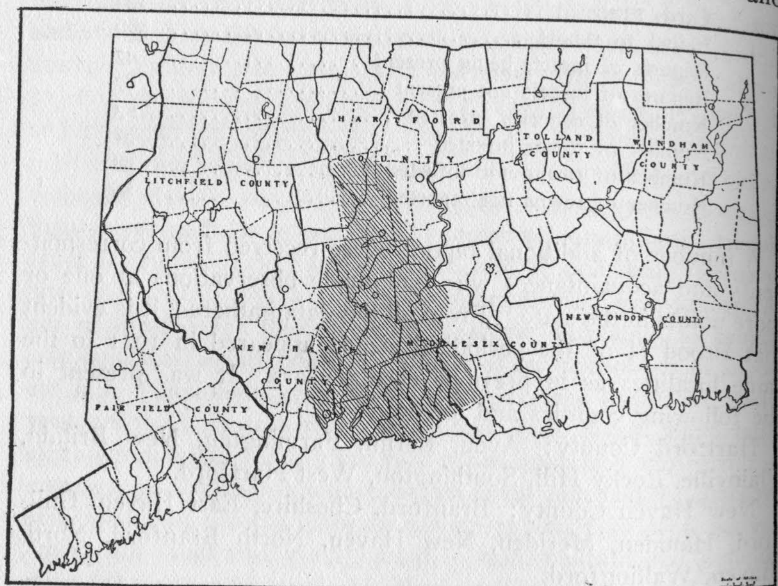

FIG. 2. Map of Connecticut showing area occupied by Brood II of the periodical cicada in 1911.

the ridge northward; Hanging Hills and vicinity, Meriden; Shuttle Meadow district, Southington; Rattlesnake Mountain, Farmington; Talcott Mountain, West Hartford; Lamentation Mountain, Rocky Hill; East Meriden; Middlefield; East Wallingford; Wallingford; North Haven; and Guilford.

Mr. E. C. Warner, who has a farm and orchards in the town of North Haven near Clintonville, reported on June 10th that the cicadas were very abundant in one of his peach orchards on the north side of a piece of woodland, and that he counted 136 pupa skins on one tree. On June 27th he reported that much

injury had been done by the ovipositing, causing the branches to break and the leaves to wither and turn brown. Similar conditions existed also in the peach orchards of F. H. Benton, Z. P. Beach, W. A. Henry & Son, and C. O. Young, Wallingford; J. T. Molumphy, Berlin; C. N. Burnham, C. E. Lyman, Middlefield; R. Wilcox & Sons, Guilford; and H. F. Baumgardt, Hamden.

Ovipositing occurred in the woodland generally, and the broken branches dried up, giving the trees a brown appearance as if scorched by fire. In some of these thickly infested areas the cicadas were much more abundant than seventeen years ago, while in other localities they were less abundant. Mr. Willis I. Savage of Berlin stated as follows: "The ground in a neighboring orchard that was uncultivated was covered with them, so that they could be picked up by the quart. They seem to be in larger numbers than seventeen years ago." Mr. E. Rogers of the Shuttle Meadow district, Southington, wrote: "There are more than there were seventeen years ago." Mr. Marcus Cooke of Wallingford says: "More are seen here than seventeen years ago." Mr. J. Norris Barnes of Yalesville wrote: "These insects are present in the woods in the locality of the old Hough and Barnes orchard site, where seventeen years ago they were very abundant." On the other hand, Mr. S. G. Cooke of Branford states: "Not as many as thirty-four years ago, when they did great damage in my apple orchard. When they appeared seventeen years ago, I gave them a good dose of Paris green mixed with ashes while they were helpless, which killed most of them. Very few there this year." A friend who observed the cicadas in 1894 told me that the trees on the east slope of Saltonstall Ridge in East Haven were brown on the northern part of the ridge, but that the limits of injury reached only about half its length, and was sharply defined, the southern half of the ridge being green. As no such appearance could be noticed in 1911, or important injury detected in the locality, it is fair to assume that the cicadas were scarce there, or at least much less abundant than seventeen years ago.

DATE OF APPEARANCE.

The first account that came to my notice regarding the presence of the cicadas was from a Southington correspondent, published in a New Haven newspaper of April 29th, 1911, stating that workmen on the farm of Benjamin Parkin plowed up countless numbers of the pupæ. The records of first emergence of the adults, so far as reported, are as follows: Farmington, May 12th, A. B. Cook; Unionville, June 4th, A. A. Moses; Avon, June 4th, J. W. Alsop; New Britain, about June 1st, D. N. Camp; Elmwood, June 3d, F. H. Stadtmueller; Berlin, May 28th, W. I. Savage; Rocky Hill, June 3d, Miss M. J. Harris; Middletown, June 2d, F. E. Boardman; Durham, May 28th, H. J. Nettleton; Killingworth, June 7th, Mrs. M. I. S. Evarts; Wallingford, about May 25th, A. T. Henry, May 31st, G. A. Hopson, June 1st, C. D. Hall, June 2d, M. A. Cooke; Branford, June 2d, S. G. Cooke. The cicadas were thickest about the middle of June, and then began to decrease in numbers, and soon after July 1st they had disappeared.

Damage to Trees.

Though the pupæ come out of the ground and crawl upon the trunks, branches and foliage of trees and shrubs, and the adults emerge, leaving the old shells hanging there, they produce no appreciable injury to the trees except the splintering of the twigs caused by the females in laying their eggs. Several correspondents wrote to this office that the cicadas were eating up their trees. But as the adults are sucking insects, they could at most only suck out a little of the sap, and could not devour any of the tissues. In laying eggs, however, by means of the sharp, tough and horny parts of the ovipositor, the female is able to puncture the hard wood and lay eggs in it. The ovipositor consists of three spear-shaped pieces or blades, the lateral ones having serrated edges for cutting. These pieces slide lengthwise upon each other, and are very effective in mutilating the twigs.

The eggs are laid in longitudinal rows of punctures along the under side of the twigs of the previous season's growth, having a diameter of between one-fourth and one-half inch. Where there are many punctures in a twig it is often so weakened that it breaks in the wind, and though sometimes falling to the ground, it usually hangs, and the leaves dry and turn brown. There is damage to the trees, no doubt, from the effects of great numbers of the larvæ sucking at the roots, but this injury is difficult to observe or estimate, and probably is usually attributed to other causes.

The greatest damage noticed by the writer was where peach trees had been used for egg-laying. The weight of the fruit caused the twigs to break and hang down, and the fruit as well as the leaves withered. In portions of the orchards mentioned nearly all the fruit was destroyed. Some twigs had five or six peaches each, and broke very readily from their own weight. Nearly all hung, however, until the wood became dry and brittle before separating entirely from the tree. In addition to the loss of the crop for the season, about a season's wood growth was destroyed, leaving little or no chance for the formation of fruit buds for the following year. On apple and other fruit trees the results were similar, though apparently much less serious than with peach trees.

On rapid growing trees the scars soon heal, but on trees making a slow growth they do not heal for several years. Ordinarily, however, there is little or no permanent injury to the tree, and soon after the insects disappear the orchardist thinks little about them. The accounts of serious injury which one reads in newspapers are generally based upon the imagination or upon other causes, and are not the verdict of men who have given careful study to the subject. The appearance of the splintered twigs is shown on Plate V, *b*.

Habits and Life History.

Some six or seven weeks after the eggs are laid in the twigs, the young cicadas hatch from them, drop to the ground, and work their way into it, going twelve or eighteen inches beneath the surface. Here they live a subterranean life for seventeen years, where it is difficult to follow their movements and development. Yet this has been done in three or four cases by the Bureau of Entomology, and it was found that the larvæ molted four times, the fourth molt usually occurring about the tenth year. They burrow chiefly with their forelegs, suck the juices from the small roots from one-eighth to three-sixteenths of an inch in diameter, and upon such food they subsist for the full period of seventeen years, when the pupæ crawl out of the ground, leaving round exit holes about three-eighths of an inch in diameter. Sometimes these holes are very close together, and in several instances came out of the middle of a private road, where the ground was very hard and solid. Earlier records of Brood II show that in some cases the pupæ make cones or huts by raising the soil up around their burrows to a height of two or three inches. None of these were observed in Connecticut in 1911.

The pupa crawls up the trunks of trees or upon the twigs or leaves, the stems of weeds, or upon buildings and fences, and soon the skin splits along its back and the adult cicada emerges, at first a greenish white, limp, soft body. It remains near, clinging to the surface with wings hanging downward, and soon hardens and assumes its normal appearance. Within a week or so after emerging from the shell the adults have mated and the female has begun to lay eggs. As all do not emerge at the same time, some adults may be found for a period of about six weeks.

The old shells remain upon the trunks and branches for a long time. I counted nearly a hundred on the trunk of one tree in Wallingford, and Mr. Warner counted 136 on one tree in North Haven.

The rattling noise is made entirely by the males, which have curious sound boxes or drums on the under side of the body just back of the legs at the base of the abdomen.

Description.

Egg. About 2 mm. long, white or pale yellow, transparent, slender, curved and pointed at both ends.

Larva. Dirty white, light brown or yellowish color. A wingless grub, with forelegs modified for burrowing, and with sucking mouth; resembling pupa. More or less hairy.

Pupa. About one inch long, nearly three-eighths inch thick, light brown or tan in color, with prominent legs, the fore pair fitted for burrowing. Head and eyes prominent, antennæ relatively small and inconspicuous. Abdomen large. Thorax and abdomen smooth and shiny. Head and legs hairy.

Adult. Wingspread of about three inches. Body from one to one and one-fourth inches long, about three-eighths of an inch thick. Wings transparent, shiny. Costa bright orange-yellow, other veins fuscous shading to orange at base of wings. Margins and marginal cells more or less fuscous-shaded, the shading and venation at base of marginal cells forming a W near the apex of each forewing. Body dark brown or black above, waxy. Ventral surface of body and legs brown shading to orange. Eyes bright coral red in life, color mostly disappearing in death.

Antennæ filamentous, inconspicuous, tapering, 6-jointed, black. The female has a sharp-pointed abdomen with a horny ovipositor folded up on the ventral surface near the tip. The male has a larger and more blunt abdomen, with a pair of sound boxes or drums on the under side at the base, just back of the rear legs.

The appearance of the adults and pupal shells may be seen on Plates IV and V, and in figure 3.

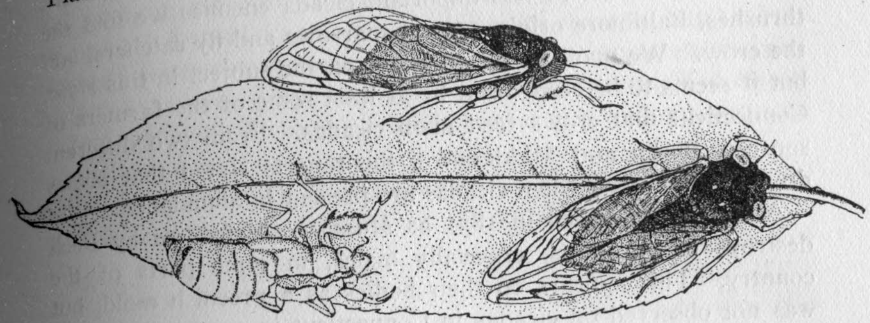

Fig. 3. Periodical cicada, adults and pupa shell on leaf. Natural size.

Natural Enemies.

No parasites were reared from cicada eggs in Connecticut in 1911, though four species of dipterous (two-winged flies) larvæ are known to feed upon them in the United States. Four species of hymenopterous (four-winged flies) insects are known to parasitize the eggs, though only one of these, *Lathromeris cicadæ* How., is at all abundant. This has been found sufficiently abundant in some parts of the country to considerably check the periodical cicada. Several species of mites are also known to feed upon cicada eggs.

This insect has predaceous enemies, one of the most important of which is the large digger wasp or cicada killer, *Sphecius speciosus* Dru., which stings the adult cicada and carries it away to its underground nest to serve as food for the young wasps. The sting paralyzes but does not kill the cicada, and the wasp lays an egg on the body of the cicada, upon which the young wasp larva feeds. No doubt predaceous ground beetles devour some of the newly hatched young, as well as the emerging pupæ.

It is probably true that birds devour large numbers of cicadas. Hundreds of cicada wings were seen on the ground in many places in Wallingford, Guilford and other towns, and Mr. Orrin Gilbert observed similar conditions at Middletown. Marlatt mentions* the investigations of Mr. A. W. Butler, who found thirty-one species of birds that fed upon the periodical cicada in Southeastern Indiana in 1885. The most important of these were the English sparrow, and among native birds, the robin, blackbird, catbird, red-headed woodpecker, flicker, towhee, and orchard oriole. In the list of less important cicada enemies we find the thrushes, Baltimore oriole, several sparrows and fly catchers, and the crow. We made no observations on the subject in this state, but it seems to be recognized by at least some of the farmers of Connecticut that crows feed upon cicadas. From two different sources, Berlin and Middletown, the reports stated that crows do not bother corn when cicadas are present in abundance.

A fungus described in 1851 as *Massospora cicadina* by Peck destroys many adults, especially males, in some parts of the country. This appears on their bodies as a greenish mold, but was not observed on cicadas in Connecticut in 1911.

Preventive Measures.

It is hardly practicable to enforce any measures for the destruction of the larvæ or pupæ in their subterranean chambers, except in a restricted way on private grounds and over small areas. Carbon disulphide injected into holes twelve inches deep, one for each square yard, the holes closed, will undoubtedly prove fatal to the larvæ.

The pupæ and adults may be gathered by hand and destroyed for the protection of choice trees or shrubs on private grounds. Mr. Abner Hoopes of West Chester, Pa.,† had a field of nursery stock containing some 240,000 peach trees near the edge of woodland infested by Brood X in 1902. Seven men were employed for over two weeks, and by actual count these men each destroyed more than 1,000 cicadas every day, or a total of about 100,000 altogether. Nevertheless, in spite of this work, Mr. Hoopes lost 12,000 out of the 240,000 trees from the attacks of the cicadas.

Small and choice specimen trees may be saved from injury by covering them with mosquito netting.

* Bureau of Entomology, Bull. 71, p. 138. 1907.
† Entomological News, Vol. XVIII, p. 108. 1907.

The newly emerged adults may be easily destroyed by dusting with fresh insect powder or pyrethrum in the early morning, while the dew is on them. Spraying with kerosene emulsion seems to be fairly satisfactory in destroying the adults, especially if diluted not more than five or six times.

Various repellent substances have been tried from time to time, and Slingerland* found some evidence that ordinary whitewash will partially prevent them from ovipositing, especially if there are untreated trees near at hand. Alwood† observed that where orchard trees were sprayed with Bordeaux mixture they were injured considerably less than those untreated. Though we have no real evidence, it seems probable that a spray of dilute lime-sulphur, such as is now used on the foliage for summer spraying, might be even more effective as a repellent than Bordeaux mixture.

For a more detailed account of the periodical cicada or seventeen-year locust the reader should consult Bulletin No. 71, Bureau of Entomology, U. S. Department of Agriculture, by Dr. C. L. Marlatt, a publication from which the writer has drawn freely in preparing this paper. It contains a series of maps showing the distribution of each brood, and also gives a complete bibliography regarding this insect, up to the time of its publication in 1907.

Descriptions of other kinds of cicadas occurring in Connecticut may be found in Entomological News, Vol. XVIII, p. 16, 1907.

THE MAPLE LEAF-STEM BORER.

Priophorus acericaulis MacG.

The life history of this insect was first discovered in 1906, and published in Entomological News, Vol. XVII, page 313, and mentioned in the report of this station for that year, page 295, and it was again rather common in 1911. Specimens of its work were received on May 25th from Brookfield Center and from Glastonbury, on May 31st from Meriden, and on June 1st from Derby. It was also noticed in New Haven, Wallingford, and several other towns by entomologists from this office. Apparently it was more

* Bureau of Entomology, Bull. 71, p. 143. 1907.
† Bureau of Entomology, Bull. 40, p. 75. 1903.

abundant in 1911 than it has been since 1906. The insect is one of the sawflies, and was first described by Dr. A. D. MacGillivray from material sent him from this office, in Canadian Entomologist, Vol. XXXVIII, page 306, September, 1906. As no adequate account of the species or illustrations of its work have ever appeared in the station publications, this brief article is included here in hope that the illustrations on Plate VI may enable someone to recognize the trouble.

Characteristic Injury.

The petioles or stems of the leaves are tunneled by the larvæ, and break off at a point half to quarter of an inch from the blades. The blades fall late in May and early in June, often covering the ground, while the stems or petioles remain upon the tree until ten days or two weeks later, when they are shed and drop to the ground. Property owners not understanding the trouble are greatly alarmed, and fear that the tree will lose all of its leaves. In the very worst cases that have come to my notice, however, not more than one-third of the leaves dropped. If there is a storm about June 1st, often a large number of leaves are taken off in one or two days.

Life History and Habits.

The egg is laid on the stem at the base of the leaf-blade about the first week in May, though probably oviposition extends over two or three weeks. There is no record regarding the time necessary for the eggs to hatch. The larvæ tunnel in the stems for about a month, often eating out the inside completely, and leaving only a cylinder of epidermis closely packed with castings. The stem thus keeps its shape, or perhaps is somewhat swollen, but it has no strength. The epidermal tissue is usually eaten nearly through when the larva approaches maturity, about three weeks after hatching, and the stem breaks off at this point. The greater portion of the stem hangs upon the tree for a week or ten days, ripens at the base as it would in autumn, and drops to the ground. The larva emerges from the stem through a hole in the side and goes into the ground three or more inches, and pupates in an earthen cell resembling the cell of the common currant worm, a closely allied species. The adult emerges the following May, and is a small four-winged fly with transparent

wings, black antennæ, head and thorax, and with honey-yellow abdomen and legs.

The egg is colorless, about 1 mm. long and five times as long as thick, falcate or curved, with ends blunt and rounded. The full-grown larva is about one-third of an inch long and one-sixteenth of an inch in thickness, light yellow, with dark yellow or light brown head. Egg and larva are shown in figure 4.

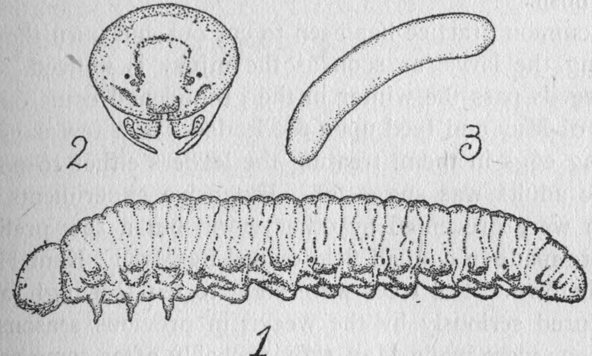

FIGURE 4. Maple leaf-stem borer. 1, full-grown larva; 2, head of same; 3, egg. All greatly enlarged.

Natural Checks and Remedies.

A single example of a chalcidid parasite, still undetermined, but resembling *Pteromalus,* was reared from the material in the breeding cages.

No experiments have been made with remedies, but as it took seven years to finally obtain the adults of this species, it is evidently not hard to destroy. The knowledge of its life history indicates that if the ground under the infested trees be cultivated, or sprayed with kerosene emulsion about June 15th, when the larvæ are going into the ground, a large proportion of them will be destroyed.

RECORD OF PRELIMINARY TESTS TO PREVENT DAMAGE BY THE WHITE PINE WEEVIL.

By W. E. Britton and B. H. Walden.

The white pine weevil, *Pissodes strobi* Peck, is the most serious insect pest of young white pines in Connecticut. This insect has been present in the state for many years, but its injury has greatly increased during the past few seasons, owing to the fact that the white pine is being extensively planted as a forest tree. The larva of the weevil bores in the terminal shoot or leader of the past season's growth, usually killing it in one season, thus checking the tree for one year. If this was the extent of the injury, one of the lateral branches would gradually assume an upright position, taking the place of the leader, but this in turn is often killed by the weevil, so that in a few seasons the tree is but a stunted bush.

The common practice has been to cut out and burn the leaders containing the larvæ as soon as the injury is noticed. As the adult weevils pass the winter in the ground and come out about the first of May and feed upon the leaders for a few days before depositing eggs in them, treating the leaders either to poison or repel the adults was suggested. Extensive experiments in this direction were prevented by other work, but a few preliminary tests were made in a small field owned by Mr. E. Kent Hubbard of Middletown. The trees were eight to ten feet high, and had been injured seriously by the weevil in previous seasons. The applications were made May 17th, probably after some eggs had been laid as a number of adults were present at this time. Mr. Wickson, the superintendent, observed a pair of adults on May 13th, and treated a number of trees on that date. The materials used and the results are given in the following table:

Materials used.	No. trees treated.	No. trees losing leaders.	Remarks.
Paste lead arsenate,* 4 lbs. in 50 gallons water, 1¼ oz. per gal.	9	1	No injury from treatment.
Paste lead arsenate, 4 ozs. in 1 gallon water..............	11	3	No injury from treatment.
Commercial lime and sulphur, 1 pint in 1 gallon water........	3	0	No injury from treatment.
"One for All," 8 ozs. in 1 gallon water..................	8	0	Nearly all leaders treated showed injury.
Whale-oil Soap, 8 ozs. in 1 gallon water..................	8	1	No injury from treatment.
Tree Tanglefoot..............	3	1	No injury from treatment.
Checks......................	10	6	

* This treatment made by Mr. Wickson May 13th. All other treatments made May 17th.

The applications should have been made about May 1st, or perhaps earlier in certain seasons. The lead arsenate applied May 13th appeared to give better results than the stronger mixture (at the rate of 12 lbs. in 50 gallons) applied five days later. Though these experiments are not extensive enough to form any definite conclusions, they indicate that considerable injury from the weevil can be prevented by spraying the leaders with lead arsenate at the proper time. Trees up to four or five feet high could be sprayed with a good knapsack pump at a small cost.

There were not enough trees sprayed with lime and sulphur to form any conclusions. It would simply act as a repellent, and must be tested further to note its value, also to watch the effect on the trees; yet in this case not even the pine leaves were injured by the mixture, which was of the same strength as is commonly used on dormant fruit trees to kill San José scale. Whale-oil soap is more expensive to use than the materials above mentioned. Tree Tanglefoot is impracticable on account of the difficulty in applying it, and on account of injury "One for All" of the composition and proportions used must be abandoned, though the manufacturer claims that its composition has been changed so that no injury now follows its use.

THE CHERRY TENT-MAKER OR CHERRY TORTRIX.

Archips cerasivorana Fitch.

This insect was first described by Fitch in his third report on the noxious insects of New York, page 382, but seems to have been seldom mentioned in literature. As it attacks chiefly the choke cherry, it can scarcely be considered as an injurious insect, and this may explain the small number of references. Nevertheless, the nests are very conspicuous, and may be seen by any observer. For this reason a note regarding it is included here.

According to Weed,* the eggs are laid in summer in flattened masses on the bark of choke cherry bushes near the ground. Though at first yellow, the egg-cluster soon turns dark brown, and is almost indistinguishable from the bark except on close inspection. These eggs do not hatch until the following spring, when the larvæ crawl to the top of the bush and there construct their nest or tent, which is generally cone-shaped, being largest

* Bureau of Entomology, Bull. 26, n. s., p. 33. 1900.

at the base near the ground, and tapering upwards until it reaches a sharp point at the top. The entire bush is enveloped and the branches drawn together and fastened by the web, inside of which the caterpillars feed. An illustration from the U. S. Department of Agriculture, used in Smith's Economic Entomology, figure 371, shows between fifteen and twenty of these tents close together, and some of them apparently as high as a man's head. Usually they are less abundant, but may be seen singly or in clusters of a few nests each in clumps of choke cherry bushes along the roadsides or hedgerows. Specimens were received in 1911 from Roxbury and Milford. There is but one brood each year.

Though the choke cherry is the principal food plant, it also feeds upon the garden cherry and upon birch, especially *Betula populifolia*. Kellicott* stated that in 1882 this insect was "too abundant in certain ornamental birches in Buffalo." Spraying with lead arsenate would, of course, prevent damage.

The caterpillar is reddish brown in color, about one and one-fourth inches in length, and with a dark brown shiny head.

The adult moth has a wingspread of about an inch. Fore-wings reddish brown, with darker brown patches. Secondary wings and under surface lighter reddish brown. Adult, larva, pupa and nest are shown on Plate VII.

THE POPLAR MOCHA-STONE MOTH OR TENT-MAKER.

Melalopha (Ichthyura) inclusa Hubn.

A note in last year's report, page 710, mentions the prevalence of this insect, which also continued to be abundant in 1911. The caterpillars feed gregariously upon the different kinds of poplars and willows, and make small webs which remain on the twigs and resemble the winter nests of the brown-tail moth. The caterpillars do not remain in the nests, however, through the winter, like the brown-tail caterpillars. They rest in them while feeding, but pupate in September or early October. The empty webs hang to the twigs after the leaves fall, and are frequently mistaken for brown-tail nests.

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* Fifth Report U. S. Ent. Commission, p. 505. 1890.

Evidently there are two generations annually, as the larvæ are found during May and June and during August and September, and the adults appear in March and may be taken during April and May, and again in July and August. The loosely spun cocoons may be found between partially folded leaves on the ground. Ordinarily this insect is not sufficiently abundant to cause much damage, and when it does appear in numbers, spraying the trees with lead arsenate is a satisfactory remedy.

The fully matured caterpillar is about one and one-half inches long and between three-sixteenths and one-fourth inch in thickness, body nearly cylindrical, with first and second and eleventh and twelfth segments tapering. Color dark brown or black. with four narrow dorsal lines honey-yellow in color; three similar lines show laterally above the spiracles, and below them the entire body color, including prolegs, is honey-yellow, excepting the true legs, which are black. Head black, somewhat shining, covered with soft hairs. On each of the fourth and eleventh segments there is a closely set pair of high, pointed tubercles, dark brown in color, bearing hairs. Body more or less thickly covered with soft curved hairs, white and light brown in color.

The adult moth has a wingspread of about one and one-fourth inches, color light brownish gray, with apical third of wings darkened with reddish brown or fawn and marked with fine white lines. Head dark brown, and a patch of the same color upon the thorax has margins extending in convergent lines to a point at the base of the secondaries.

Both larva and adult moth are shown on Plate VII, *a*. This insect is also called the poplar defoliator and the poplar prominent.

THE COLORADO POTATO BEETLE.

Leptinotarsa decemlineata Say.

By B. H. Walden.

The Colorado potato beetle or "potato bug," as it is often wrongly called, is probably one of the best known insects in the state, but as many inquiries are being received about it as well as for literature regarding it, the following account is given.

The Colorado potato beetle, as the name suggests, is supposed to be a native of Colorado, where it was first observed feeding upon one of the nightshades common in that region. Through the introduction of the potato by the western settlers, the beetle found a food plant preferable to the native nightshade, and began to spread eastward over the sections in which potatoes were then grown. The insect was described in 1824 by Thomas Say, but did not begin to attract attention as a pest of potatoes until about 1865, when the insect had crossed the Mississippi river in its eastward journey. The potato beetle reached the Atlantic coast about 1872-73. The spread of the insect had been so rapid that in 1876 it covered about one-third of the United States, and methods of treatment were discussed at a meeting of the Connecticut Board of Agriculture held during that year.*

The insect is too well known to need detailed description. The adults, which are of a yellowish color with ten longitudinal black stripes on the wing covers, pass the winter in the ground and emerge early in the spring, often before the potato plants appear above ground. The beetle feeds for a few days, when the female lays a number of masses of orange-colored eggs, usually on the underside of the leaves. The eggs hatch, depending upon the temperature, in 4-10 days. The larvæ or "slugs" become full-grown in about 16 days to 3 weeks and then go into the ground to pupate. The adults of the second brood begin to appear in about two weeks. There are two broods each season. The egg-laying period may extend considerably over a month, so that the insect is found in all stages nearly all summer, and the adult beetles often cause as much injury as the larvæ.

Other cultivated plants often seriously injured by the Colorado potato beetle are egg plants, tomatoes, tobacco and occasionally peppers. It feeds readily on any of the wild solanaceous plants, and in the absence of these has been known to attack cabbage, thistle and mullen.

Remedies. It is interesting to note that the Colorado potato beetle was the first insect against which an arsenical poison was used. In small fields the beetle can be kept in check by jarring the adults into a pan of kerosene, and picking off any egg-masses at the same time. Large fields are treated with arsenical poisons. Paris green was one of the first poisons employed for this purpose, and is extensively used at the present time. It can be

* Conn. State Board Agriculture Report for 1876, pp. 263-268.

applied dry while the dew is on the plants by means of a powder gun at the rate of about one pound to the acre. The objection to this method is that many of the powder guns cannot be accurately adjusted to evenly distribute so small a quantity of material, and many of the plants will be burned by an excess of Paris green, while others will not receive sufficient poison to be effectual. A better method is to mix the Paris green with 10-20 parts of cheap flour, sifted land plaster or air-slaked lime before applying It is always advisable to add lime (air-slaked) to neutralize the soluble acid usually contained in Paris green, and if this is done no injury will result. Large plants can be much more thoroughly treated by spraying. The Paris green should be used at the rate of one pound in 100 gallons of water to which two pounds of fresh slaked lime has been added. It can be combined with Bordeaux mixture, which is used to control blight, without the addition of the extra lime.

Lead arsenate is replacing Paris green in spraying potatoes as in all other spraying with arsenicals. The paste lead arsenate should be used at the rate of three pounds in 50 gallons of water, or the dry lead arsenate at the rate of 1½ pounds in 50 gallons of water. The lead arsenate is less liable to injure foliage, sticks to the leaves much better than Paris green, and one application is often as effectual as two or more of the latter.

Poison should be applied as soon as the young larvæ begin to hatch, and the number of applications to be given will depend upon the abundance of the pest as the season advances.

Often only an occasional plant will be infested at first and with a small amount of poison in a compressed air knapsack sprayer one can treat these in a short time. Frequently this will reduce the numbers so that no further treatment will be necessary.

Dr. J. B. Smith of New Jersey recommends spraying potatoes as soon as the beetles begin to feed in order to kill these before the eggs are laid.

Attention is called to the following articles for a more complete account of the Colorado potato beetle:

The Colorado Potato Beetle. Report of New Jersey Agr. Expt. Station, pp. 452-458. 1895.

The Colorado Potato Beetle. Circular No. 87, Bureau of Entomology, U. S. Dept. Agr. 1907.

THE PEACH SAWFLY IN CONNECTICUT IN 1911.

By B. H. Walden.

The peach sawfly, *Pamphilius persicum* MacG., which was discovered in the state in 1906 and found to be not only a new enemy of the peach but an undescribed species, was discussed in the Seventh Report of the State Entomologist.*

In the orchard of Barnes Brothers at Yalesville, which was sprayed in 1907, the treatment was so successful that the insect has not again appeared in sufficient numbers to require further treatment, but it has spread gradually to other orchards, and is now well distributed throughout the central and eastern part of New Haven county, is present in the western portion of Middlesex county, and probably extends into the southern part of Hartford county. In 1910 considerable injury was reported in the orchards of Barnes Brothers at Durham and in the orchards of Charles E. Lyman at Middlefield, although as far as we learned no peach trees were sprayed during that season to control this insect. The peach sawfly also stripped many small trees in the orchard of J. A. Martin, Wallingford, in 1910, and on June 9th, 1911, the writer visited this orchard by request to learn if the insects were abundant enough to cause serious injury later. The owner stated that the adult flies were very abundant during the previous week. At the date of the visit there were very few adults present. There were, however, many hymenopterous insects (unidentified) flying about the trees which might be mistaken for the sawflies. These may have been parasites of the above pest. Eggs of the sawfly were present in a large section of the bearing orchard, and were more numerous, four to five on a leaf, in the two-year trees that were defoliated the previous season. The owner was advised to spray the young trees the following week with lead arsenate and also that part of the bearing orchard where the eggs were the most numerous, and to watch the remainder of the orchard and to spray if there was any indication of the trees being defoliated. The owner sprayed the trees as advised, including many more of the bearing trees. In all between eight thousand and ten thousand trees were sprayed

* Report Conn. Agr. Expt. Station, pp. 285-300, Pl. I–VI. 1907-08.

with lead arsenate, two lbs. to 50 gallons of water, to which was added 1½ quarts commercial lime-sulphur. No injury was reported to the foliage and the sawfly was held in check. Several isolated trees not sprayed were badly eaten.

In the Durham orchards of Barnes Brothers about 20,000 peach trees were sprayed with lead arsenate, using three lbs. in 50 gallons of water. Many of the trees were badly injured by the spray, and some trees that were given, as considered by the men, "an extra good treatment," dropped nearly all their leaves. The lead arsenate was a standard brand guaranteed to contain 15 per cent. arsenic oxide. One and one-half pounds of the lead arsenate would probably have been sufficient to kill the sawfly larvæ, as insects of this class are very readily killed. The lead arsenate used in spraying 6,000 peach trees without injury in 1907 contained less than 12 per cent. of arsenic oxide. Whether the higher percentage of arsenic oxide in the lead arsenate used in 1911 was responsible for the injury or whether the injury was due to soluble arsenic or to weather conditions, we are unable to state. The indications are that this brand of lead arsenate contained an excess of soluble arsenic, as one orchardist severely injured the foliage of apple trees from an application of it. In the station experiments the past season, peach trees were sprayed with lead arsenate combined with lime-sulphur preparations with little or no injury, as follows:

(*One orchard.*)

The first and second sprayings with dry lead arsenate, 2–50, with commercial lime-sulphur at the rate of 1–150.

Two lbs. dry lead arsenate with self-boiled lime-sulphur 8–8–50.

No injury to foliage observed.

(*Two orchards.*)

First spraying with paste lead arsenate, 3 lbs., with self-boiled lime-sulphur 8–8–50.

A very slight injury to the foliage.

A different brand of paste lead used in each orchard.

In the self-boiled lime and sulphur preparations the lime may tend to neutralize any soluble arsenic that may be present in the lead arsenate. In spraying for the peach sawfly we would advise using only 1½ lbs. of paste lead arsenate in 50 gallons of water.

HOW TO GET RID OF ANTS.

In Lawn or Garden. With a crowbar make holes eighteen inches deep in the nests. If a section of the lawn is infested, holes should be made about two feet apart over the area. In each hole pour about two fluid ounces of carbon disulphide and stop up the opening. The fumes will penetrate the tunnels and kill the ants. Fire should not be used near this liquid, which is inflammable.

In Cellar, Kitchen or Pantry. Place naphthalene flakes in the runways or around the edges of shelves and corners of rooms where the ants usually enter and travel. They are soon driven away.

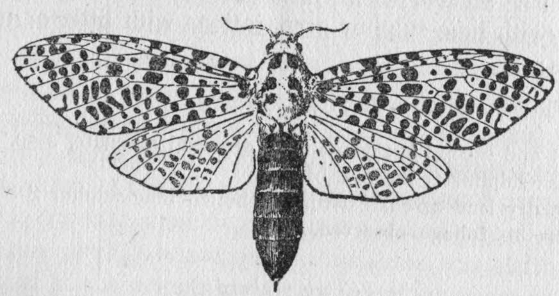

FIGURE 5. Female Leopard Moth. Natural size.

THE LEOPARD MOTH.*

Zeuzera pyrina Linn. (= *æsculi* Linn.)

By W. E. BRITTON, *State Entomologist, and*

G. A. CROMIE, *Superintendent of Trees in the City of New Haven.*

APPEARANCE OF INFESTED TREES.

Many of the magnificent elms that have stood as landmarks on the streets and in the central parks of New Haven and other coastwise cities of Connecticut for over a century are dying with little outward apparent cause. And not only are the veterans being destroyed, but trees of all ages suffer where apparently receiving sufficient food and moisture. Dead branches may be seen in numbers, standing above the leafy masses in the tree-tops. Each storm brings down numbers of branches, many of them in full leaf, and if the broken ends are examined, one will notice that just underneath the bark the branch has been girdled. This is the work of an insect that has only within the last few years reached Connecticut, but which has already proved itself our most serious insect enemy of shade trees,—the leopard moth.

Trees recently infested show small twigs broken over and wilted, the leaves on the ends of occasional branches turn yellow and in a few weeks drop. Trees in a later stage show a mass of dead upper branches, as shown on Plate IX, while from the trunk and larger limbs sprouts or suckers appear. Here and there branches are seen with comparatively few, small, sickly leaves. Yet when the tree is cut down the trunk and larger limbs have the appearance of perfect health.

Since the larva bores largely in the sapwood and cambium, the damage done by it is unusually severe, the work of one insect often being sufficient to kill a small tree. Remaining in the wood during the greater part of its life, it is rarely seen by the casual observer, and for the same reason no general and convenient

*This paper was published as Bulletin 169, November, 1911, in an edition of only 3,000 copies, and distributed to entomologists and others known to be interested. It is here reproduced with slight emendations.

methods of controlling it are available, as in the case of insects which eat the foliage. It does not confine its attacks to elms, but is a very general feeder, being found to some extent on nearly all our deciduous trees and larger shrubs. Like many other insect pests that have at various times become unusually destructive, this leopard moth is not a native of this country, but was introduced here probably from Europe. The number of dead branches caused by it not only threatens the life of the tree, but falling from the height to which some of our large trees have grown, are a source of great danger to property and to persons passing beneath them. In Newark, N. J., scarcely a large tree of species susceptible to attack stands to-day, uninjured by this pest, while numbers of young elms recently planted are being deformed.

In Central Park, New York City, Dr. Southwick "has removed hundreds of loads of branches killed by this insect," while in Cambridge, Mass., numbers of old elms have already been removed from this cause.

In New Haven the damage is especially severe in the older sections of the city, within a radius of one mile from the City Hall. On Central, Wooster and Broadway Greens most of the older trees have either been removed or are badly mutilated by the removal of the dead wood. In other parts of the city the insect is present, but severe damage can be found only in occasional groups of trees. Because the female moth is a poor flyer, a tree (or a group of trees) is liable to be the home of succeeding generations as long as portions of it remain alive, while trees only a short distance away are often free from the pest. The trees of New Haven are at present especially liable to injury because they are large and in long, close rows, with interlacing branches, and of species readily attacked.

This Insect a Pest in Europe.

Though apparently the leopard moth is less serious as a pest of shade trees in Europe than in this country, it nevertheless does considerable damage. Theobald[80] states that it attacks chiefly the cherry, apple, pear and plum in England, but that he has also seen young walnut trees killed by it, and furthermore that "it has been decidedly on the increase in apple trees during the last few years." He also remarks that the leopard moth has

long been known as a borer into the trunks of various trees in England and all over Europe. In addition to the trees just named, Miss Ormerod[73] mentions ash, beech, birch, elm, holly, lime, oak and horse chestnut. Gillanders[78] includes the hawthorn and sycamore among the trees attacked and injured in England. Rev. J. G. Wood[66] many years ago wrote that though the leopard moth infested fruit trees in England, it seemed to do little if any harm to them. Eckstein[72] writes of the leopard moth as also attacking syringa, willow, maple, mountain ash and mistletoe in Germany, in addition to the food plants already mentioned here. Kollar[64] states that in the neighborhood of Vienna the leopard moth injures the trunks of elm, walnut, pear and apple trees. To this list, according to Judeich-Nitsche[70], may be added linden, poplar, cytisus, alder, pomegranate tree, spindle tree (*Euonymus*) and pine.

The leopard moth is figured in Atlas d'Entomologie[75] Forestiere, plate 29, by E. Henry.

The foregoing references have been cited here to show that the insect is a recognized pest of trees in Europe, although Dr. L. O. Howard, who has made several trips through Europe, states in a letter that the insect does not seem to be especially destructive in any part of Europe which he has visited.

Occurrence in Other Countries.

Though the leopard moth is found throughout Central and Southern Europe, according to the Bureau of Entomology[56] it also occurs in Asia Minor, Northern Morocco, Algeria and Southwestern Africa. Mr. South[81] states that it is also present in Corea and Japan.

According to P. Lesne,[79] this insect is the worst pest of the cork oak in Algeria, though after three years work he claims[84] to have brought it under control by the use of carbon disulphide squirted into the galleries, or better yet, placed in gelatine capsules small enough to be inserted in the burrows. The moisture in the wood dissolves the gelatine in twenty-four hours, and the fumes then kill the borers.

History of its Spread in America.

The leopard moth occurs in Europe, and is believed to have been introduced from there into the United States, though the date of its introduction is uncertain. The species is included by Walker in his list of Lepidoptera in the British Museum,[65] as occurring in North America, and by John G. Morris in his Synopsis of the Described Lepidotera of North America,[1] with a brief description, and the locality given as "North America." Two years later (1864) the late Professor A. S. Packard, in his Synopsis of the Bombycidae of the United States[2] also includes *Zeuzera pyrina* with the same statement as occurs in the Morris catalogue, from which it may have been copied. *Zeuzera pyrina* may also be found in the list (page 10) of North American Lepidoptera, published by the Brooklyn Entomological Society in 1881.

Professor John B. Smith,[14] however, doubts the identity of the species listed as *Z. pyrina* in Walker's catalogue, which Morris, and probably Packard, had followed. Smith visited the British Museum and was unable to find any specimens or records[18] there to warrant Walker's citation that *Z. pyrina* occurred in North America at the time his catalogue was issued.

The first definite record of the occurrence of the leopard moth in America is a short note by Mr. Jacob Doll in Papilio,[3] which states: "A fine example of this well-known European species was taken in a spider's web in Hoboken, N. J., in June, last, by Mr. Schmitz. It was alive and was endeavoring to escape from the web. The specimen is now in the collection of Mr. B. Neumoegen." This was written in 1882, and the moth taken in 1881.

Entomological News for March, 1904,[46] states that this specimen was a female, and was captured in 1879 instead of 1881. Be that as it may, the destructive work of the moth was observed in Central Park, New York City, in 1884, by Dr. E. B. Southwick, and in 1887 at Newark and in 1889 at Arlington and Orange, New Jersey. In 1894, Dr. Southwick pronounced it one of the worst insect pests attacking shade trees.[27]

In 1894, Smith stated[28] that Col. Nicholas Pike reported that the leopard moth occurred in Connecticut. It was soon noticed in cities near New York, though spreading much faster toward the northeast along the coast than in any other direction. In 1905, Dr. Felt[47] reported the pest at Kensico, N. Y., a point twenty-five miles north of New York City. The earliest Massachusetts record that we can find is that of a male taken by Mr. C. A. Frost[50] at Medford, July 1st, 1903. In 1907, Professors

C. H. and H. T. Fernald[49] called attention to the presence of the insect in the vicinity of Boston. In 1909 the senior author learned of its great destructiveness to the trees of Cambridge. Mr. E. H. Armstrong has observed its work at Taunton, Fall River and New Bedford, and Chapman[63] reports its presence at Concord, Lowell and Lawrence, as well as at many other places

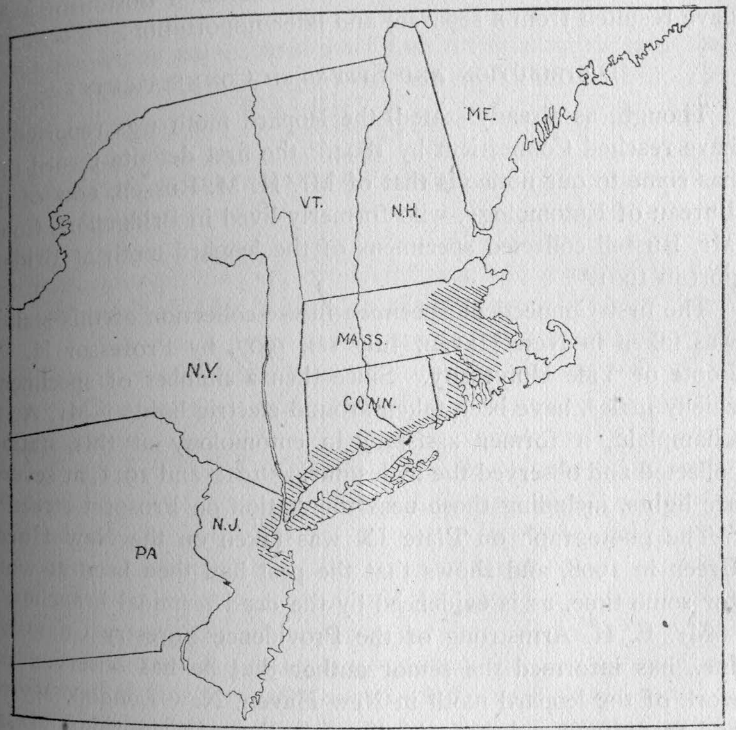

FIGURE 6. Shaded area shows present distribution of the leopard moth in the northeastern states. Cape Cod may also be infested but we have no records to show it.

nearer Boston. Mr. Armstrong is authority for the report that the insect occurs at Providence, Newport, Westerly and East Greenwich, in Rhode Island.

The leopard moth is reported by Professor Smith[53] as occurring as far south as Long Branch, N. J., and Mr. Bartlett has seen it at Asbury. At the present time, as is shown by the map, Fig. 6, the insect occurs from Asbury, N. J., at least to the vicinity of Lawrence, Mass., and in nearly every city along the coast, between these points, much damage has been done by it to shade trees. We have no records of the occurrence of the insect at points more than twenty-five miles inland. It is difficult to explain why it should spread so much more rapidly toward the northwest, along the coast, than in any other direction. Chapman questions[63] whether the infestation around Boston may not have resulted from a separate and later importation.

Distribution and Spread in Connecticut.

Though, as already stated, the leopard moth was reported to have reached Connecticut by 1894,[28] the first definite record that has come to our notice is that of Mr. H. M. Russell, now of the Bureau of Entomology, who formerly lived in Bridgeport, Conn. Mr. Russell collected specimens of the leopard moth at Bridgeport in 1901.[56]

The first Connecticut specimen in the collection of this station was taken in New Haven, July 1st, 1907, by Professor H. W. Foote of Yale University. Since then a number of specimens, chiefly males, have been taken around electric lights. Mr. A. B. Champlain, a former assistant in entomology at this station, collected and observed the males during 1910 and 1911, at several arc lights, including those near the station on Prospect street.

The photograph on Plate IX was taken on the New Haven Green in 1908, and shows that the pest had then been at work for some time, as is evidenced by the dead terminal branches.

Mr. E. H. Armstrong of the Providence Forestry Company, Inc., has informed the senior author that he has observed the work of the leopard moth in New Haven, New London, Mystic and Stonington and that with the exception of Cambridge, Mass., he considers New Haven the worst infested spot that has come under his notice.

Mr. F. A. Bartlett of the H. L. Frost & Bartlett Company states in a letter that he has observed the work of the insect in practically every town and city along the Connecticut coast this year, and that it has been especially serious at Bridgeport and less so at Stamford and South Norwalk. He also saw a little of its work at Danbury, which is about twenty-five miles inland.

Mr. D. J. Caffrey, assistant in charge of the gypsy moth work, observed, in 1911, many trees showing the characteristic leopard moth injury at Wallingford, about twelve miles from the coast.

In September, 1910, the leopard moth was found infesting young apple trees in a nursery at New Canaan, Conn., the adult insect was reared from the larva, and a short account was published in the Journal of Economic Entomology[61] for June, 1911. This locality was less than ten miles from the coast. The insect was found again in the same field in September, 1911.

Description.

Adults.—Wing expanse from two and one-half to three inches in the female and about one and three-fourths inches in the male. Wings dirty white and semitransparent, with a yellow or brownish front margin to the fore wings and the same color extending along the principal veins. The wings are marked with metallic blue dots, as shown in the accompanying illustrations, Figure 1, and Plate XVI, *a*. The markings are much more pronounced in the female than in the male, which sometimes has very faint dots. Color much brighter in the female. Thorax white or yellow dorsally, with six blue-black spots, three in a row on each side. Ventral side, black; abdomen, black, with more or less whitish pubescence, and the female has an extensile three-jointed ovipositor, by means of which eggs are laid under the edges of bark; legs, black; the second and third pairs of femora bearing whitish woolly hairs. The female has thread-like and the male feathery antennæ. The female is shown in Figure 1, and both sexes on Plate XVI, *a*.

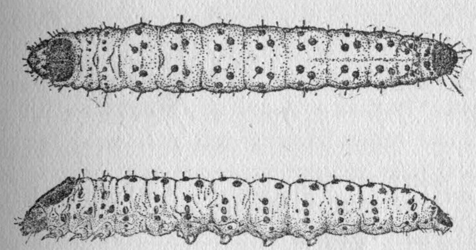

Figure 7. Leopard moth caterpillar. Dorsal and lateral views, natural size.

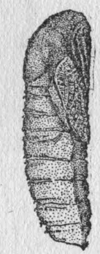

Figure 8. Pupa, natural size.

Egg.—The eggs are about the size of a pinhead, or one-sixteenth of an inch long, oval, somewhat pointed, and salmon or orange-yellow in color. They are usually laid singly or in groups of two, three, or four each. Shown on Plate XVI, *b*.

Larva.—Length about two and one-fourth inches, dirty white, dull yellow, or flesh-colored, marked with dark brown or black tubercles, each bearing a short bristle. The fourth to the tenth segments inclusive bear two pairs of tubercles, the front pair being closer together than the rear pair. The second, third, eleventh and twelfth segments have smaller tubercles arranged more nearly in transverse rows. Laterally, there is a row of brown tubercles just above and another row just below the spiracles. A second row of smaller tubercles may be seen on the bases of the legs and pro-legs. The large cervical shield and smaller anal shield are dark brown. Head, dark brown, with upper part of front lighter. Legs, light brown. The larva is shown in Figure 7, and on Plate XVI, *c*.

Pupa.—About one and one-half inches long, scarcely tapering, anal extremity, blunt; dark brown in color. On the proximal and distal margins of each abdominal segment there is dorsally a ridge consisting of a number of short, black spines or teeth, pointing backward. Similar spines or hooks, projecting forward, occur on the ventral surface of the posterior segment. Shown in Figure 8.

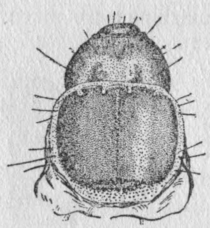

FIGURE 9. Head and cervical shield of larva, much enlarged.

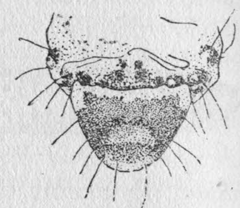

FIGURE 10. Anal plate of larva, much enlarged.

All stages of the leopard moth are shown in the accompanying illustrations.

LIFE HISTORY AND INJURY.

Just as the manuscript of this bulletin was ready for the printer, a publication on the same subject by James W. Chapman,[63] and published by the Bussey Institution of Harvard University, came to hand. Mr. Chapman, by original observations, has made an important contribution to the habits and life history of this insect, and we have, therefore, revised several paragraphs in this bulletin, to include the chief results of Mr. Chapman's studies.

The adult moths appear during a period extending from May to September, according to the circular issued by the Bureau of Entomology.[56] In New Haven, however, by far the greater number are found during the early part of July, while specimens have been secured during late June and the first week in August. The male is much the smaller, and flies with ease, being attracted

by the electric lights. The female has a heavy body, and flies very little, preferring, if possible, to lay eggs on the same tree where she emerged from the pupa. For this reason, high trees, isolated, and one hundred feet or more away from others injured by the leopard moth, may remain uninfested for years, while continuous rows of trees with branches touching are soon infested throughout.

The moths eat nothing and live at the most but a few days, the male dying immediately after copulation, the female as soon as the eggs are laid. One female captured by the junior author lived three days.

The eggs are inserted in crevices in the bark, or beneath plates of bark, one to several in a place, usually in the higher branches of the tree. They may, however, be laid on larger branches or on the trunks of small trees. They are less than one-sixteenth of an inch in length, oval, and yellowish or salmon colored. Several observers, including the junior author, have found the eggs laid by females in confinement, in several masses, due, no doubt, to the unwillingness of the female to deposit them sooner than necessary under unsuitable conditions. Numbers of the borers, just hatched, were found, and in every case they were working singly, usually just above a bud or twig on one of the smaller branches. This, according to J. W. Chapman,[63] means that the new larvæ do not enter the branch at the place where they hatch, but crawl some distance to the smaller twigs. Although this is the rule, the junior author has found several which had entered branches two to five inches in diameter, taking advantage of crevices in the bark. Each female may deposit from 400 to 800 eggs.

The larvæ hatch within a few days (ten days, according to Mr. Walker[26]), being plentiful in the latter part of July, and immediately commence their destructive work, boring into the branches. A careful examination of the twigs of an infested tree will show a slight amount of the white, powdery sawdust expelled by each larva during the first few days after hatching. In a few days the character of the expelled frass changes to small cylindrical pellets, light golden or brown in color.

Several experiments made by Mr. J. W. Chapman[63] are of value in showing the activity of the newly-hatched larvæ. A number of these were placed at the base of a fresh lilac bush and soon commenced to climb. On reaching the twigs, they were at once taken off and again placed at the base, when they would immediately commence climbing again. In this way four of those making the greatest progress had in four hours traveled distances varying from twenty-five to eighty feet.

Other experiments showed that some of the more recently hatched larvæ were able to crawl from fifty to one hundred feet on the ground, through grass and rubbish, while others nearly full-grown would move very little, but would protect themselves by spinning together small particles of sticks and dirt.

Growth is rapid, and the larvæ reach a length of about an inch by the end of the first season. The general tendency is for the insect to work upward from the hatching point, or from any opening made for expelling the frass. Small twigs are hollowed out, leaving little but a shell of bark, and small branches may be girdled, causing them to break off during a heavy rain. Where the young hatch in larger branches, the regular burrows are often varied by small, irregular patches eaten out of the inner bark. Branches too small, in a dying condition, or otherwise unsuitable, are vacated, the insect crawling on the outside of the bark and making a fresh entry on another and usually larger branch. A burrow may strike a knot or small branch, when, after going back several inches, the insect starts in a new direction. New outlets may be made, and the use of old ones discontinued from time to time. These outlets are always in some protected situation on the under side of a branch or in a crotch. They are kept covered with a closely woven silk web, this being broken and remade each time the frass is expelled. In one case the web was broken by the junior author and remade by the insect five times within an hour. This web certainly helps to conceal the hole, and may be used to keep out air, parasites, ants and other insects. Unlike the galleries of the sugar maple borer, those of the leopard moth are kept clear, all frass being removed as soon as a small pile has accumulated, and cement sidewalks under badly infested trees are often littered with the brownish pellets expelled from the burrows.

During the latter part of October the larvæ leave the outer wood and bore slanting holes upwards and into the wood two inches or more from the bark, where they remain in a dormant stage over winter. Sharp[74] cites Kalendar to the effect that the larva forms a temporary cocoon in which it passes a winter sleep before again feeding in the spring, but this is not the case in Connecticut, as Mr. Cromie has taken numbers of naked larvæ from the branches during winter.

The boring is continued in the same manner during the next summer, but the damage done is now much greater, both the insect and the branches attacked being larger. Branches four to eight inches in diameter may be entirely girdled, or large patches of wood may be eaten out. The wounds made the preceding year now show at their worst, the bark falling away, and ugly ridges being made where they have partially healed.

When fully grown, the larvæ are about two and one-fourth inches in length, and most of them do not enter the pupa state until the early part of the succeeding summer, when they are nearly two years old. The writers have reason to believe that some of those hatched early change to pupæ and complete the life cycle as those appearing latest during the next year. However, those passing the second winter continue active boring in the spring, changing to brownish pupæ in May or later. This is done in a small chamber within a few inches of where the larva has previously cut its way almost through the bark. It also further protects itself, before pupating, by a fine web placed between itself and the place of exit. In from four to six weeks the pupa cuts through the bark and, by means of protuberances on the abdominal segments, wriggles itself partially out of the hole, where it leaves the shell or pupa case after it flies, as may be seen on Plates XI, *b*, and XV.

As shown before, this insect attacks to some extent nearly every tree, native or exotic, growing in this region, except evergreens, so that a full list is not necessary. However, in New Haven the American elm is one of the kinds most severely attacked, while, owing to its dark, plated bark, even on the smaller branches, the insects in it are very hard to detect. With it, in amount of injury done, may be classed the silver maple and the sycamore maple. Other common species often seriously injured are ash, English elm, basswood or linden, tulip, sugar, red and Norway maples, poplar and horsechestnut. The honey locust, sycamore, sweet gum, and oak seem much less liable to attack, in many cases, in New Haven, remaining uninjured, although standing in rows with affected elms.

Natural Enemies and Checks.

In this country no parasites have been recorded that hold the leopard moth in check. In Europe a chalcidid parasite of the subfamily Encyrtinae, *Litomastix* (*Copidosoma*) *truncatella* Dalm., has been reared by E. A. Fitch. (Entomological Magazine, Vol. XVIII, p. 116.) This and an ichneumonid, *Schreinaria zeuzeræ* Schrein (not Ashm.), are mentioned in a letter to Mr. Cromie from the American Consul-General at Berlin, the information being received by him from the Kaiserliche Biologische Anstalt für Land- und Forstwirtschaft in Dahlem-bei-Steglitz. The former, *L. truncatella,* is probably the same as was reared in this country from the cabbage looper, *Plusia brassicæ* Riley. (Rept. of Ent. U. S. Dept. Agr. 1883, p. 121.)

An examination of hundreds of the caterpillars and pupæ, as well as the burrows made by them, shows that the leopard moth is remarkably free from natural enemies of all kinds. In no case was there evidence of either parasitic or predaceous insects. Dr. L. O. Howard, who has given some attention to the subject, has not found that any effective parasitic check exists even in Europe, though he has promised to bring to America the species known to occur there. Mr. Cromie found in New Haven a caterpillar dead in its burrow and full of small maggots, but these proved to be a Phorid fly, *Aphiochæta nigriceps* Loew., which probably did not attack the borer until after it had died from some other cause. This was the only indication found of an insect being destroyed while in its burrow. All pupæ, the stage generally exhibiting parasitism, seemed to have developed properly. Undoubtedly some check to the insect must exist before the burrow is developed, because of the small number of burrows found as compared with the large number (several hundred) of eggs, laid by each female. Either the female is unable to deposit any large number of her eggs in proper situations, and they thus fail to hatch, or the eggs themselves are largely eaten by the birds or insects found in cities. The writers have noticed that English sparrows search for and apparently find food on elms infested by the leopard moth in July, when the eggs should be plentiful and the young borers just hatching, but their prey might have been other insects. In many cases small holes, barely started by newly hatched larvæ, were found vacant, indicating that birds had secured the insects before they were able to enter the wood.

As the leopard moth is a pest chiefly of cities and towns, it is thought that certain birds, especially woodpeckers, assist in checking it, especially in the country districts. The habits of the moths in flying about electric lights would lead one to expect that many of them might be eaten by bats and night-flying birds. It is also believed that sparrows sometimes may feed upon the eggs or young larvæ. Smith states[58] that the leopard moth is a serious pest only where the English sparrow has driven away the native birds.

No other explanation can be given of the scarcity of the leopard moth in the country, adjacent to infested towns, except the presence of insectivorous birds. This tendency of the insect to become a pest only within cities and towns is noted by several English, French and German writers, as well as in this country. Mr. James Walker of Newark, N. J., states that infested elms placed in a nursery outside the city limits of Newark were rid of the larvæ by woodpeckers. This coincides with a statement made by P. Lesne,[79] who mentions having seen in Northern Algeria numerous woodpecker holes ending in the burrows of the leopard moth. While traveling from one branch to another, a habit of this insect, it is exposed to the attacks of birds. Mr. J. W. Chapman[63] also cites evidence of squirrels in the Boston parks chewing the smaller branches to secure the larvæ, which they relish.

Especially in early summer, numbers of small girdled branches in full leaf are broken off by storms. Nearly all of these contain the caterpillar which has done the girdling, and the branch soon wilts and dies. Though most of the larvæ desert the branch within two or three days after it falls, the junior author has found several of these shrunken and in a dying condition on the branch, showing that the insect cannot sustain life on the dead wood. It is also evident that very few of those which leave the branch are able to again find and climb a large tree. On city streets these branches are usually gathered at once and destroyed because of their hindrance to traffic. In parks it is even more necessary that this should be done, as here the insects can easily leave the fallen branches and enter shrubbery or small trees.

Remedial Treatment.

In view of the protected life led by this insect, treatment is especially difficult. Tunneling under the bark during the greater part of its life, it is not affected by arsenical or contact sprays. The protracted period during which it may appear as a moth hinders effective action against the adult. Isolated trees recently infested, and small trees with smooth bark, can be saved by a thorough inspection two or three times a year, followed by the removal of badly infested branches and the destruction of larvæ found, either by the injection of carbon disulphide (bisulphide) into their burrows or the insertion of a hooked wire to draw them out. Large trees badly infested should be cut down at once.

Unfortunately, this insect lives so concealed a life as to attract little attention until it is well distributed in a town or city and serious damage has been done to the trees. Where not already present, all planting stock should be bought from nurseries free from this pest,—probably in a district not yet affected. A careful watch must be kept for its first appearance, when, because of the inability of the female to make long flights, the removal of the trees for a couple of hundred feet around the affected section will form a quarantine that will greatly help to keep it in check. Special attention can then be given to all trees in and close to the affected area. Most citizens are averse to having trees removed from in front of their property until they are very far gone, but stern measures are necessary in preventing the spread of this insect.

Electric Lights. The moths are attracted by the strong arc lights used for street lighting, and numbers of them, largely males, could be secured in the flying season by sending men around to collect them from nine to twelve o'clock at night, or by the payment of a small bounty to boys, according to the quantity collected. This method of check, especially where females are secured, is of immense value, as it is much easier to prevent eggs being laid than to find the larvæ, which would otherwise hatch.

Mr. J. W. Chapman,[63] during the month of July, had placed in the Harvard College yard three six ampere arc lights, without globes or reflectors. About twelve inches beneath each light a pan three inches deep and twenty-four inches in diameter was suspended by wires. The pan was then half filled with water, with a thin film of kerosene on top. These lights were run as traps during the first two weeks of July, the insects being

attracted to the lights and then falling into the pan and being killed by the oil. In this way 279 male and 58 female moths were taken. Undoubtedly if the traps had been placed during June, when the moths first began to fly, a correspondingly larger number would have been taken.

Removal of Affected Branches. Trees badly affected are best removed, as the pruning of large numbers of branches leaves only mutilated specimens not worth the cost of the repeated inspection and treatment required.

Pruning should be done while the tree is in foliage, preferably twice a year, once in spring and once in late summer. The number, size and color of the leaves is the best guide as to affected branches. The tendency is not to remove many of these, which, if left, will probably die later in the season, or at least harbor numbers of eggs and of the young larvæ whose work does not yet show. All dead branches should be removed at a point well below the beginning of the green wood, so as to be more likely to secure the insects doing the damage. Branches containing small leaves, leaves thin or yellowish in color, or those where the leaves are few and scattered, are sure to be infested and should be removed.

Inspection, and Destruction of Larvæ. On large numbers of trees over fifty feet in height, the expense of this method is prohibitive, and the difficulty of locating the insects renders it impracticable. Especially is this so with elms of even smaller size, because of the rough, scaly bark on all but the smallest twigs. Also on such trees the branches are very numerous, long, slender and horizontal, making climbing in some places impossible.

To find out how successfully this method could be applied to large elms, the junior author selected several badly infested ones, sixty to eighty feet high, and had two of his best climbers treat them under his personal inspection, without limiting them as to time. Then live branches which had thus been carefully examined were cut from the tree and the bark peeled with a draw knife, exposing all leopard moth galleries. Less than twenty-five per cent. of the larvæ on the infested branches had been secured while on the tree. Also, Mr. Chapman, in describing the experiments in Harvard College yard, states that previous to placing the trap lamps, in which over three hundred moths were secured, "the yard had been patrolled since early spring by three men, who spent their entire time searching out and destroying the larvæ and pupæ of the moth."[63] On smaller trees, in New Haven, especially of species with smooth bark, it was found possible, by a thorough inspection, to secure practically all of the older larvæ.

In East Orange, New Jersey, where there are few elms, and the trees are, as a rule, from ten to fifty feet in height, the following method, carefully applied for three years, has placed the leopard moth under control:—Gangs of men, trained to the work, in August and September of each year look on the ground and sidewalk under every tree for the piles of brownish pellets and sawdust dropped by the borers. Carefully spotting the branch over each pile, the man climbs the tree and, if experienced, can locate nearly every hole, which, at that time, is covered by the silk web, when the insect is either secured with a wire, or carbon disulphide is injected from a small oilcan, and the hole stuffed with putty or soap.

Although the burrows are usually well cleared of frass, allowing the fumes of the carbon disulphide free access, there may be other outlets to the burrow, so the method of securing the insect with a wire is surer. A piece of No. 16, soft, steel wire is used, one end being bent into a very small hook, and sharpened from time to time by cutting the end of the hook in a slanting direction with a pair of linesman's pliers. Often the insect cannot be reached without cutting the burrow open for some distance with a stout jackknife, but this is easily done, as there is only the bark to cut through, and the real injury is not increased. If the branch is found to be nearly girdled, it had better be cut off.

In this way the larger larvæ (those in their second summer), which, of course, are found in the larger branches, are destroyed, preventing the laying of eggs the following summer. The same method is followed out the succeeding fall, when the younger larvæ, which, by this time, have grown large and come down to the larger branches, are also procured.

In high trees, the wind so scatters the falling pellets as to make it impossible to ascertain from their location on the ground the number or location of the insects in the tree.

Disposal of Infested Wood. It is very often not convenient in large towns or cities to burn the infested wood secured after

storms or by the trimming and removal of trees. Often the wood could be utilized by people in the vicinity in which it is collected, or it may be left at some nearby public dump.

During the spring of 1911, the junior writer secured a number of branches broken off by storms, and containing larvæ. The borers remained in the wood for a few days, until the leaves began to wilt and the wood commenced to dry, when most of them left the branches. Unable, however, to find new green branches to enter, they soon grew thin and died. Mr. Chapman,[63] with older larvæ, secured later in the season, found that the borers were able to exist during the winter in wood removed from the tree and to emerge as moths the following spring. Unless the wood is to be used immediately, or placed in a dump where they will soon be buried by ashes, dirt, etc., branches secured by trimming or blown down by storms should be burned.

Care in Planting. Until some effective check is found for this insect, it is best not to plant too heavily those species of trees which are especially liable to attack. Species with short, strong branches, covered with smooth bark, should be given the preference, being more easily inspected and taken care of by the methods just given. Planting the young trees a greater distance apart than usual, makes it more difficult for the insect to spread from one tree to another.

In this connection, it might be said that, in Brooklyn, one of the first cities in America to be infested, Mr. J. J. Levison reports the insect as far less injurious than formerly, although no direct measures have been taken for its control, and the junior author has seen there rows of elms and other trees almost untouched by this insect.

Care of Trees. Although trees in good health are not immune to attack, many authorities claim that they are less liable to injury than unthrifty trees. It is certain that in New Haven the greatest damage by the leopard moth has been done to trees on streets where the conditions are most adverse to tree life, and at least wounds are more easily healed, and recovery after attack is surer, where the trees are kept in a thrifty condition.

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68 1890 Ormerod, E. A. Manual of Injurious Insects, p. 320 (brief illus. acct.).
69 1892 Ormerod, E. A. Text Book of Agricultural Entomology, p. 132 (mention, illus.).
70 1895 Judeich (J. F.)-Nitsche (H.) Forstinsektenkunde, p. 773 (illus. acct.).

71 1895 Schlich, Wm. Manual of Forestry, vol. iv, p. 264 (descr. note about injury and food plants).
72 1897 Eckstein, K. Forstliche Zoölogie, p. 479 (brief acct.).
73 1898 Ormerod, E. A. Hand Book of Orchard and Bush Fruit Insects, p. 132 (illus. acct.).
74 1901 Sharp, D. Cambridge Natural History, vol. vi, p. 395 (mention).
75 1903 Henry, E. Atlas d'Entomologie Forestiere, p. 29 (illus.).
76 1904 Theobald, F. V. Report on Economic Zoölogy, ii, p. 30 (note).
77 1905 MacDougall, R. S. Journal Board of Agriculture (London), 12, No. 2, p. 115. Abstract Expt. Sta. Record, vol. xvii, p. 1092 (remedial treatment).
78 1908 Gillanders, A. T. Forest Entomology, p. 247 (brief illus. acct.; sycamore, hawthorn).
79 Lesne, P. Compt. Rend. Academy Science (Paris) 146, p. 493 (great damage to cork oak in Algeria).
80 Theobald, F. V. Report on Economic Zoölogy, p. 24 (brief note).
81 1909 South, R. The Moths of the British Isles, p. 348.
82 Theobald, F. V. Insect Pests of Fruit, p. 46 (illus. acct.).
83 Theobald, F. V. Report on Economic Zoölogy, p. 29 (brief note, illus.).
84 1911 Lesne, P. Compt. Rend. Academy Science, 152, p. 1269. Abstract Expt. Sta. Record, vol. xxv, p. 464 (larvæ in cork oak).

SUMMARY.

The leopard moth occurs in Europe and parts of Asia and Africa, and was probably accidentally introduced into this country from Europe more than thirty years ago, being first noticed at Hoboken, N. J., and later spreading toward the north and east along the coast. At the present time it is found from Asbury, N. J., to Lawrence, Mass., but has not been taken more than twenty-five miles inland.

The larvæ or caterpillars cause great damage to nearly all kinds of shade trees by boring in the branches just under the bark and cutting large galleries, often across the grain, thus girdling them. Dead branches extending above the mass of foliage in the tree-tops are a sign of attack, and many twigs will be broken off or wither during the summer. The pest has been especially destructive to elm and silver maple trees in the coast cities and towns of Connecticut, but is not so abundant in the open country. It has caused much damage also in the cities of New Jersey, New York City, Providence, Cambridge and Boston.

The adult moths are dirty white, with semitransparent wings marked with metallic blue dots. These have an expanse of one and three-fourths inches in the male to two and one-half inches in the female. The larva is yellow or dirty white, marked with brown or black dots, and about two inches long. See illustrations.

The moths appear about July 1st, the males being very common around electric lights, and the females lay eggs singly or in groups of two, three or four, in the crevices of the bark or near the buds. The larvæ, hatching in a few days, begin to tunnel in the twigs, and by the end of the season are about one inch in length. They leave the small branches and crawl over the bark to enter larger ones, cutting large galleries in them and expelling the frass through round holes, which they soon close with silk webs. During October the borers go deeper into the wood, and remain through the winter two inches or more beneath the bark. They pupate in their burrows the second spring, and before the moth emerges the pupa works itself partly out of the opening, and the adult flies away, leaving the empty case protruding from the burrow.

There are few natural checks, only one parasite being known in this country and four in Europe. It is believed, however, that certain birds, especially woodpeckers, prevent the spread of the leopard moth in the open country. Many larvæ are doubtless killed by the breaking off of the branches, which in cities are carted away and destroyed.

Removing infested branches; injecting carbon disulphide (bisulphide) into the burrows, and stopping the opening; probing with a hooked wire for the larva; are some of the methods of control.

Planting species of trees not badly infested, like oaks, honey locust and sycamore, and especially those kinds that do not grow very large, and have a smooth bark; placing trees further apart, so that the larvæ cannot easily crawl from one to the other; and keeping the trees well nourished and vigorous, are the chief preventive measures.

HOW TO GET RID OF FLIES.

Flies breed in filth and then travel over food. They are especially attracted by filth and by the odors of the pantry and kitchen. Coming from foul and decaying animal and vegetable matter, their feet and bodies carry many germs which may be and are deposited upon human food. Several important diseases of mankind are spread in this way, including typhoid fever, cholera and dysentery.

Though flies may breed in any decaying animal or vegetable matter, probably ninety-five per cent. of them develop in stable manure.

Life Period. Each female may lay 120 eggs, which hatch in less than twenty-four hours, and the maggot and pupa stages each last about five days, making only ten days from the egg to the adult fly. The adult fly may live for many weeks.

Abolish Breeding Places. Prevent the breeding of flies by not allowing manure to accumulate about stables. It should be

removed once each week. If not feasible to do this, keep it in a screened shed or cellar, or treat it with oil every few days. Garbage cans and swill tubs should be covered, and not kept near the kitchen. Sanitary closets should be maintained.

Screen all Human Habitations. In order to reduce the danger of contracting disease through the agency of flies, these insects should not only be reduced in numbers, but even the few should be kept out of houses. All rooms should be provided with screens. It is especially important that the dining room, kitchen and pantry should be kept free from flies, and it is equally important to keep flies from the sick room.

Food should never be exposed to flies.

To Kill Flies in Houses. 1. One of the best fly poisons is formalin mixed with water in about five per cent. strength, exposed in a shallow dish. The flies will drink it and die. Professor R. I. Smith of the North Carolina Station recommends one tablespoonful of commercial formalin to a half-pint cup of half milk and half water, placed on a shallow plate, with a slice of bread in the liquid. The bread gives more surface upon which the flies may alight. Formalin fly poison is not dangerous to use and is especially successful in reducing an abundance of flies if the room can be closed and if they do not have access to any other form of moisture.

2. Traps are also serviceable.
3. A liberal use of insect powder (Pyrethrum) in a tight room will stupefy the flies and they may be swept up and burned.
4. Sticky preparations such as "Tanglefoot" fly-paper will catch many flies.
5. Use wire fly-killers to destroy stragglers.

BRIEF NOTES.

A Migration of the Cotton Moth into Connecticut. During the last week of September a swarm of brown moths appeared in New Haven and probably other Connecticut towns and cities. It was the cotton moth, *Alabama* (*Aletia*) *argillacea* Hubn., from the Southern States, which in its larval stage feeds only upon cotton, and is believed not to hibernate in the United States, except possibly in Texas. The great abundance of this insect in the South in 1911 was mentioned by Mr. W. D. Hunter in a paper given at the Washington meeting of the American Association of Economic Entomologists, December 27-29, 1911. Considerable injury to the cotton plant resulted from the attacks of the caterpillars.

In New Haven, the moths were resting by hundreds on the walls of the railroad station, and other buildings, especially near the water front, were literally covered. The following account was copied from one of the local papers:

Army of Moths Nearly Tie Up Railroad.

"Swarms, several of them, containing a few millions, more or less, of brown moth millers have descended on Union station, and the trainmen's shanty, and for a time so large was the number of the invading host that they made folks about the depot think a heavy storm was coming up. The moth millers settled themselves at the east end of the station on platform pillars on the side of the depot and some more swept to the west end and beyond and cluttered up the walls of the trainmen's shanty just west of the station to such an extent that there was scarcely a spot where the boards could be seen. The visitors were most active when the sun came out periodically during the day.

It was reported that they settled so thickly on the rails near the yard master's shack in the Water street yard that a switcher with a small string of cars behind it could not get under headway because the wheels of the locomotive, passing over the millers, slipped."

Another newspaper stated that the brown-tail moth had reached the city in great numbers, and threatened to do much damage. On September 25th I counted thirty of these moths inside a closed trolley car on Whitney avenue on the way to my office. During a residence of nearly eighteen years in New Haven I have never before observed or collected this insect, though the station collection contains specimens taken in Waterbury by Mr. H. S. Woolley. Such a swarm is therefore unusual, but the migration in 1911 was extensive and widespread, according to reports in Science by Professor H. T. Fernald, who observed the moths at Amherst, Mass., and Mr. J. L. Randall, who reports them at Pittsburgh, Pa. Dr. Henry Skinner, in Entomological News for November, page 415, records them as being present in great numbers at Philadelphia, and Mr. R. A. Muttkowski, in the same journal for February, 1912, page 83, records the abundance of the moths in the vicinity of Milwaukee, Wis. In the Ottawa Naturalist for 1911, page 129, Mr. Arthur Gibson reports it as being unusually abundant throughout Western Ontario in September, 1911. A

single example was received from Mr. H. S. Douglas of New London. Professor John B. Smith states* that, though the cotton moth does not breed in New Jersey, "each year adults fly north in considerable numbers after midsummer, and some of these flights reach us, as a swarm or in scattering individuals."

A Dipterous Parasite of the Imperial Moth. Mr. Champlain collected a chrysalis of the imperial moth, *Basilona imperialis* Dru., cutting it out of the ice on the edge of a pond at Lyme, Conn., December 4th, 1910. On February 6th, 1911, the chrysalis was fractured and showed six Tachinid puparia inside. On April 20th a perfect specimen emerged of one of our large Tachinid species, *Latreillimyia bifasciata* Fabr. This fly has a body about half an inch long, thorax grey or pruinose, abdomen black, with two yellow bands on last two segments. Body more or less covered with stiff hairs or bristles.

A Borer in Spruce Twigs. On June 4th, 1910, a spruce twig containing a borer was received from a local nursery. The borer was a lepidopterous larva not familiar to us, and was placed in the breeding cages. The adult proved to be a small pyralid moth, and was identified by Dr. H. G. Dyar of the U. S. National Museum as *Dioryctria abietella* D. & S. Dr. Dyar stated that the specimen was typical, and like those from Europe, but was different from those reared in this country from pine cones.

Prevalence of Hickory Bark Borer. The hickory bark borer *Scolytus quadrispinosus* Say has caused much damage to native hickory trees, especially in the southwestern part of the state, during the season. Some trees in New Haven show signs of attack. This is the same beetle that in 1901 killed more than 110 hickory trees on the Hillhouse place in New Haven. The infested trees were cut, which is about the only remedy. An account of this insect may be found in the Report of this Station for 1901, page 267, and the beetles and their work are shown on Plate VIII of that report. Utilizing the trees for timber and fuel and destroying the bark and refuse before May 1st will kill most of the overwintering beetles in the bark.

The Apple-Leaf Crumpler. On May 12th, 1911, a case-bearer with trumpet-shaped case on apple was received from Mr. E. D. Curtis of Litchfield. Adult moths appeared in the breeding cages June 21st, and proved to be the apple-leaf crumpler,

*Report N. J. State Museum: Insects, p. 471. 1909.

Mineola indiginella Zell. The larva also feeds upon plum, cherry and quince, but is seldom destructive, especially if spraying is generally practiced to control the codling moth. The adults are shown on Plate II, *a*.

Chrysanthemum Leaf-Miner or Marguerite Fly. On April 8th we received from R. H. Comstock of Milford a plant of marguerite daisy having leaves infested with the chrysanthemum leaf-miner or marguerite fly, *Phytomyza chrysanthemi* Kow. The leaves were badly tunneled by the larvæ, some of which had pupated in the tunnels. On April 16th the first adult, a small two-winged fly, emerged, and by April 20th a good series of adults had been obtained. This is probably a native American insect, and attacks chrysanthemums, marguerites, feverfew, cinerarias, eupatoriums and tansy. The eggs are laid in or on the under sides of the leaves and after hatching the minute larva mines or tunnels in the tissues of the leaf between the upper and lower epidermal layers, the mined areas showing as whitish markings on the green leaves. The damage has been so great in some instances that the growers had to abandon the commercial growing of these plants. Gathering and destroying the infested leaves, especially the first ones to appear, has been practiced with good results. Where greenhouses can be fumigated with hydrocyanic acid gas, this would undoubtedly prove the most effective of any treatment. It is also probable that some of the oil or nicotine sprays may penetrate sufficiently to destroy the larvæ.

Tent Caterpillars. The apple tent caterpillar, *Malacosoma* (*Clisiocampa*) *americana* Harr., has not been very common in the vicinity of New Haven for several seasons. Apparently it is more abundant elsewhere, judging by the letters received. Specimens were sent from Westport, Stamford, New Haven, Union, and Lisbon. This insect has been mistaken for the gypsy moth, but is entirely different in appearance, as the caterpillar is more decidedly brown in color, and with a more prominent white dorsal line than the gypsy caterpillar. Neither does the former bear prominent tubercles, or such conspicuous bristly hairs. Moreover, the tent caterpillar is found chiefly on apple and wild cherry, and it makes a nest in the forks of the branches, remaining within the nest at night and during stormy weather, but going out of it to feed on pleasant days. When about fullgrown, the caterpillars have a habit of clustering on the outside of the nest, where they are very conspicuous. An account of this insect may be found in Bulletin 139, and in the Report of this Station for 1902, page 139.

The forest tent caterpillar, *M. disstria*, was twice received from Hartford. This species makes no tent, but the caterpillars feed singly, often clustering on the trunks of trees when fullgrown and ready to pupate. The forest tent caterpillar has a decided though peculiar blue tint, and instead of a continuous white dorsal line, a row of keyhole-shaped white spots along the back.

Woolly Pine Aphids, *Chermes pinicorticis* Fitch and *Chermes pinifoliæ* Fitch. Frequently pine trees growing in woodlands or in ornamental plantings in parks and private grounds are infested by this insect, which forms upon the smooth bark white cottony or woolly patches. If we examine the flocculent matter, we find it made up of small brown plant lice or aphids, each bearing a large number of wax filaments or threads, thus giving it the cottony appearance. This insect is usually found on the shaded trunk of the tree, sometimes nearly covering it and again only in small patches. This is called the woolly pine bark aphid, *C. pinicorticis*.

Another and larger species, *C. pinifoliæ*, known as the woolly pine-leaf aphid or pine-leaf Chermes, occurs on the leaves, the young settling around the whorls of branches and feeding especially on the new and tender growth. Though no careful study of these insects has been made in Connecticut, it is certain that both species occur here, and probably often on the same trees.

An infestation of one and possibly of both forms together occurred in the white pine plantation of the Middletown Water Company in Middlefield. In response to inquiries, we advised that the trees be sprayed with kerosene emulsion. A visit to the plantation was made June 22d, 1911. Men were then spraying, and had already treated about 7,000 trees out of 38,000 planted there. The others were sprayed later. The trees were set in 1904, and though a few trees here and there had died from root injury, most of them had made a good growth.

The kerosene emulsion spray was successful in killing the woolly aphids, as the white patches disappeared and there was only an occasional slight injury to the leaves of the trees.

The Woolly Apple Aphis. The woolly apple aphis, *Schizoneura lanigera* Hausm., causes some injury to apple trees in Connecticut, though undoubtedly it is a much more serious pest in territory further south and west. Specimens were received in 1911 from Seymour, West Haven, Clinton and Putnam. Occasionally in the nursery a tree is seen with the insects on trunk or lower branches, and often the characteristic bluish white woolly or cotton appearance is noticed on large trees, especially in wounds or cankered areas which are prevented from healing because the aphids cluster there and suck out the sap for their food. On small branches an irregular knotty formation usually results from the attacks of the aerial form, and the root form causes similar irregular swellings upon the roots. This is thought to be due to the poisoning of the parts attacked.

The root form survives the winter, and the aphids migrate in spring to the trunk and branches. In late fall a generation of winged aphids appears, and these migrate and lay eggs in the crevices of the bark, thus starting new colonies.

The aerial form may be easily destroyed by spraying with kerosene emulsion, soap and water, or miscible oil. The root form may be eradicated by the use of carbon disulphide in the soil, and the free use of powdered tobacco has been tested with satisfactory results. In setting new orchards in a section where the woolly aphis causes much damage, it is advisable to mix the tobacco dust with the soil placed about the roots.

The Elm Scale. *Gossyparia spuria* Modeer. This scale insect was sent from New Haven, Yalesville, and Toronto, Canada, during June. This is one of the soft scales, having no shell or armor, and is dark brown with a marginal fringe of white wax resembling cotton or wool. The insect is oval in shape, about an eighth of an inch long, and has a tendency to locate in the cracks and crevices between the plates of bark, especially on young trees. It feeds by sucking out the sap. It sometimes attacks and kills the lower branches of medium-sized trees. There is but one generation each year, and the young are born alive about the middle of June. At first they settle along the veins on the under sides of the leaves but later return to the branches. Honeydew is freely exuded and drips upon the ground. A spray of kerosene emulsion or of common soap and water (1 lb. in 8 gallons) applied at any time of the year will kill this insect. An illustration showing the appearance of the elm scale may be found in the Report of this Station for 1905, Plate III, *c*.

The Woolly Maple Leaf Scale. The woolly maple leaf scale, *Phenacoccus acericola* King (see Report for 1905, p. 226 and Plate VII), is rapidly increasing as a pest of sugar maples, in the cities and villages of Connecticut. Samples of this sucking insect were received twice each from Bridgeport, Danbury and Ansonia, and once each from New Haven, Middletown and Greenwich, between July 12th and October 16th. Many trees seriously infested have been observed in New Haven, Hartford, Wallingford and other places, and Mr. G. A. Cromie, superintendent of trees in the city of New Haven, states that over fifty infested trees needed spraying this winter in New Haven. A forceful stream of water from the hose will dislodge many of the insects from the crevices of the bark in summer, and spraying with ten per cent. miscible oil in winter is recommended by Professor J. B. Smith of New Jersey for the bark form, while the leaf form cannot well be sprayed, but by burning the fallen leaves most of the insects are destroyed. Mr. F. A. Bartlett, however, states that the sugar maple is sometimes damaged by a fifteen per cent. oil application, when other kinds of maples are not injured.

The Locust Borer. The section of a trunk of a black locust tree filled with insect galleries sent to this office in July (see Plate VIII, *e*) showed the work of the larvæ of a beetle known as the locust borer, *Cyllene robiniæ* Forst. It has been stated that this pest is the greatest obstacle to the cultivation of the locust tree in the Eastern United States.

The eggs are deposited in the crevices of the bark during September. These soon hatch and the young larvæ feed in the inner bark until winter. During the following spring they bore into the heart-wood, and are often numerous enough to completely honeycomb the trunk with their galleries. The fullgrown larva is about three-fourths of an inch in length, somewhat flattened and club-shaped. The larvæ pupate within the galleries during the latter part of July and the beetles emerge early in September. The beetle is about three-fourths of an inch long, dull black in color with transverse yellow markings. The beetles are often abundant during the fall on the flowers of golden-rod, feeding on the pollen. The locust borer does not attack other plants.

As a rule the locust is not of sufficient value to warrant any treatment. Its value as a honey plant has been questioned. Even though the locust may blossom freely each year, only during an occasional season do the bees appear to obtain much honey from this species.

Where one is especially desirous of saving the trees it has been recommended to coat their trunks late in August with whitewash to which Paris green or lead arsenate has been added. Badly infested trees should be cut out and burned during the winter to destroy the larvæ. Trees only slightly infested could be treated with carbon disulphide during the early summer. A few drops of this liquid should be injected into the opening where there are indications of fresh borings, and the opening closed with moist earth or putty. B. H. W.

Ortho-Arsenite of Zinc. This arsenical poison is manufactured by an insecticide firm in California to meet the demand for a substitute for lead arsenate, which is supposed to cause arsenical poisoning or injury to trees through the bark, especially in the black alkali sections of the west. The ortho-arsenite of zinc is a white powder containing about 40 per cent. of arsenic oxide, fully twice the amount contained in the average paste lead arsenate, and the cost somewhat less than the latter.

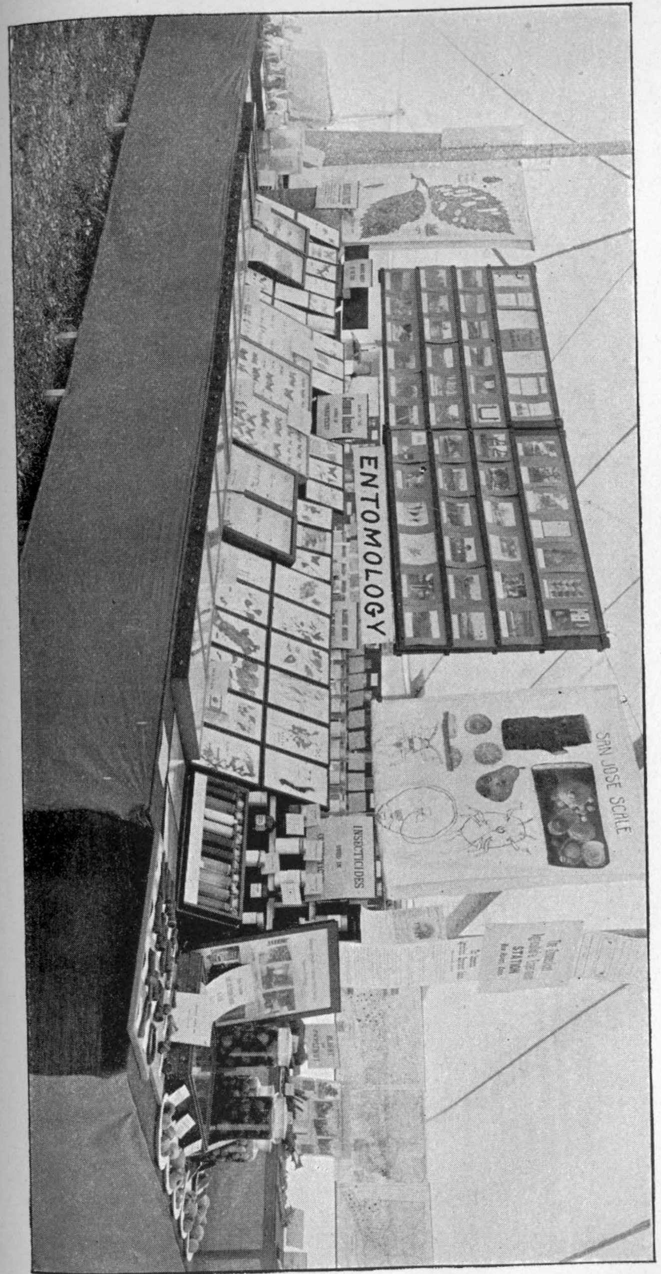
A quantity of the ortho-arsenite of zinc was purchased by Mr. E. M. Ives of Meriden, who sent a small sample to the station. The chemical department tested a portion of this and found it to contain very little soluble arsenic. Several small trees, including apple, peach and plum, were sprayed May 12th with ortho-arsenite of zinc, some at the rate of 3 lbs. in 50 gallons of water and the others at the rate of 1½ lbs.

The trees were examined four days later and no injury to the foliage was observed from either treatment.

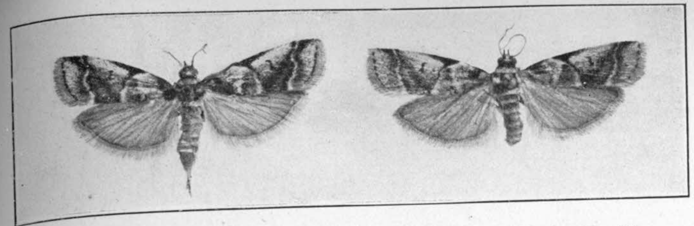
Mr. Ives sprayed about 15 bearing apple trees with the material and noticed no injury to the foliage. A second application to the same trees was made seven days after the first, using ¾ of a pound of ortho-arsenite of zinc to 50 gallons of water. The foliage was so badly injured that some of the trees dropped many of their leaves. Mr. Ives had been spraying with paste lead arsenate, but stated that this mixture was all drawn from the pump and barrel before putting in the arsenite of zinc.

The manufacturers agreed to send this department some of the material for further tests, but this was not received.

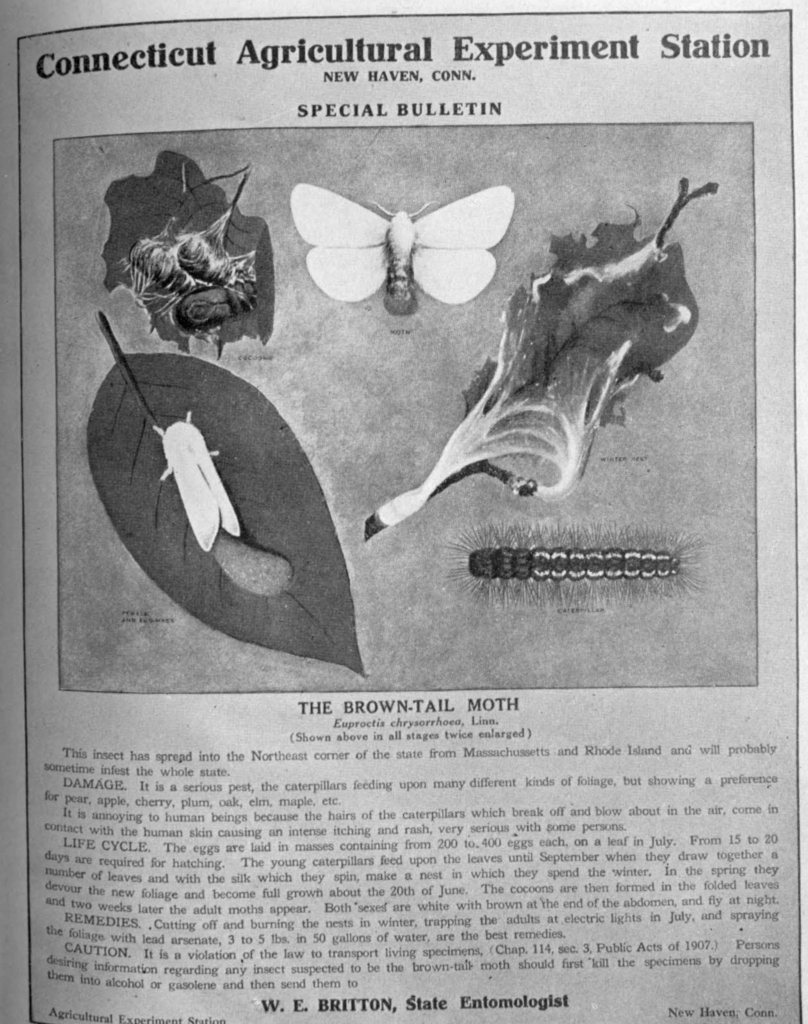
B. H. W.



A portion of the Entomology Exhibit at the Fairs.



a. Adult of the apple leaf-crumpler *Mineola indiginella* Clem. Twice natural size.



Connecticut Agricultural Experiment Station
NEW HAVEN, CONN.

SPECIAL BULLETIN

THE BROWN-TAIL MOTH
Euproctis chrysorrhoea, Linn.
(Shown above in all stages twice enlarged)

This insect has spread into the Northeast corner of the state from Massachussetts and Rhode Island and will probably sometime infest the whole state.

DAMAGE. It is a serious pest, the caterpillars feeding upon many different kinds of foliage, but showing a preference for pear, apple, cherry, plum, oak, elm, maple, etc.

It is annoying to human beings because the hairs of the caterpillars which break off and blow about in the air, come in contact with the human skin causing an intense itching and rash, very serious with some persons.

LIFE CYCLE. The eggs are laid in masses containing from 200 to 400 eggs each, on a leaf in July. From 15 to 20 days are required for hatching. The young caterpillars feed upon the leaves until September when they draw together a number of leaves and with the silk which they spin, make a nest in which they spend the winter. In the spring they devour the new foliage and become full grown about the 20th of June. The cocoons are then formed in the folded leaves and two weeks later the adult moths appear. Both sexes are white with brown at the end of the abdomen, and fly at night.

REMEDIES. Cutting off and burning the nests in winter, trapping the adults at electric lights in July, and spraying the foliage with lead arsenate, 3 to 5 lbs. in 50 gallons of water, are the best remedies.

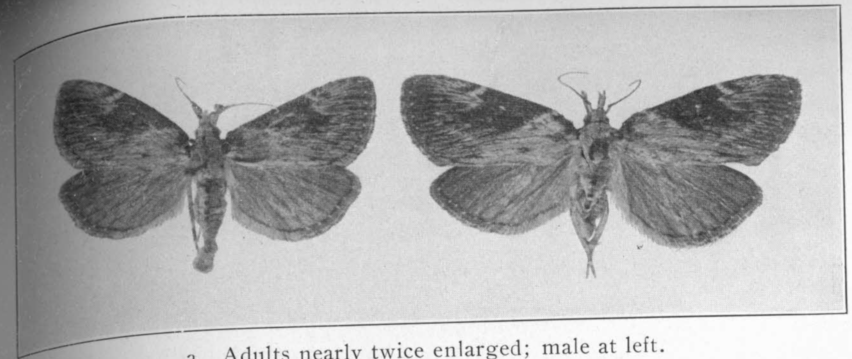
CAUTION. It is a violation of the law to transport living specimens, (Chap. 114, sec. 3, Public Acts of 1907.) Persons desiring information regarding any insect suspected to be the brown-tail moth should first kill the specimens by dropping them into alcohol or gasolene and then send them to

W. E. BRITTON, State Entomologist

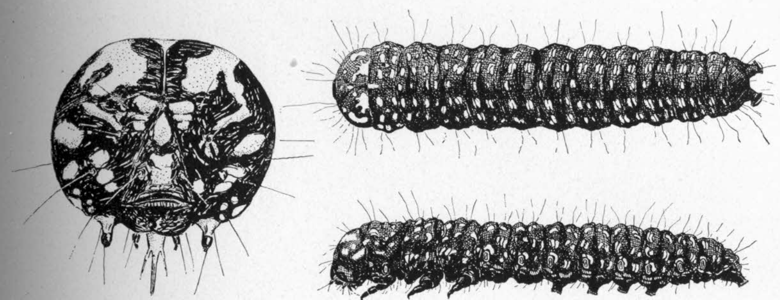
Agricultural Experiment Station — New Haven, Conn.

b. Fac simile of the brown-tail moth placard.

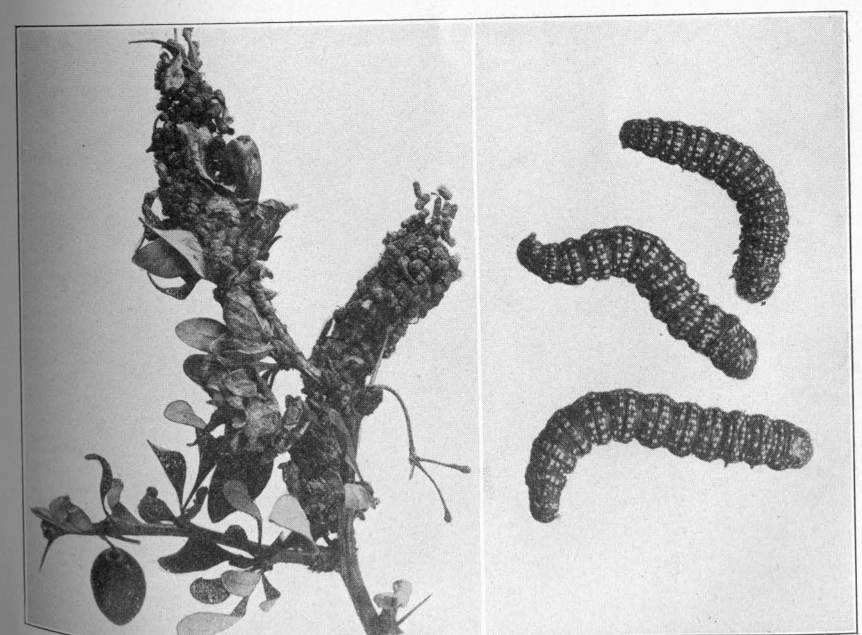
APPLE LEAF CRUMPLER AND BROWN-TAIL MOTH.



a. Adults nearly twice enlarged; male at left.



b. Larva dorsal and lateral views, about twice enlarged; front view of head at left, greatly enlarged.



c. Nest at left natural size, larvæ at right twice enlarged.

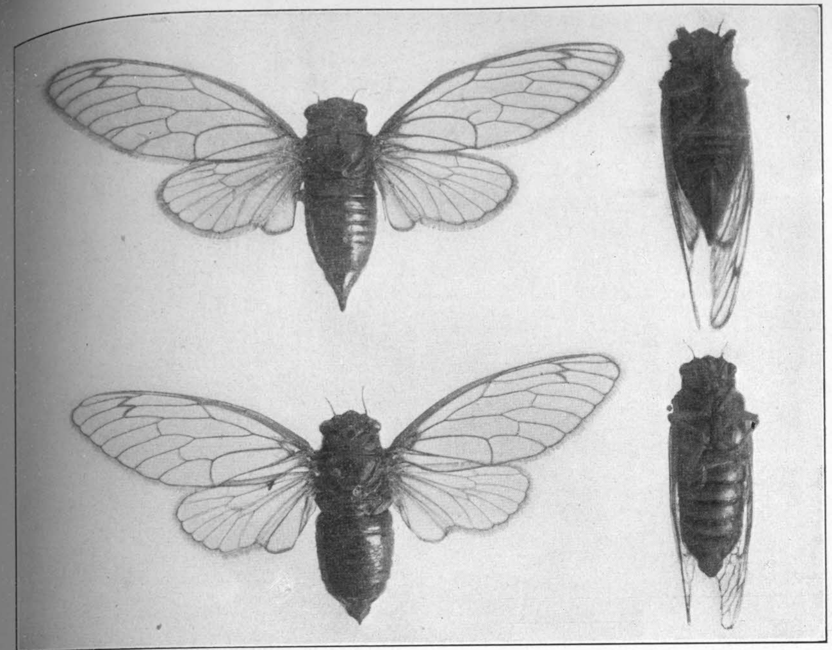
Omphalocera dentosa Gr. A PEST OF BARBERRY HEDGES.

PLATE IV.

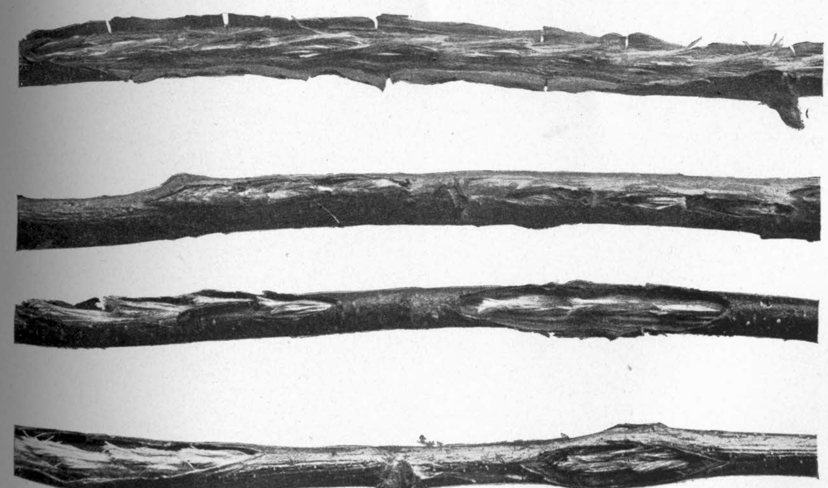
a. b. c.

a, pupal shells on leaf ; b, adult and pupal shells on tree trunk ; c, adults and pupal shell on twigs; *a* and *c* natural size, *b much reduced.*

THE PERIODICAL CICADA.

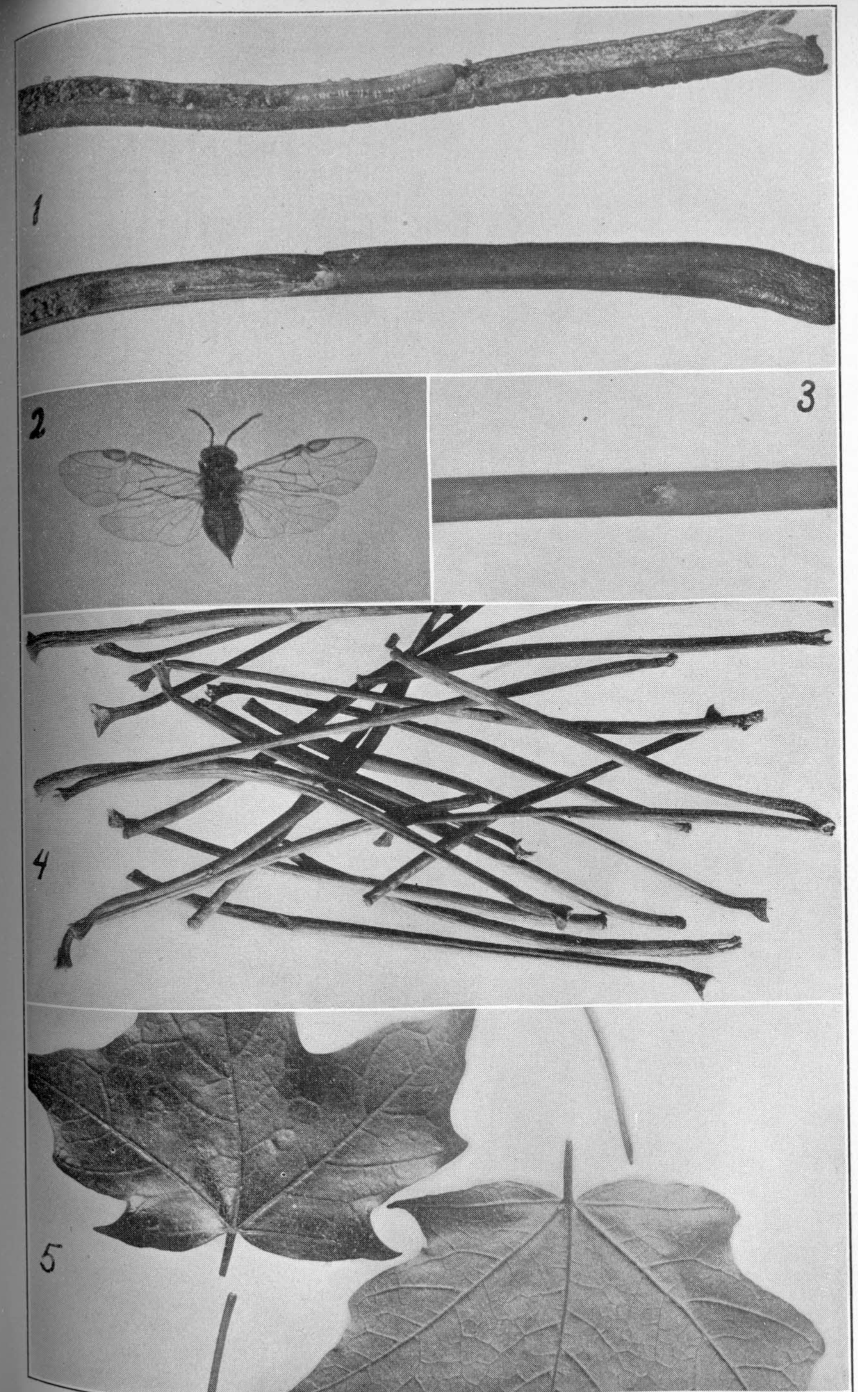


a. Males (below) and females (above). Natural size.



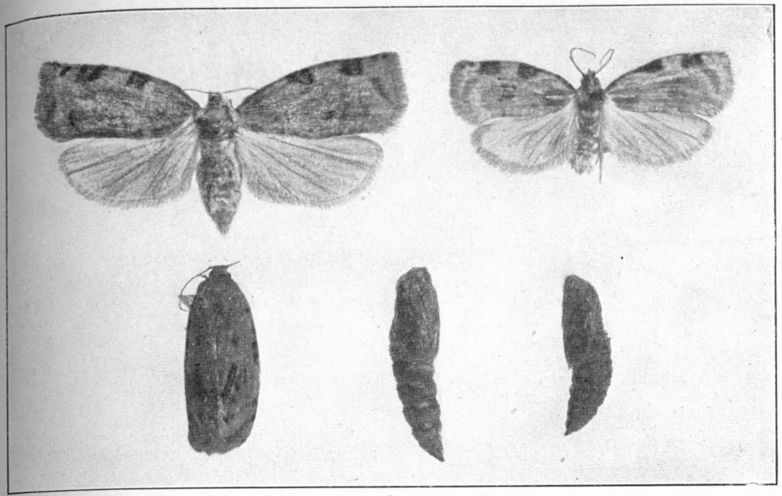
b. Twigs mutilated by the females in laying eggs.

THE PERIODICAL CICADA.

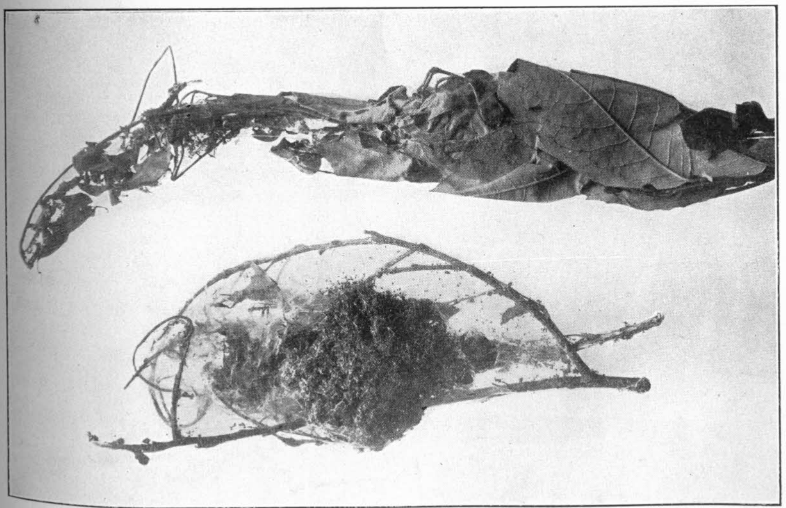


1, larva in stem; 2, adult female; 3, exit hole of larva in stem; 4, stems which have been severed; 5, leaves with severed stems.

THE MAPLE LEAF-STEM BORER AND ITS WORK.

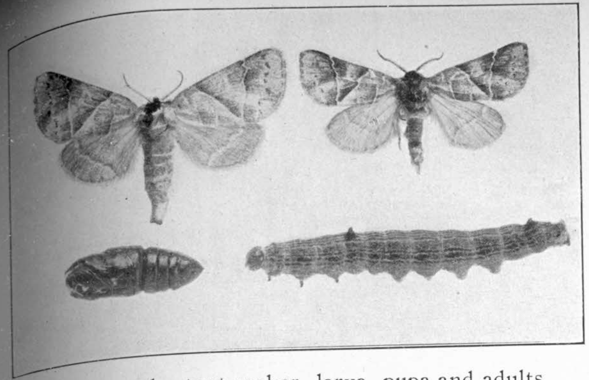


a. Pupæ and adults. Twice enlarged.



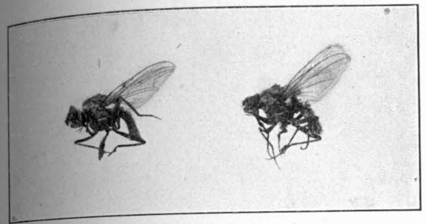
b. Nests or tents. Much reduced.

THE CHERRY TENT-MAKER.

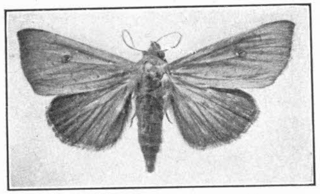


a. The poplar tent-maker, larva, pupa and adults.

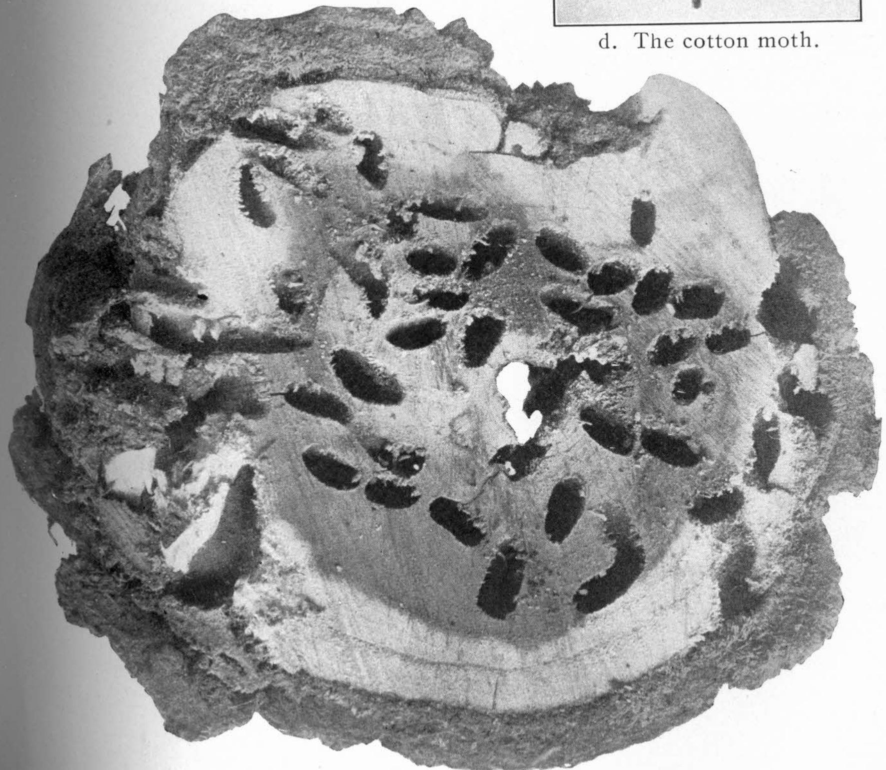
b. Parasitized cocoon of imperial moth.



c. The onion fly, twice enlarged.

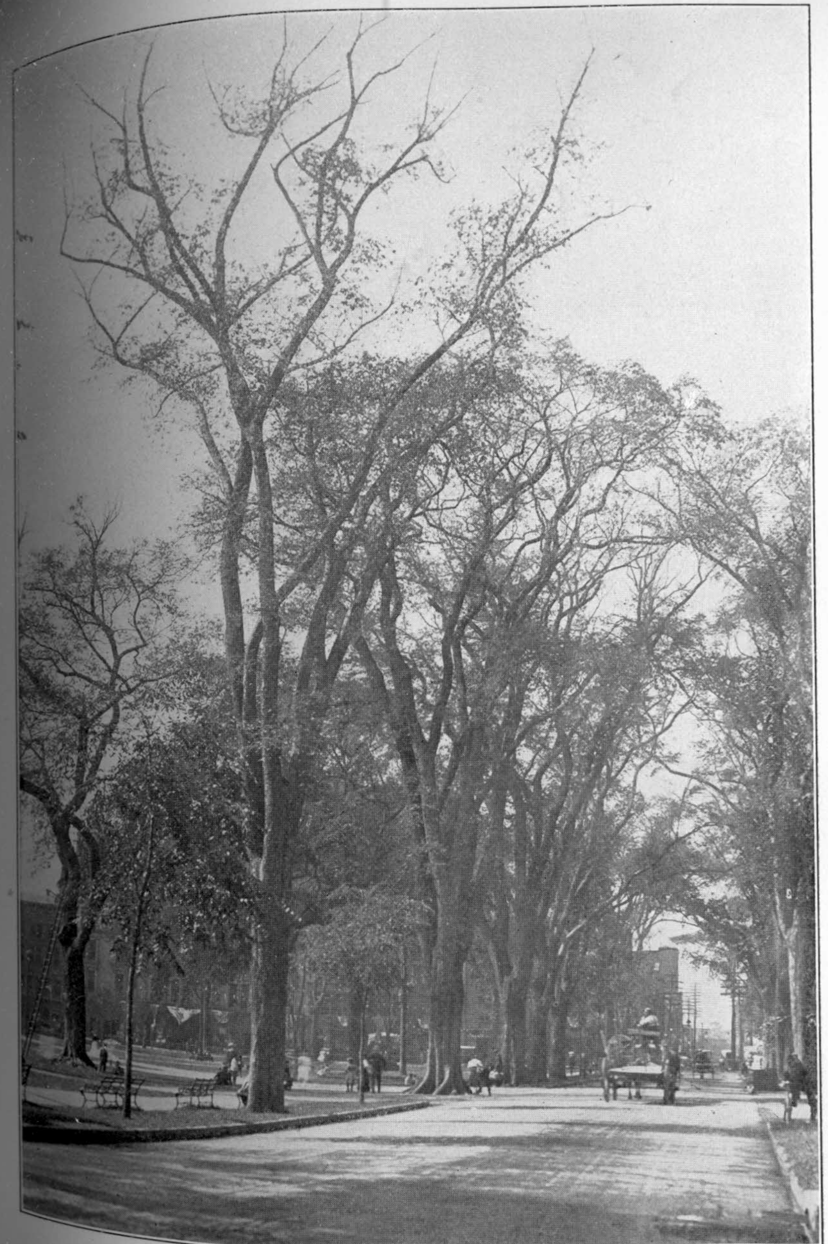


d. The cotton moth.



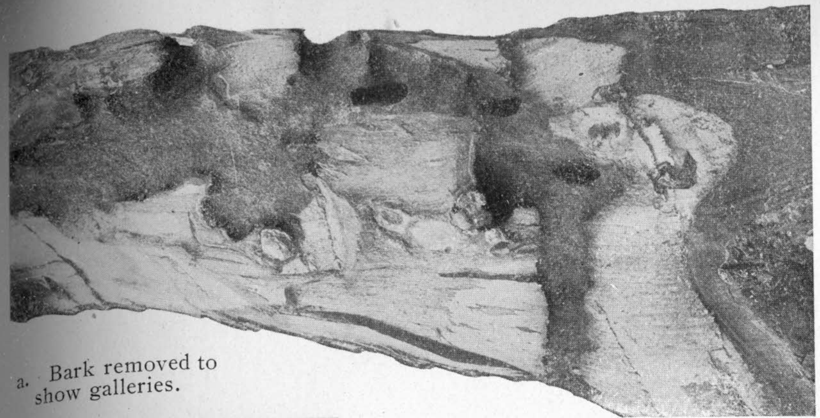
e. Cross section of locust tree showing injury by locust borer.

MISCELLANEOUS INSECTS. All except c natural size.

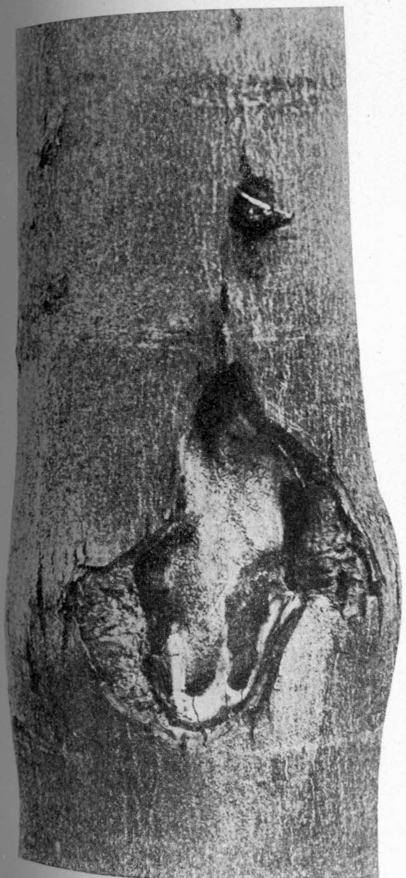


Trees injured by leopard moth show dead terminal branches. View on New Haven Green. Photo. loaned by Geo. Dudley Seymour.

WORK OF LEOPARD MOTH.



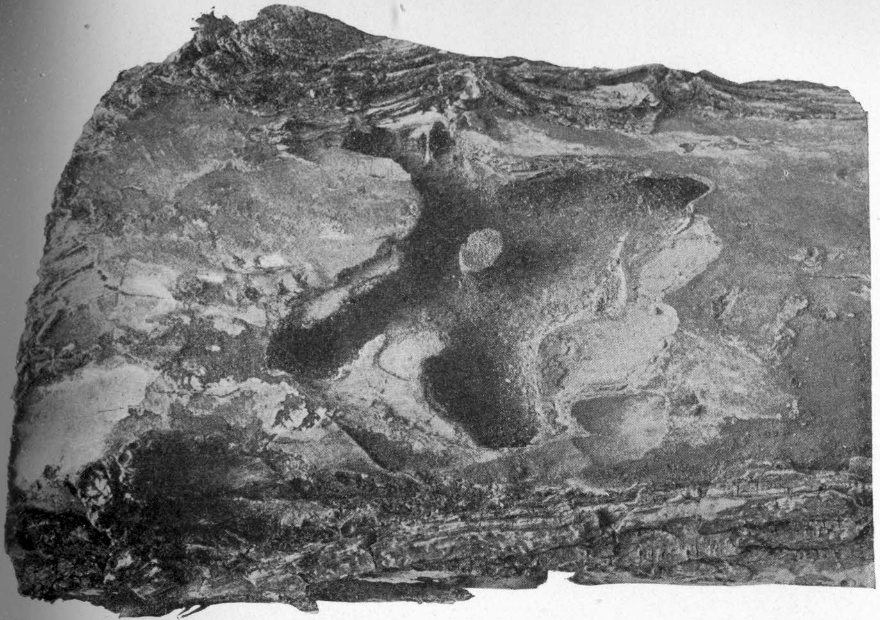
a. Bark removed to show galleries.



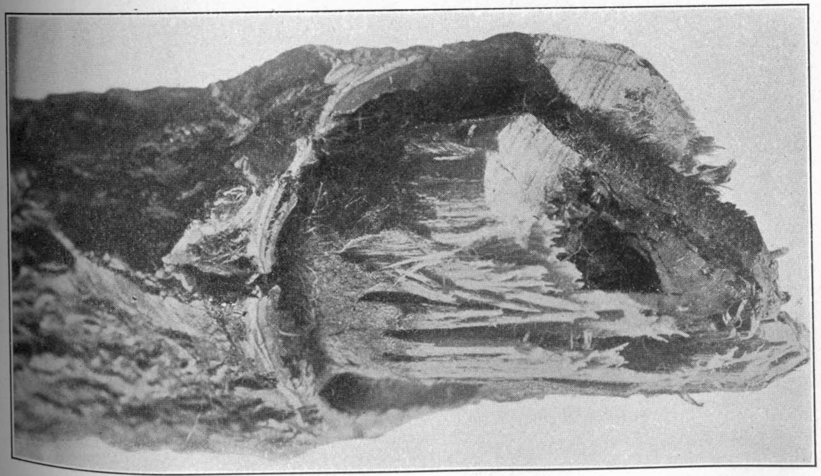
b. Wound on maple trunk beginning to heal. Pupa case above.

c. Winter resting place of larva. Natural size.

LEOPARD MOTH GALLERIES.



a. Elm branch showing galleries of the leopard moth larva.



b. Elm branch girdled by larva and broken.

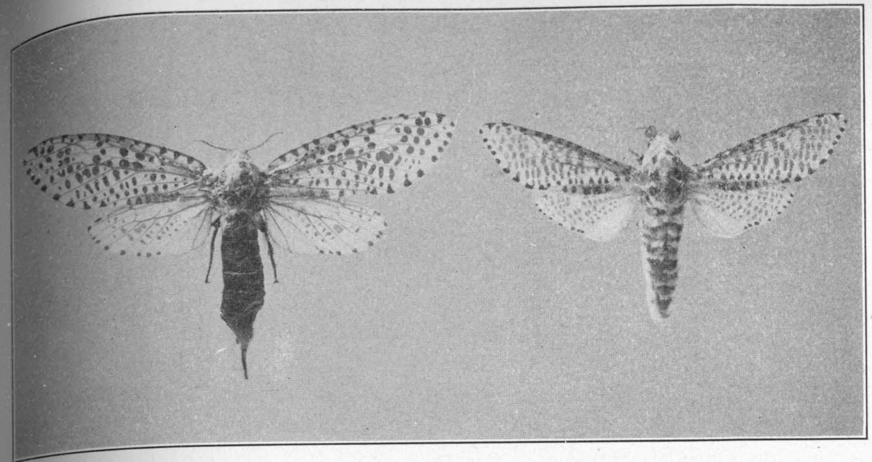
LEOPARD MOTH INJURY.

Dead branches with bark removed to show galleries.

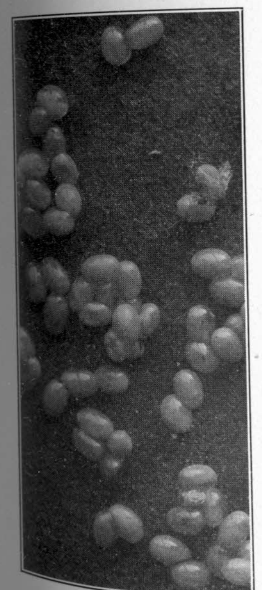
ELM BRANCHES KILLED BY LEOPARD MOTH.

Male leopard moth reared from apple nursery stock.

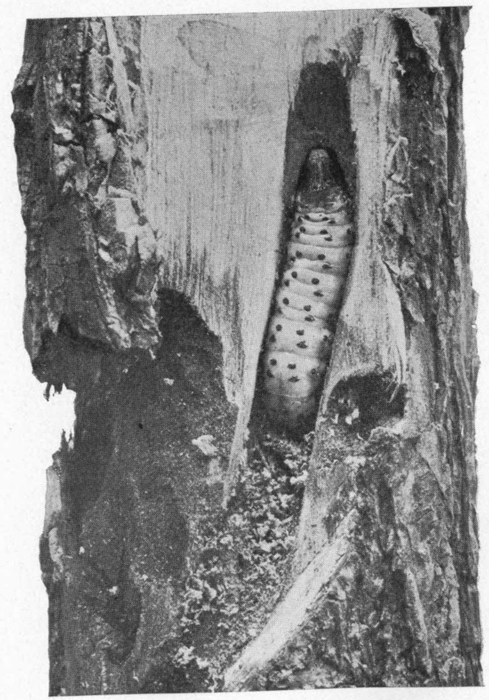
LEOPARD MOTH, JUST EMERGED.



a. Adult leopard moths, female at left. Natural size.



b. Eggs, greatly enlarged. Photo. loaned by J. W. Chapman.



c. Larva in its burrow. Natural size.

EGGS, LARVA AND ADULTS OF LEOPARD MOTH.

PART V.

TESTS OF SUMMER SPRAYS ON APPLES, PEACHES, ETC.

By G. P. CLINTON, S.D., *Botanist*, and
W. E. BRITTON, PH.D., *Entomologist*.

CONTENTS.

Introduction. Beginning in 1889, when Professor Thaxter described in the annual report for that year some miscellaneous spraying experiments with Bordeaux mixture, this Station has year by year carried on spraying experiments against the fungi and insects that attack our different fruits. The most extensive of these were made on apples and peaches in 1910, and described in Part VII, pages 583 to 618 of the Biennial Report for 1909-10. The present bulletin is a continuation and extension of those experiments. In 1910 the spraying tests were made in seven different apple orchards in different parts of the State, and something like 317 apple trees, varying from those just set out to large trees, were given from one to four treatments. There were also sprayed 160 peach trees in four different orchards. To determine the results, the trees were not only watched during the season, but at harvest 60,000 apples and 25,000 peaches were individually examined, and the presence of each particular spray, fungous and insect injury was recorded.

In the work of 1911, reported in the present paper, we not only continued and extended the spraying work with apples and peaches, but also made some miscellaneous experiments, in a smaller way, on pears, quinces, plums, cherries and currants. The number of trees and bushes that were sprayed from two to three times during the year were apples 688, pears 25, quinces 8, peaches 231, plums 42, cherries 156, currants 90.

To determine the results of this year's tests, there were examined and noted as previously 93,000 apples and 24,000 peaches, thus making for the two years' examination 153,000 apples and 49,000 peaches. These experiments have thus been extensive and varied enough to justify some general conclusions regarding the summer spraying of apples and peaches in this State, especially concerning the fungicidal efficiency and probable spray injury of commercial lime-sulphur sprays as compared with Bordeaux mixture. As these were the chief points under investigation, the main experiments are now concluded and reported here.

A 50-gallon barrel of spray mixture will thoroughly spray from four to ten large to medium-sized apple trees and, as a rule, from ten to eighteen medium to small trees. A barrel of mixture will cover from twenty to thirty-five bearing peach trees, according to their size.

We have tried a great variety of spraying apparatus in these experiments, making most use of that employed at the farm where the experiments were conducted. Two of these were gasoline power sprayers, of which that used at the Henry farm, shown in Plate XVII, a, proved to be a very compact and useful type. Ordinarily, however, in the smaller Connecticut orchards, the hand pump, mounted on the side of the barrel, is the most convenient form of spraying apparatus. This pump may be one of several different makes, but should be powerful enough to supply two lines of hose and keep up a pressure of from seventy-five to one hundred pounds. With the detached horizontal pumps (see Plate XVII, b), which are more powerful, a pressure of one hundred to one hundred and fifty pounds can be had, while with power sprayers even a higher pressure may often be easily

maintained. On the whole, however, one hundred to one hundred and twenty-five pounds pressure is sufficient unless one wishes a very misty spray. For orchard work the disc type of nozzles has now almost entirely supplanted the Bordeaux and Vermorel nozzles, and this type was used in our experiments. See Plate XVIII, b.

The writers wish especially to acknowledge their indebtedness to the various growers in whose orchards these experiments were carried on during the two years. Much of the details of the work of spraying and fruit examination was in the hands of the writers' assistants, E. M. Stoddard of the botanical and B. H. Walden and A. B. Champlain of the entomological departments.

TYPES OF SPRAYS USED.

Cost of Materials. From dealers we have obtained prices of the materials and brands of sprays used in our experiments. These prices are those obtaining in January, 1912, f. o. b., for moderate amounts of material, such as the average farmer purchases. From these prices we have worked out the cost of the different sprays per barrel of fifty gallons. In the cost of the fungicides, however, we have not included the cost of the lead arsenate included as an insecticide, as this is not always used. As we have ordinarily used this in the paste form at the rate of three pounds per fifty gallons, and as the price ranges from seven to eleven and one-half cents per pound (when purchased in one hundred pound lots), the cost of the insecticide when used with the fungicide adds twenty-one to thirty-five cents to the cost per barrel. Neither do these prices include the cost of transportation, or making up and applying the mixtures. The following figures show the variation in prices of materials used:

Commercial lime and sulphur, $7.00 to $10.00 per barrel, according to brand, etc. Lead arsenate, paste form, $7.00 to $11.50 per one hundred pounds, according to brand, etc. Lead arsenate, dry form, $16.50 to $22.00 per one hundred pounds, according to brand, etc. Lime, seventy-five to eighty-seven cents per one hundred pounds, according to brand and size of barrels. Sulphur, $2.50 to $2.95 per one hundred pounds, according to kind, etc. Copper sulphate $5.50 to $7.50 per one hundred pounds, according to where purchased and whether ground or in crystals.

Types of Sprays. In the following paragraphs we describe the various fungicides (A to F) and insecticides (G), and have grouped them under headings indicating their general relationship.

A. *Bordeaux Mixture.* This fungicide is made by pouring weak solutions of copper sulphate and freshly slacked lime water together, or the former into the latter, thereby producing a mixture with a blue suspended sediment of copper hydroxide, which is generally considered the fungicidal agent. Ordinarily the home-made mixtures are superior to the commercial ones, as well as cheaper. For years Bordeaux mixture has been the standard fungicide for the treatment of a great variety of fungous diseases. Owing to its tendency to russet the fruit and burn the foliage of apples, especially in wet seasons, there has been a demand, particularly in recent years, when any blemish on an apple is apt to detract from its commercial value, for some modification of Bordeaux mixture, or the substitution of some fungicide of equal value that will not so injure the fruit and foliage. Weather conditions, especially late spring frosts, also seem to be important factors in the russeting of apples, since in some years there is considerable russeting of certain varieties that have not been sprayed at all.

Our experiments have shown that on the whole Bordeaux has the best fungicidal value of any of the sprays tried, and in 1911, when we used the weaker strength, not nearly so much russeting resulted. Ordinarily Bordeaux is used in the 4–4–50 formula; that is, four pounds copper sulphate, four pounds of fresh lime, and fifty gallons of water. This strength we now believe should be used on apples only in the first spraying, on the unfolding leaves, before the blossoms have opened. The subsequent sprayings should be of the 1–4–50 formula, that is, using only one pound of copper sulphate. Lead arsenate is the insecticide commonly used with Bordeaux, and apparently this is not responsible for the russeting or burning, as that occurs with Bordeaux used alone. Compared with the commercial lime-sulphur sprays, even weak Bordeaux is apt to produce more russeting on such susceptible varieties as Baldwin. The cost of the home-made Bordeaux per barrel varies with the strength used, as follows: 4–4–50 formula, from twenty-five to thirty-four cents; 1–4–50 formula, from eight to eleven cents. This would make the average cost of material for three sprayings, one of the 4–4–50 and two of the 1–4–50 strength, from fourteen to nineteen cents per barrel.

B. *Commercial Lime–Sulphurs.* These are preparations of lime, sulphur and water boiled together in certain proportions, usually 60–125–50, whereby a certain amount of lime and sulphur combine forming soluble polysulphides of lime, which represent the fungicidal and insecticidal ingredients of the amber-colored liquid as it appears on the market. The lime-sulphur solution was first used in the West, and has been used extensively for eight or nine years in Connecticut, on dormant trees to kill San José scale, but during the past three or four years it has been considerably used in much weaker solution as a summer spray for fungi. The different brands, as placed on the market in concentrated form, usually test from twenty-six to thirty-four degrees Baumé. The common practice is to use from one to one and one-half gallons of these concentrated solutions to fifty gallons of water for summer spraying. The strength of the lime-sulphur solutions, both concentrated and diluted, may be determined by the use of hydrometers* if they do not contain other matters, like salt, etc.

Numerous tests of commercial lime-sulphur solutions as summer sprays for apples by various experimenters during the last few years have given encouraging results. Some of these tests have shown a fungicidal value nearly equal to that of Bordeaux, while the injury to the fruit and leaves has been considerably less, especially as regards russeting of the fruit. Our tests in 1910, when apple fungi were not very troublesome, showed these sprays to have nearly the same fungicidal value as Bordeaux mixture, and to cause very little russeting as compared with the latter. In 1911, however, when fungi were much more abundant, we did not get such uniform results in controlling them, especially the sooty blotch, with lime-sulphur sprays as with Bordeaux. There was also some russeting and considerable scald (more of the latter than with Bordeaux), especially with certain brands. It

* Hydrometers made especially for testing lime-sulphur solutions may be purchased from the Bausch & Lomb Optical Company of Rochester, N. Y. While these are valuable for testing the concentrated solutions, we are inclined to believe that their use by orchardists in making up dilute solutions will be limited.

is quite unlikely that scald will usually be as prevalent as last season, since the unusual hot weather in July was responsible for scald on some apples not sprayed at all.

The insecticide commonly used with the lime-sulphur sprays is lead arsenate, and there is some question whether or not the injury is due to it. Used alone, lead arsenate in our experiments has not caused as much injury as when used with lime and sulphur. This seems to indicate that it is the combination of the two that produces the injury. The recent work of Stewart of Pennsylvania seems to show that the injury can be largely eliminated by the use of pure lead ortho-arsenate. When this is used with the lime-sulphur no soluble arsenate, which is known to be very injurious to vegetation, is formed. While the lime-sulphur solutions promise to be valuable as apple sprays, they have not yet been tested as long or as thoroughly as the Bordeaux. We are not yet ready to recommend them to the exclusion of Bordeaux, especially on those varieties not so liable to russeting or on those very susceptible to fungous attack.

The concentrated lime-sulphur solutions are made on a large scale by some of our orchardists somewhat cheaper than they can be purchased of the manufacturers. It takes some apparatus and attention to details to manufacture them, and for the ordinary grower it is apparently cheaper and more satisfactory in the end to buy the commercial brands. Their cost, diluted ready for use in the orchard, depends somewhat on the amount used. At the rate of one and one-quarter gallons they cost from seventeen and one-half to twenty-five cents per barrel of spraying mixture, according to the brand used. As there is no sediment, lime-sulphur is easily diluted and applied, and when diluted is not nearly so disagreeable in spraying as when used as a winter spray. The following are the brands used in our experiments:

Blanchard. This was used in two apple orchards each year, and gave fairly good results as a fungicide. Very little leaf injury or russeting resulted, though a little scald showed in one orchard in 1911. It was used without lead arsenate in one peach orchard in a small way in 1911, at a strength of 1–150, and gave fairly good results in controlling scab, with very little injury to the foliage, and none to the fruit. The density test in 1911 was 31° Baumé at 24° C.

Grasselli. In 1910 this was used in three apple orchards, and in 1911 in two apple orchards and one peach orchard. It gave fair results as an apple fungicide in 1910, but in one orchard in 1911 it did not control sooty

blotch nearly as well as did the Bordeaux. There was no conspicuous leaf injury, and as a whole not much russeting, though in the Stevens orchard in 1911 this injury was nearly as conspicuous as that on the Bordeaux trees, while there was even more scald. Considerable injury to the peach foliage resulted in the Henry orchard when used at the rate of 1–150 with lead arsenate added. In 1910 it tested 33¾° B. at 23° C., and in 1911 32¾° at 15½° C.

Niagara. This was used only in 1910, in four apple and one peach orchard. This brand was said to have some lime sediment in it to prevent burning. It showed fair fungicidal value, and gave about the same amount of russeting and leaf injury as did the other brands used in the same orchard. In one case quite a little scald resulted on a certain variety. On peach foliage, used at a strength of 1–75 with lead arsenate added, some little injury resulted, less, however, than might be expected at this strength. It tested 33¼° B. at 23° C.

Sherwin-Williams. In 1910 this was tried in four apple orchards, and in 1911 in four apple orchards and one peach orchard. Comparatively little russeting or leaf injury was noticed from it on apples, and only a little scald in 1911. A little injury to cherry and peach foliage was noticed in 1911, but not at all conspicuous. It seemed to have fair fungicidal value. In 1910 it tested 33½° B. at 23° C., and in 1911, 34° B. at 12° C.

Sterling. This was not tried in our general spraying experiments, being used only on a few trees in our Centerville orchard in 1911 to note its effect on foliage. No conspicuous injury resulted at a strength of 1–50. It only tested 29½° B. at 21° C.

Thomsen. The results of this spray, which was used in two apple orchards only in 1911, were rather unsatisfactory, as in both cases more or less leaf injury (see Plate XX, b), some scald, and in one case considerable russeting, resulted. It did not give as good results in preventing sooty blotch, etc., as did the Bordeaux and another lime-sulphur used in the same orchard. The strengths used were 1¼ and 1 to 50, with lead arsenate added. It only tested 29° B. at 21° C.

Vreeland. This was used only in a small way in one apple orchard in 1911. No very evident injury to the foliage or fruit resulted from two sprayings at a strength of 1¼–50, with lead arsenate added, but more sooty blotch developed than on the Bordeaux trees, though considerably less than on the checks. It tested 34° B. at 15° C.

C. *Self-boiled Lime-Sulphur.* This is a home-made lime-sulphur preparation, and contains only a small amount of polysulphides in solution, with a large amount of free sulphur and slaked lime as sediment. The sulphur is brought into solution only by the heat developed by the slaking lime. It was first advocated by Scott, of the United States Department of Agriculture, as a substitute for Bordeaux on apples, and later as the best spray for peaches.

We have made the 8–8–50 formula as follows: Eight pounds of fresh lime are started slaking in a barrel with a little water (warm water preferably in cool weather) and when the mass has begun to heat in good shape, eight pounds of sulphur flour is quickly sifted in and thoroughly stirred with the slaking lime. This, at the consistency of a rather thick paste, is allowed to heat for fifteen minutes from the time the sulphur is added, when it is cooled down with additional water. The mixture is stirred and strained into the spray barrel to remove the coarser sediment, and diluted to the fifty gallons.

The trouble in making this mixture is even greater than in making Bordeaux, and there is more bother in spraying because of the coarser sediment. It possesses fungicidal value almost equal to Bordeaux, and apparently somewhat better than the commercial lime-sulphur at one and one-quarter strength. It varies, however, in strength and value with the heat developed in boiling it, and as a rule it is better, in order to obtain sufficient heat, to make it up in three-barrel lots at a time.

We used this fungicide in three apple orchards in 1910, and in two in 1911, also in our experimental orchards at Centerville. We used it each year in all of the peach orchards that were sprayed, also somewhat on cherries, plums and currants. While it has considerable merit as a fungicide on apple, it has caused some russeting and scald, though not nearly as much russeting as Bordeaux, but about the same as the commercial lime-sulphur. Taking everything into consideration (difficulty of making, some injury, fair to good fungicidal value), we see no particular advantage in its use as a fungicide for apples. For peaches, however, and likewise for cherries and plums, where there is always danger of burning from Bordeaux, and also often from the commercial lime-sulphurs, especially if used with lead arsenate, we believe that it is the best fungicide to use, especially since it has given very good results, and produced on the whole the least injury of any spray tried. Its cost per barrel varies from twenty-six to thirty cents.

D. *Miscellaneous Sulphur Sprays.* We include under this heading several commercial sprays differing from straight lime-sulphur in having some other substance than lime and sulphur entering into their composition. These sprays have caused more injury than the others to foliage when used as directed by their manufacturers. Apparently, in some cases at least, this is due to the use of some caustic other than lime, such as soda or potash, to bring the sulphur into solution, and this alone, or when combined with an insecticide, produced more or less serious injury to the foliage. The three brands that we have used are as follows:

Sulfocide. This is a somewhat darker and more viscid substance than the commercial lime-sulphur solutions. It has been used in two apple orchards, one each year, besides in our Station experimental orchard, and in two peach orchards. It cannot be used with lead arsenate, because a soluble arsenate is formed that severely burns the foliage. In 1910, with Paris green, one-half pound to the barrel, but without lime added, we found it producing more or less injury both to apples, at a strength of 1–200, and to peaches at a strength of 1–400. Without the poison, at these strengths, much less injury was caused. In 1911, used on apples, as recommended by the manufacturer, at the rate of 1–300, with only one-quarter pound Paris green per barrel, and with the addition of lime, little injury resulted, but it is questionable whether at these strengths it possesses sufficient fungicidal and insecticidal values. On peaches in 1911, without poison, used in two sprayings, one at the strength of 1–500, and one at the strength of 1–600, little injury resulted, but it was too weak to do much good as a fungicide. From the results of our experiments with the spray, we do not recommend its use at all on peaches. It costs twenty-five cents per barrel at the 1–200 rate, and seventeen cents per barrel at the 1–300 rate. It tested 39½° B. at 20° C., but this means little. The manufacturers claim thirty per cent. of sulphur in solution.

Bogart's Sulphur Compound. This is a dark, rather thick liquid, something like Sulfocide in appearance. It evidently has more or less oil in it, as indicated by its rather viscid nature and low specific gravity, 16° B. at 23° C. It has been used only at the Station experimental orchard, but both in 1910, at the strength of 1½–50 and 1–75, and in 1911 at the strength of 1–100, when lead arsenate was used with it, there resulted considerable injury to the foliage. This was apparently due to the presence of the lead arsenate, since when used at the rate of 1–100 in 1911 without this poison it produced no injury. Apparently, like Sulfocide, this has some alkali present, which unites with the lead arsenate to form a soluble arsenate which is injurious to vegetation. Whether or not Paris green, with the addition of lime, could be used in it without this injury, was not determined. The cost per barrel was twenty-five cents when used at the rate of 1–100.

One-for-All. This is a paste somewhat resembling axle-grease in appearance, and is said to consist of wool grease, sulphur, and some poison. It was used only in 1910 in one apple orchard, at the rate recommended by the manufacturers, five or six pounds to fifty gallons of water, but this produced such serious injury to the foliage that it has not been tried since. Formerly this was made with an arsenite as the insecticide, and this probably explains the resulting injury. The manufacturer states that lead arsenate is now used as the insecticide. The cost was thirty to thirty-six cents per barrel, according to whether five or six pounds were used, but this included the cost of the insecticide as well.

E. *Atomic Sulphur.* This is a chemical preparation in which pure sulphur is said to exist as extremely finely divided particles. It is placed on the market both with and without lead arsenate. As sulphur alone has been long considered a fungicide of some value, and as some think that it is the sulphur finally liberated in the commercial lime-sulphur that gives its fungicidal action, there was some reason to suppose that this commercial preparation would have value. All our experiments have showed it to have a fungicidal value apparently about equal to that of Bordeaux. The Atomic sulphur comes in the form of a clay-like sediment, covered with a little water. It is rather difficult to thoroughly stir it up in this, ready for further dilution. Once diluted in the spray barrel, it requires some agitation to keep it in suspension, but remains suspended rather better than one might expect.

It was used only in 1911, at the rate of ten and twelve pounds to fifty gallons of water. In every case where used, one, and in most cases two of the sprayings, were with the form containing lead arsenate, so we cannot state what is the effect on vegetation of the Atomic sulphur by itself. It was used in one apple and three peach orchards, also on some cherries and currants. We had not expected any trouble from this mixture, and yet in every case, except with the cherries, there was more or less injury to the foliage and also considerable scald on the fruit of both apples and peaches. No doubt part of the scald can be attributed to the extremely hot weather, but in most cases it was worse with this fungicide than with others in the same orchard. Because of this injury, the difficulty of mixing, and its high cost, which amounts to ninety-three cents to $1.11 per barrel, according to strength, including the cost of lead arsenate, we cannot recommend this as highly as we could wish, on account of its evident fungicidal value.

F. *Sulphur and Lead Arsenate.* This is a home-made preparation consisting of three pounds lead arsenate paste, six pounds sulphur flour, mixed together with a little water into a paste and

then diluted to fifty gallons with water. It was based on the belief that sulphur has more or less fungicidal value. The lead arsenate helps to keep the sulphur in suspension, and causes it to adhere to the foliage. The mixture, however, requires constant agitation, and easily clogs the nozzles. It was tried in 1910 in two, and in 1911 in five apple orchards. It showed some value as a fungicide in 1910, but in 1911 seemed to be of little value, especially against fruit speck and sooty blotch. On the whole, it produced very little injury on the foliage, and very little russeting of the fruit, perhaps less than anything else tried except lead arsenate alone. On account of its poor mixing qualities, the necessity of the use of poison when at times none is needed, and its apparent low fungicidal value, we cannot recommend it for general use. It costs, including the lead arsenate, from thirty-six to fifty-two cents per barrel.

G. *Lead Arsenate, etc.* We used this chiefly in the form of paste, at the rate of three pounds in fifty gallons of water, and of the following brands: Ansbacher's, Grasselli's, Sherwin-Williams', Swift's and Vreeland's. Ordinarily no injury resulted from its use alone, in most cases the amount of russeting being no greater than that on the unsprayed fruit. It probably has some fungicidal value, chiefly by lessening insect attacks, and thereby lessening fruit speck and general rot. This was especially true in 1911, and on the whole, trees sprayed that year with lead arsenate had less sooty blotch than the check trees. While in our experiments we had no direct injury from lead arsenate when used alone, no doubt part of the injury caused by the various fungicides when used in combination with it can be traced to the formation of soluble arsenates. We have heard, however, of some cases where lead arsenate used alone, for some unaccounted reason, produced serious injury. There was one case, where part of the trees of the same variety in the same orchard and sprayed the same day had the foliage badly injured, while others did not.

In the dry form, Vreeland's and Devoe & Raynolds' were the only brands used. These were used at the rate of one and one-half pounds per barrel, and when used alone or in combination with lime and sulphur, seemed to have about the same value as the paste forms. Their relative cost per barrel is about the same, or a little higher, than the latter.

Ortho-arsenite of zinc, supposed to be especially valuable because of non-injurious action on the foliage, caused very considerable injury (see Plate XX, a) where it was used by Mr. Ives in one of his orchards. He used it at a strength of three-quarters pound to fifty gallons, and saw no injury after the first spraying, but soon after the second was made, which was seven days later than the first, the leaves began to drop, until about one-half had fallen off. We do not know the explanation of this, as the same brand tested by us in an experimental way gave no injury.

GENERAL RESULTS OF TWO YEARS EXPERIMENTS.

APPLES.

Experimental Conditions. As stated elsewhere, these experiments have been carried on in a variety of orchards in different parts of the State, under varying conditions. Some of the orchards have been well kept up as regards cultivation, pruning, fertilization and spraying, while with others the reverse has been true. The trees ranged in age from those just set out in our own experimental orchard, and those just coming into bearing in some of the commercial orchards, up to trees at least fifty years old.

We have aimed in our experiments to include at least the more common commercial varieties of the State, as well as those especially subject to fungous and insect attack. Most of our work has been on the Baldwin and Greening, as these are the two chief commercial, as well as family, varieties grown here. The following are the twenty-one varieties from which more or less extensive data were obtained: Baldwin, Colvert, Early Harvest, English Russet, Fall Pippin, Gravenstein, Greening, Hubbardston, Hurlburt, Jonathan, King, Mann, Pound Sweet, Red Astrachan, Roxbury Russet, Russet, Spitzenburg, Strawberry, Sutton, Sweet Apple, Yellow Transparent.

Our usual method was to select orchards that promised favorable conditions for experimentation, and then, just before blossoming time, those trees best suited for our purpose and which gave promise of a crop of apples, were reserved for our work. In most cases we furnished the materials, and the owners supplied the apparatus and the necessary extra labor for spraying. In the fall we aimed to be on hand when the apples were picked. Where

the apples were not too numerous, all on the tree were taken for the counts, but with a full-bearing tree, often only from 500 to 1,000 from different parts of the tree were taken. These were all examined for fungous, insect, or spray injury, and each particular kind listed. The records of each tree were kept separate, but in our tables the data from the same varieties having the same treatment are combined. The details of the results for 1910 were not published because of lack of room, and because fungous injury was not so prevalent that year. The results of 1911, however, are given in detail in the tables that follow.

In comparing the results, care has to be used not to draw unwarranted conclusions, since there is considerable variation in the manner in which the various fungicides under different conditions act in preventing fungous and insect attacks, as well as in causing injury. There is also great difference in the susceptibility of different varieties to attack, in abundance of fungi and insects present in different seasons, or in different orchards, and even on different trees in the same orchard. The safest method is to compare only varieties in the same orchard, near together, which, except for spraying, have had exactly the same treatment. We can take the same number of trees of different varieties in one or more orchards and fairly safely compare one treatment with another. In our tables we have even sometimes combined the data when the varieties were not the same, so that extra care is needed here in judging the combined figures. However, we have given sufficient data for one to judge of the combinations made and the conditions that existed.

Immune and Susceptible Varieties. Fungi. We have mentioned that different varieties vary greatly in their behavior toward fungi even under the same conditions. This resistance or tolerance also varies with the same variety toward different fungi. While apparently we have no variety entirely immune to any one, to say nothing of all fungi, still the difference in different varieties is marked enough to attract attention. According to our observations the varieties especially subject to *scab* are Early Harvest, Fall Pippin, Newtown Pippin, McIntosh, Fameuse, Strawberry, Wine Sap, and under some conditions, Greening. Yellow Bellflower has also been sent to the Station as a susceptible variety. On the other hand, Baldwin and Russets of various kinds are rarely injured to any extent. As regards *rust*, the following varieties have been found susceptible, some of the first mentioned being quite so: Betchel's Flowering Crab, Wealthy, Fallowater, Missouri Pippin, Hurlburt, Delicious, Jonathan, Sutton, Russet, Spitzenburg, King; and Westfield Seek-no-further, Rome Beauty and Black Twig have been sent in as susceptible varieties. Baldwin and Greening seem to be varieties not badly attacked. *Sooty blotch* was most conspicuous, at least, on green-skinned varieties, especially on Greening and Mann, and also somewhat on Fall Pippin, and while common on Russet and Baldwin, is not nearly so evident. *Fruit specks* of various kinds have appeared especially on Baldwin, Spitzenburg, Jonathan, Red Astrachan, Fall Pippin, King, and light-skinned seedlings. *Rot* is likely to occur on any variety when fully matured, but perhaps the early summer varieties, Fall Pippin, and Greening in storage, suffer more than the others.

Insects. Varieties of apples do not show as marked susceptibility or immunity regarding attacks of insects as they manifest regarding fungous diseases. On the other hand, it is well known and commonly recognized that early ripening, especially the sweet and less acid varieties, are more liable to be attacked and severely injured by the *apple maggot* or *railroad worm* than the late or very acid kinds. It is easy to understand why the early kinds are attacked, as flies of nearly all kinds are always most abundant in late summer and early fall. The adults, therefore, would naturally deposit eggs in the soft and ripening fruit rather than in the hard and immature apples. Strongly acid varieties are evidently not favorable for the development of the larvæ. It has often been observed that certain kinds of apples, especially Ben Davis and Rhode Island Greening, are more liable to be attacked by *San José scale* than other varieties. As regards *codling moth, canker worms, lice* and other insects, it is doubtful if one variety suffers more than another.

Spray Injuries. Under a preceding heading (Types of Sprays) we have discussed the injuries caused by the different sprays. Here we wish to describe the general kinds of injury. There are three types of injury, namely: *leaf burn, fruit russet,* and *fruit scald.*

Leaf Burn. This is a trouble not uncommon on the foliage with certain sprays under certain conditions. It varies with the type and strength of the spray, the presence or absence of a

poison, and with weather conditions. That caused by Bordeaux is the most common, though there are other sprays which would, under certain conditions, be much more serious, if commonly used. With Bordeaux, at least, the trouble does not usually appear until some time after the spraying, indicating, perhaps, some chemical change in the coating that produces the injury with subsequent rain. The injury takes the form of small, reddish-brown specks, or distinct circular spots about one-quarter inch in diameter, though often these run together into extended irregular areas separated from the healthy tissues by a deeper colored border. It is frequently difficult to distinguish the small circular spots produced by spray injury from those caused by the black rot fungus, which often appears on the leaves in spring without signs of a fruiting stage.

The leaves, if seriously spotted, drop prematurely, and even some of those showing little evident injury turn yellow and drop. We have seen apple trees lose from one-half to two-thirds of their foliage in this way from Bordeaux injury, and have observed even worse injury from other sprays. The Bordeaux injury is perhaps not particularly different from that of other sprays, except possibly in its slower action and the less danger of a scorch burn, which involves all, or the greater part of, the tissues. Those sprays that contain injurious ingredients, or form injurious combinations resulting from the addition of an insecticide, usually show the injury much quicker. With Bordeaux, and perhaps this is true of some other sprays, we are inclined to believe that there is much less danger of injury on the young unfolding leaves than after they are fully grown, other conditions being the same. This is probably because the sediment on the young expanding leaves is being stretched over a wider surface all the time, and there is some protection by the hairs on the under surface, the upper smooth surface being folded together on the midrib up to a certain stage of development.

We have had some little injury from the self-boiled lime-sulphur and from the commercial lime-sulphur, but not in a conspicuous way except in one or two cases. Often the injury occurred on a certain variety or on one side of the tree a little more exposed to the sun. Atomic sulphur has not injured apple foliage much, but on peach and currant there was evident injury in some places. The miscellaneous sprays, as Sulfocide, Bogart's Sulphur Compound and One-For-All, have at certain strengths, and especially with the addition of insecticides, given very serious foliage injury, so care has to be exercised in the use of these sprays, paying especial attention to their strength, and the nature and amount of the insecticide used with them. The sulphur and lead arsenate paste spray, and lead arsenates used alone, have given no injury in our experiments, though complaints have been made to the Station of lead arsenate injury under conditions hard to explain, some of the injuries seeming to be due to the brand used, and some perhaps to the manner in which it was used. We have not studied especially the variation of different varieties in susceptibility to spray injury, though no doubt this exists in some degree. In the orchard sprayed by Mr. Ives with Ortho-arsenite of zinc, he said that the leaves of the Sutton Beauty trees suffered much less than those of other varieties, and we have had much less injury on this variety in our experiments.

Russeting. This is an injury of the fruit first showing while still small, and continuing about as evident when mature, in which the skin of a naturally smooth variety is more or less roughened after the manner of a russet apple. When very badly russeted, apples are sometimes more or less stunted in their growth, and occasionally show conspicuous cracks. No spray that we have tried develops this trouble as frequently or as badly as Bordeaux. Sometimes the self-boiled, and certain of the commercial lime-sulphurs (especially Thomsen's and Grasselli's in 1911), have caused some trouble of this kind. Dilute Bordeaux is not so liable to produce conspicuous injury, and we are now recommending that where this spray is used on the young fruit it be only of the 1–4–50 formula, though the first spraying, on the unfolding leaves, may be of the 4–4–50 strength, because of its greater fungicidal value at a critical time for scab. Of the varieties in our experiments, Baldwin showed the worst russeting. We also had serious injury on Pound Sweet, Early Harvest and Yellow Transparent, one case each. Greening, Jonathan and Spitzenburg developed more russeting than the average varieties, while Sutton and Russet developed the least. In the case of the Russets, of course, this is a natural condition, and would not show as an injury except when very prominent. An apple moderately russeted is not as imperfect an apple as one with a moderate

amount of scab or sooty blotch, so that the cure is not quite so bad as the disease, if it does not affect a greater per cent. of the fruit, which, however, is sometimes the case.

Scald. This is an injury of the fruit (see Plate XIX, b) in which a deeper and continuous russeting of the tissues takes place, usually on one side or end. Like russeting, it occurs when the fruit is of small size, but is apt to become more prominent with its growth. In fact, the tissues often crack open and offer entrance to fungi, producing a subsequent dry rot. This trouble was much more frequent in 1911 than in 1910. While occurring somewhat more conspicuously with Atomic sulphur than with other sprays, it was also occasionally found on fruit sprayed with self-boiled lime-sulphur, Bordeaux, and some of the commercial brands of lime-sulphur. Some little scald was found on the unsprayed apples, but never as much as on the same varieties when sprayed. Those varieties on which the most scald was found were: Jonathan, Spitzenburg, King, Early Harvest, Baldwin, Greening and Russet.

Relation to Weather. There are two ways in which weather bears on the problem of spraying, first by increasing or decreasing fungous or insect troubles, and second, by increasing or decreasing injury from the sprays used. It is not our purpose here to discuss at length the relationship of weather and fungi. It is quite generally known that a wet season as a whole is favorable for more general and extensive development of these pests than a dry one; likewise, there is considerable connection between their extensive development and the kind of weather at certain periods of the year. These remarks apply as well to the diseases of peach, etc., as they do to the diseases of apples. For instance, a cold, wet spring means an unusual development of rust and scab of apples, and peach leaf curl. Wet weather in late August and early September means that there will be serious rotting of peaches, and is favorable for the development of the sooty blotch of apples.

The relationship of insects to weather is perhaps not so marked as that of fungi, but severe winters help to decrease San José scale, and perhaps other insects. Dry weather in spring and early summer is liable to develop aphid troubles.

It is, however, more particularly of the relation of spray injury to weather that we wish to speak. It is quite evident that the amount of russeting of apples varies greatly in different seasons, as shown by the percentages on the same varieties in 1910 and 1911 (see Table I), much more injury showing in the former year. It is also equally certain that russeting frequently develops independent of any spraying, as shown by our check trees of the different varieties each year. It is ordinarily believed that Bordeaux russeting is much worse in a season wet at the time of spraying than in one dry at that time. We believe that equally injurious are the late spring frosts, coming after the fruit has set, and to this source we attribute much of the russeting, banding and cracking found on unsprayed apples.

Scald also is certainly closely related to weather conditions, as it occurs somewhat on unsprayed fruit. It develops on the outermost apples and usually on the exposed side of the tree, namely, east of south to west of south. It developed in 1911 during the unusually hot weather of June and July. This summer was so unusual as regards heat and drought that we need not expect scald to be as common in ordinary years. While scald may apparently result as a burn, due to the presence of moisture on the fruit in the hot sun, still there is no doubt that part of it is due to chemical irritation, since it was worse with some sprays than with others.

Spray injury to the leaves, especially of the scorch type, may also bear some relation to weather conditions, such as bright sunshine at the time of spraying. Rains or dews help to dissolve chemical substances from the spray coating, which has gradually been changing in nature, and so perhaps bring about injury in time. A scorch type of leaf injury is sometimes seen on trees that have not been sprayed. Whether or not this may be due to water on the leaf in the presence of the hot sun, as is sometimes claimed, we do not know. We think, however, that it is sometimes due to a lack of sufficient moisture to replace that lost by unusual evaporation, as in the case of young trees recently set out. Because of the apparent relationship between spray injury and weather conditions, some writers have advocated that spraying should not be done on unusually bright days, especially in the hottest part of such days. We have no data along this line, but if, as others claim, the best results in preventing fungous diseases of the apple are obtained by spraying just before a rain, the

Table I.—Condensed Results of Apple Spraying Experiments in 1910 and 1911.

Treatments.	Varieties.	Apples counted in 1910.	Apples counted in 1911.	Per cent. Perfect.		Per cent. Russet, etc.		Per cent. Fungi, etc.		Per cent. Chewing Insects.		Per cent. Sucking Insects, etc.	
				1910.	1911.	1910.	1911.	1910.	1911.	1910.	1911.	1910.	1911.
1. Bordeaux Mixture	Baldwin.	6552	5203	49.2	74.7	42.9	16.9	1.0	2.8	7.7	4.1	.5	2.0
	Greening.....	1196	6522	64.9	76.3	19.5	10.5	6.5	3.2	19.0	6.9	.3	3.7
	Pound Sweet.	622	0	6.9	0	89.5	0	2.3	0	20.1	0	....	0
	Russets	1065	2743	64.9	84.7	.8	.1	9.5	2.2	26.0	11.2	....	2.0
	Spitzenburg .	0	763	0	68.8	0	11.5	0	3.9	0	17.3	0	.7
	All others....	0	6927	0	68.8	0	17.7	0	2.9	0	7.8	0	3.6
	*Totals..	9435	22158	50.2	74.4	38.2	13.0	2.8	2.9	12.0	7.4	....	2.9
2. Commercial Lime-Sulphurs	Baldwin......	11476	8240	65.9	71.2	22.2	14.4	3.1	11.6	9.4	3.8	.2	.6
	Greening	187	3991	56.7	80.5	11.2	3.5	4.3	6.5	38.0	5.3	....	4.3
	Pound Sweet.	4626	0	88.1	0	....	0	5.4	0	7.0	0	....	0
	Russets......	1563	213	66.3	76.5	.4	4.2	10.0	3.8	24.3	13.6	....	2.3
	Spitzenburg .	0	311	0	75.2	0	10.6	0	1.1	0	13.2	0	0
	All others....	5268	5535	84.5	86.5	2.5	5.7	5.0	1.8	7.7	6.0	.4	.1
	Totals...	23120	18290	74.5	78.0	11.7	9.2	4.5	7.2	9.8	5.1	....	1.3
3. Self-boiled Lime-Sulphur	Baldwin.....	3945	1092	66.8	69.0	22.8	1.8	.9	13.0	9.2	14.7	.4	1.6
	Greening	305	369	48.8	72.1	12.1	2.4	8.8	4.6	37.0	17.1	....	4.3
	Russets......	434	707	50.5	66.2	0	2.7	14.1	4.5	39.6	22.1	....	6.1
	Spitzenburg .	0	2933	0	76.5	0	8.3	0	3.0	0	12.3	0	.7
	All others ...	0	842	0	88.0	0	1.3	0	2.3	0	8.6	0	0
	Totals...	4684	5943	64.1	75.2	20.0	5.1	2.6	5.0	13.9	13.7	....	1.8
4. Sulfocide	Spitzenburg .	0	596	0	69.3	0	3.5	0	6.7	0	22.7	0	.2
	All others ...	0	1174	0	79.3	0	2.8	0	4.7	0	13.8	0	0
	Totals...	0	1770	0	75.9	0	3.1	0	5.4	0	16.8	0	.1
5. Atomic Sulphur	Spitzenburg .	0	1000	0	70.5	0	12.0	0	4.5	0	13.5	0	.4
	All others ...	0	1071	0	85.8	0	7.9	0	1.4	0	6.0	0	.2
	Totals...	0	2071	0	78.4	0	9.9	0	2.9	0	9.6	0	.3
6. Sulphur and Lead Arsenate (paste)	Baldwin.	1672	3706	72.0	69.2	17.2	8.5	1.4	18.5	9.4	3.8	.2	.7
	Greening	495	1327	90.5	69.0	....	1.1	3.6	24.6	5.9	5.7	....	0
	Russets......	0	204	0	60.3	0	0	0	28.9	0	10.8	0	0
	All others ...	0	585	0	80.0	0	2.4	0	3.2	0	14.7	0	0
	Totals...	2167	5822	76.2	70.0	13.3	5.9	1.9	18.7	8.6	5.6	....	.4
All Fungicides	Totals...	39406	56054	67.6	75.4	19.1	9.8	3.7	6.3	10.7	7.5	....	1.8
7. Lead Arsenate	Baldwin.....	1225	10164	71.5	72.9	16.7	6.3	2.2	14.9	11.2	6.2	....	.8
	Greening	0	2120	0	82.5	0	1.6	0	6.6	0	7.6	0	1.9
	Russets	587	770	69.2	46.1	.3	.9	16.0	14.9	14.8	8.7	....	41.2
	All others....	0	1204	0	88.5	0	.8	0	2.7	0	6.6	0	1.5
	Totals...	1812	14258	70.7	74.2	11.4	4.8	6.7	12.7	12.4	6.6	....	3.2
8. Checks; No treatment	Baldwin	11058	6577	60.4	36.2	19.5	12.0	3.0	34.0	17.6	25.4	1.1	1.1
	Greening	1420	4778	46.1	42.9	22.7	1.1	14.4	37.9	21.8	20.7	.2	2.0
	Pound Sweet.	638	0	71.2	0	....	0	10.7	0	19.0	0	....	0
	Russets	381	1250	24.7	46.7	....	0	11.5	13.0	68.2	40.7	....	2.8
	Spitzenburg .	0	1849	0	48.4	0	1.8	0	25.0	0	30.6	0	.8
	All others....	4433	8070	73.6	69.4	.3	1.4	5.0	11.4	21.2	17.3	....	1.9
	Totals...	17930	22524	62.1	51.1	13.9	4.4	4.9	24.8	20.0	22.8	....	1.7

* Per cents. of "Totals" in all of these tables represent per cents. figured from the total counts and not the average of the per cents. given.

selection of this cloudy period, when possible, may lessen spray injury and increase spray efficiency.

Spray Benefits. The benefits that result from spraying depend largely upon four factors: (1) fungicidal and insecticidal efficiency of the sprays used; (2) number, thoroughness, and dates of application; (3) freedom of the sprayed plants from spray injury; (4) relative abundance of fungous and insect pests. We have already discussed most of these points rather fully, and so confine our remarks here chiefly to the general results of our two years' work.

Fungi. There is considerable variation in the prevalence of fungous troubles on apples in different years, and even in the same year in different orchards. The former variation depends upon the weather conditions we have already discussed, and if we could forecast these we might be able to determine beforehand whether or not an orchard should be sprayed, and if so, how frequently. While it may not be quite so essential to spray each year in this State for fungous troubles as for insects, still, it seems on the whole a paying and necessary procedure for first-class apples. The results, however, will not always be equally good each year or in each orchard, because of variations in the four factors mentioned above.

On the whole, as far as fungi are concerned, there is no need for a winter or a dormant treatment of the trees, and this is desirable for insects only in the case of the San José scale, when the lime-sulphur sprays or the miscible oils can be used to advantage. Our remarks, then, apply only to summer spraying. In this State three sprayings keep most of the fungi and insects under control, and where fungi, especially scab, are not abundant, these may be reduced to two by omitting the first one, on the unfolding leaves. Where an orchard has been sprayed year after year we have found that as a rule the fungous troubles are less prominent than insect pests if spraying is omitted for a year. This is probably because certain of the fungi, as scab, black rot, and sooty blotch, can carry over on the branches, and repeated spraying has more or less cleaned them out there. For the same reason they are more conspicuous in an orchard that has not been sprayed for some time.

With three sprayings, having lead arsenate in the last two, we find that if the right fungicide is used, apple scab, sooty blotch,

fruit speck, rot and codling moth are fairly well controlled, and these include the worst of our fungous and insect pests. On the other hand, such treatment does not give decided control of rust or black rot on the leaves. Complete removal of the diseased branches, combined with spraying, is helpful with the latter trouble, but the prevention of rust evidently requires the continuous coating of the leaves from the time they first appear in early May until the middle of July, when all danger of infection from the "cedar apple" stage is over.

The development of the various fungi on the sprayed and unsprayed trees is shown by the following table taken from all of the sprayed and unsprayed trees in 1911. Baldwin spot, while not a true fungous trouble, is included because it is often difficult to distinguish in field examination from the real fungous fruit specks. From this table it is seen that sooty blotch and fruit speck were by far the worst troubles on the unsprayed trees, and that these were greatly reduced by the treatments. The total results of all the Bordeaux treatments show that these troubles were reduced still further by that fungicide, since with it only .4% fruit speck and 1.1% sooty blotch developed. The combined data follow:

Percentages of Fungous Diseases on Sprayed and Unsprayed Apples.

	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.
All fungicides......	0.6%	0.9%	0.8%	0.1%	0.1%	3.6%
All checks..........	1.3%	6.5%	2.1%	0.1%	1.5%	13.3%

Insects. The benefits of the treatment as regards injury from the attacks of the codling moth, lesser apple worm, and other chewing insects in 1911 and 1912 are seen in Table II. Lead arsenate is slightly more effective against the codling moth when used alone or with plain sulphur than when combined with any of the fungicides, though in commercial lime-sulphur it shows less wormy fruit than in self-boiled lime-sulphur or in Bordeaux. In 1910 there were five times as many apples showing injury by the codling moth on the unsprayed or check trees as upon the sprayed trees, and more than eight times as many on the check trees as on those sprayed with lead arsenate alone or in combination with plain sulphur. In 1911 the check trees had five times as many as the average of all sprayed trees, and more than seven times as many as the trees sprayed with lead arsenate alone or with lead arsenate and sulphur. With other chewing insects the benefit is less marked. The poison in the spray only imperfectly controls the curculio, and of course is not intended to control such sucking insects as the apple louse and San José scale. Possibly the weak lime-sulphur solutions have some slight effect on the last two, but certainly the Bordeaux mixture does not.

Table II.—Summary of Effect of all Sprays on Chewing Insects in 1910 and 1911. Percentages of Injured Fruit.

Fungicide and Insecticide Sprays.	1910.				1911.			
	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Total.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Total.
	%	%	%	%	%	%	%	%
Bordeaux and Lead Arsenate	9.27	.55	5.7	15.52	2.5	0.7	4.3	7.5
Commercial Lime-Sulphur and Lead Arsenate	5.32	.76	4.13	10.21	1.5	0.3	3.3	5.1
Self-boiled Lime-Sulphur and Lead Arsenate	8.03	3.13	10.03	21.24	4.2	1.8	7.7	13.7
Sulfocide and Paris Green*	....	....	....	....	6.7	3.1	7.1	16.9
Atomic Sulphur and Lead Arsenate†	....	....	....	....	3.9	0.9	4.8	9.6
Sulphur and Lead Arsenate	3.4	0.8	2.3	6.5	1.4	0.3	3.9	5.6
Averages of above combinations	6.11	1.22	3.57	10.9	2.4	0.7	4.4	7.5
Averages of Lead Arsenate alone	3.5	0.25	8.25	12.0	1.3	0.3	4.9	6.5
Averages of all sprayed trees	5.74	1.08	4.24	11.06	2.2	0.6	4.5	7.3
Averages of all unsprayed trees	28.82	0.86	10.5	40.18	10.1	2.0	10.6	22.7

General. Our spraying experiments with the various fungicides, including an insecticide, have not always given a higher per cent. of perfect fruit than where an insecticide alone was used. This was due to the fact that the insecticide used alone has given little spray injury, while the fungicides often produce spray injury that wipes out largely or entirely the percentage gained by lessening fungous attack. Thus from Table I we see that in 1911 the percentages of perfect fruit in the combined data of all the orchards and varieties for each treatment were

* Manufacturers' directions followed. † Poison added by manufacturer.

as follows: Bordeaux, 74.4%; all commercial lime-sulphurs, 78%; self-boiled lime-sulphur, 75.2%; Sulfocide, 75.9%; Atomic sulphur, 78.4%; sulphur and lead arsenate, 70%; all the preceding fungicides, 75.4%; all lead arsenate, 74.2%; all checks, 51.1%. The preceding year the combined lead arsenate trees had even a higher percentage of perfect fruit than the combined fungicides, due to a far greater per cent. of spray russeting resulting that year. This does not mean that orchards on the whole do not need spraying with a fungicide, but rather that they need treatment with one that will produce the least amount of spray injury. It is also to be remembered that a moderate spray injury on the whole is not as bad as a moderate fungous injury or a wormy apple.

There was considerable variation between the percentages of perfect fruit from all the sprayed trees (including both fungicides and insecticides, insecticides alone) and all of the unsprayed trees in the different orchards, as shown by the following figures. For 1910: Ives orchard, sprayed trees, 67.9% perfect fruit, unsprayed, 62.5% (partially sprayed for insects); Jones orchard, sprayed, 49.1%, unsprayed, 6%; Rogers orchard, sprayed, 73.9%, unsprayed, 67.1%; Savage orchard, sprayed, 53.7%, no real checks; Smith orchard, sprayed, 78.4%, unsprayed, 71.2% (partially sprayed for insects); Stoddard orchard, sprayed, 64.2%, unsprayed, 20.2%. For 1911: Andrews orchard, sprayed, 68.8%, unsprayed, 27.9%; Clark orchard, sprayed, 76.8%, unsprayed, 61.3%; Ives 1st orchard, sprayed, 78.2%, unsprayed, 52.2%; Ives 2d orchard, sprayed 88.8%, unsprayed, 71.7%; Jones orchard, sprayed, 68%, unsprayed, 39.5%; Smith orchard, sprayed, 79.7%, unsprayed, 74.6%; Station Mt. Carmel orchard, sprayed, 74.5%, unsprayed, 55.2%; Stevens orchard, sprayed, 75.3%, unsprayed, 49.5%; Stoddard orchard, sprayed, 76.6%, unsprayed, 24.1%. Some varieties and individual trees of course showed even greater variations between those sprayed and those unsprayed. From the above data one can in almost every case pick out by the low per cent. of perfect fruit on the unsprayed trees those orchards that had not been previously sprayed. This also means that orchards that had been well sprayed in the past did not show so great a difference between the sprayed and unsprayed trees in our experiments on this account. More specific data on sprayed and unsprayed trees as regards spray injury, fungous and insect injuries of different kinds, can be obtained from the tables printed here and in our previous bulletin.

As regards the most frequently used sprays, we have compiled in the following table their rank each year as regards most perfect fruit and least amount of russeting, fungous and insect injuries. For example, in 1911, Bordeaux produced the most russeting, was first in preventing fungous attack, fourth in lessening injury by chewing insects, and third as regards perfect fruit.

TABLE III.—RELATIVE RANK OF DIFFERENT TREATMENTS EACH YEAR AS REGARDS MOST PERFECT FRUIT AND LEAST AMOUNT OF RUSSET, FUNGI, AND INSECTS.

	Perfect.		Russet, etc.		Fungi.		Chewing Insects.	
	1910.	1911.	1910.	1911.	1910.	1911.	1910.	1911.
Bordeaux*	6	3	6	6	3	1	3	4
Commercial Lime-Sulphur*	2	1	2	5	4	3	2	1
Self-boiled Lime-Sulphur*	4	2	5	3	2	2	5	5
Sulphur and Lead Arsenate†	1	5	3	4	1	5	1	2
Lead Arsenate	3	4	1	2	6	4	4	3
Checks	5	6	4	1	5	6	6	6

RECOMMENDATIONS. For the control of fungi and insects on apples in Connecticut we make the following recommendations based on the results of our two years' experiments:

(1) Winter treatment (spraying dormant trees) is necessary only in the case of the presence of the San José scale, when commercial lime-sulphur, 1-8, or miscible oils, 1-15, may be used.

(2) As a rule, three summer treatments with a fungicide are necessary to control the fungous diseases, and the last two of these should contain an insecticide. These sprayings should be made as follows: 1st, just before the blossoms open, on the young unfolding leaves (April 27th to May 10th, according to the season and variety); 2d, right after all the blossoms have fallen (May 10th to 30th); 3d, about one month later (usually June 15th to 25th).

(3) Where fungi are not prevalent, especially scab, the first treatment given above may be omitted. Occasionally, perhaps in alternate years, where fungi are quite inconspicuous and the trees have been thoroughly sprayed the previous year, the fungicide may be entirely omitted, and only the two sprayings for insects may be given.

* Also contained Lead Arsenate. † Not used extensively in 1910.

(4) For fungicides, we recommend Bordeaux mixture of the 4-4-50 strength for the first spraying, and of the 1-4-50 for the second and third sprayings; or commercial lime-sulphur, used at a strength of one and one-fourth gallons per fifty gallons of water, for all three sprayings. The former has better fungicidal value, and the latter is less likely to produce spray injury, especially russeting of the fruit. Where fungi are prevalent, the former might be used, while with varieties russeting badly, as Baldwin, the latter is likely to prove more satisfactory.

(5) For the insecticide in the above, we recommend lead arsenate, if used in the paste form at the rate of three pounds per fifty gallons of the mixture, or if in the powder form one and one-half pounds per fifty gallons.

PEACHES.

Experimental Conditions. What we have already said regarding the details of spraying and of obtaining results for apples generally applies to our work with peaches. Our experiments have not been so extensive with the latter, either in the number of orchards (three each year) and varieties sprayed or in the types of sprays used. This was largely because summer spraying of peaches in this State has never been practiced to any extent, and also because there is more danger of injury from the spraying. As the orchards did not belong to the Station, we had to proceed cautiously so as to avoid serious injury.

Treatments were made at different times and with different numbers of applications to determine what are the best stages in the development of fruit for spraying, and how few treatments may be used for the general control of fungous troubles. The following varieties were included in the experiments: Belle of Georgia, Carman, Champion, Elberta, Greensboro, Hieley, Mountain Rose, Triumph, Waddell, natural seedlings, and a few trees of other varieties from which data were not collected.

The following sprays were tried: (1) commercial lime-sulphur, at strengths varying from 1–75 to 1–300, and of the following brands, Blanchard, Grasselli, Niagara, Sherwin-Williams; (2) potassium sulphide; (3) Sulfocide; (4) Atomic sulphur; (5) self-boiled lime-sulphur. Usually lead arsenate (Paris green in a few special cases) was used in one or two of the treatments. Because in previous experiments, Bordeaux, as weak as 2–4–50, had produced serious leaf injury, this fungicide was not included in the experiments.

Fungous Diseases and Insects. In 1910 considerable leaf curl developed in the Champion orchard under investigation, though this variety does not suffer perhaps on the whole as much as Elberta and some other yellow-fruited varieties. Neither of the two years were exceptional as regards the development of the brown rot fungus, though certain varieties especially subject to rot, such as Champion, Triumph, Waddell and Hieley, were among those under investigation. In 1910 considerable rot developed among the Champions, and a moderate amount in 1911, so that this variety offered the best test for controlling this disease. Among the varieties that scab badly are Elberta, Hieley, Carman, Waddell and natural seedlings. On the whole, the conditions for testing the efficiency of spraying against scab were fair each year, so that the most satisfactory results were obtained for this trouble.

As regards insects, while the sawfly was not abundant in any of the orchards, our entomologists had worked out the control of this in other experiments. Curculios were sufficiently abundant to determine how effective and necessary for their control was the addition of poison.

Spray Injury. The foliage and young twigs of the peach are more susceptible to injury from sprays than those of the apple. What has been said in regard to the influence of weather conditions on spray injury to apples applies in large part to peaches also, although the russeting type of injury does not occur. There are three general types of injury, namely, foliage burn, twig burn, and fruit scorch. The foliage injury differs from that of apple in that the tissues of the injured spots usually drop out, leaving a shot-hole effect much like the bacterial spot of peach leaf. When the injury is very severe, the leaves are partly or entirely shed, and the injury also shows on the young twigs as reddish or purplish spots much like those caused by the scab fungus. These twig burns sometimes entirely encircle the stem, and kill it. The scorch injury to the fruit did not occur in our experiments until 1911, when the hot weather at spraying time was largely responsible for its appearance. The scorch is hidden somewhat by the hairs, but shows as a larger or smaller area usually on one side, in which the tissues are of a darker color, and often crack, thereby favoring decay by brown rot.

In 1910 our experiments emphatically demonstrated that insecticides like lead arsenate, and also Paris green, could not be used with such sprays as potassium sulphide and Sulfocide without serious injury to the trees, not only causing the foliage and fruit to drop, but killing the young twigs, and even the tree itself under some conditions. Potassium sulphide alone had been used by Sturgis in this State years before, with fair success, and we also found that, without poison, used at the rate of one pound to fifty gallons of water, it caused very little injury. Sulfocide used alone at the rate of 1–400 produced only a little foliage injury, and practically none at 1–500 and 1–600.

The commercial lime-sulphurs gave variable results, but our test conditions with these were not all the same. We believe that part of this difference was due to the brands used, since with some we got more injury than with others. However, we believe that the use of lead arsenate in these was responsible for considerable of the injury, especially when it occurred where the commercial lime-sulphur was made as weak as 1–150. But before a positive statement can be made it will be necessary to test the different brands under conditions precisely alike in all respects. Without more definite data we cannot recommend the use of a poison with these sprays, and they should not be used stronger than 1–150. Even at this strength we recommend the grower to do more or less preliminary spraying with his selected brand before bringing it into general use in his orchard.

Atomic sulphur, usually containing lead arsenate and used at the rates of ten and twelve pounds to fifty gallons, caused more injury in some tests than in others. We got from a little to considerable leaf injury, twig injury in one case, and more fruit scald than with any other spray used on peaches in 1911. All of the peaches sprayed with Atomic sulphur had lead arsenate in at least one of the applications and from the variation in number and time of the applications, we are inclined to believe that the lead arsenate was largely responsible for the injury.

Self-boiled lime-sulphur (8–8–50) gave by far the least injury of any of the fungicides, even with lead arsenate present. In fact, we have had only a very little leaf injury in a few cases, no twig injury, and comparatively little fruit scald. In 1911, in the Jones orchard, we found that when lead arsenate was used with the self-boiled lime-sulphur the trees showed a little more fruit scald, with no special difference in leaf injury, which was inconspicuous in both cases.

With self-boiled lime-sulphur, the chief harm is likely to come from too late spraying, especially in a dry season, when the spray will show on the fruit as a white sediment. The rains may wash this all off from the upper side, but still leave it somewhat apparent on the under side. In this State, if no treatments are made after the tenth of July, this sediment will so largely disappear through rains and the growth of the fruit that only in exceptionally dry years on very early varieties will any harm occur. Only the looks of the fruit are affected, the taste does not seem to be injured. Handling them for marketing will also wear off much of the sediment. We had very slight trouble of this kind with one very early variety in 1910, and none at all in 1911.

Lead arsenate, when added to the fungicide, often gives a higher color to the fruit, especially when it causes a slight injury. This was particularly noticeable with Atomic sulphur in one case, where small reddish-purple specks occurred on the skin, but not prominent enough to constitute an injury.

Benefits: Fungi. The prevention of leaf curl was tested only in the Jones orchard on the Champion, which is not especially subject to this trouble. However, enough evidence was gathered both years to show that commercial lime-sulphur used as strong as 1 to 8 or 9, if applied just as the buds begin to swell, will practically prevent this trouble. Of course this treatment takes care of the San José scale at the same time. This dormant treatment, however, had little or no effect upon scab or rot. In 1910, all of the trees having this winter treatment gave just as high a per cent. of scab, and practically as high of rot, as did those not having it, neither lot having any summer treatment. In 1911, all the trees having this winter treatment and three summer treatments did not give any lower per cent. either of scab or rot than those that received only the three summer treatments.

Brown rot, as stated before, was not serious either year, yet it developed quite prominently upon the Champion checks in the Jones orchard, especially in 1910, so we have to judge of our results in preventing this trouble from our experiments in this orchard on this variety. So far as we can judge from these

experiments, commercial lime-sulphur, Atomic sulphur, and self-boiled lime-sulphur were about equally effective in controlling the rot. In 1910, the per cent. of rotten peaches on all the trees sprayed with commercial lime-sulphur and self-boiled lime-sulphur was 23.3% as against 61.5% on the unsprayed trees; while in 1911 the total rot from all the trees sprayed with commercial lime-sulphur, self-boiled lime-sulphur and Atomic sulphur was 4.4% as compared with 13.5% on the unsprayed trees. In these experiments the peaches were picked as they ripened, the rotten ones being removed at each picking. The keeping quality of the sprayed fruit is better than that of the unsprayed, as shown by tests of sound peaches sprayed with self-boiled lime-sulphur as compared with sound unsprayed peaches, the former keeping at least two or three days longer on the average. Three days after picking, 78% of the unsprayed fruit had rotted as compared with 18% of the sprayed fruit.

The scab as well as rot was controlled about equally well by commercial lime-sulphur, self-boiled lime-sulphur, and Atomic sulphur. This trouble was abundant enough in all the orchards and on most of the varieties each year to give fair tests as to its control by each of these fungicides. In the Jones orchard in 1910 all the peaches sprayed with the commercial lime-sulphur and self-boiled lime-sulphur showed 4.5% scab against 13% on all the unsprayed. In the three orchards experimented with in 1911, the per cents. were as follows: Jones, sprayed, 2.1%, unsprayed, 21%; Henry's, sprayed, 7%, unsprayed, 40.5%; Ives, sprayed, 1%, unsprayed, 16.3%. The higher per cent. of scab on the sprayed trees in the Henry orchard over that in both the Jones and Ives orchards is probably due to the omission in this orchard of the first of the three treatments.

Insects. Again this year, as in 1910, the figures in the tables show no appreciable decrease in the percentage of insect injury by the use of lead arsenate. If the leaf-eating insects, like the peach sawfly, had been present in destructive numbers, then of course its effects would have been shown by the more perfect foliage, as has been demonstrated in previous experiments.

RECOMMENDATIONS. As a result of our experiments with peaches, we are able to make the following recommendations as regards the number and times of application, and the sprays to be used:

(1) Spraying of peaches while dormant is of value only in checking San José scale and leaf curl. One application of commercial lime-sulphur, 1-8, just before the buds begin to swell in spring, the first part of April, will take care of both of these troubles at the same time. If the scale is unusually prevalent, a previous application in the late fall of either lime-sulphur or a miscible oil, 1-15, will prove of additional value in killing it.

(2) For the prevention of scab and rot of peaches, it is as a rule desirable to give three sprayings, as follows: 1st, shortly after the blossoms have fallen (May 10th to May 25th); 2d, about three or four weeks later (June 5th to June 15th); and 3d, about one month later (July 5th to July 15th). If only two sprayings can be given, omit the first.

(3) On the whole, self-boiled lime-sulphur of the 8-8-50 formula seems to be the safest and most reliable peach spray, and this is recommended. Good results have been obtained with some of the commercial lime-sulphurs, and they are much more easily handled. There is, however, some danger of spray injury, especially with certain brands. If commercial lime-sulphur is used, a strength of not greater than 1-150, without poison, is recommended.

(4) As lead arsenate has done little to prevent curculio and as it seems to increase the danger of spray injury, we advise leaving out the lead arsenate unless there is considerable danger of sawfly injury, when it can be added in the second spraying, the same as for apples.

DETAILS OF EXPERIMENTS IN 1911.

APPLES.

In the following paragraphs we give the conditions and results in each orchard where experiments were carried on in 1911. Further details as to the results will be found in Tables IV, V. The owners or managers of the orchards were as follows: C. K. Andrews, Mount Carmel; H. E. Clark, Tuttle Farm, Middlebury; E. M. Ives, Meriden; B. T. Jones, Hamden; S. A. Smith & Son, Cheshire; W. W. Stevens, Clintonville; F. A. Stoddard, Munson Farm, Litchfield. Besides these, small orchards on the Centerville and the Mount Carmel farms of the Station were also used.

Andrews Orchard. *Conditions.* This was an orchard of Baldwins about fifteen years old that had not been sprayed, at least in recent years. No winter treatment was given this year. As it was said that fungi had not been especially bad the previous year, only two sprayings were given, corresponding to the second and third treatments, on May 25 and June 14. The following spray materials and strengths were used in each treatment:

(1) Bordeaux, 2-4-50, with 3 lbs. lead arsenate (Ansbacher's); (2) Sherwin-Williams lime-sulphur, 1-50, with 3 lbs. lead arsenate (Ansbacher's); (3) Thomsen's lime-sulphur, 1-50, with 3 lbs. lead arsenate (Ansbacher's); (4) sulphur and lead arsenate (Ansbacher's), 6-3-50; (5) lead arsenate paste (Ansbacher's), 3-50; (6) lead arsenate, dry (Vreeland's), 1½-50.

*TABLE IV.—PERCENTAGES OF FUNGOUS AND INSECT TROUBLES ON SPRAYED AND UNSPRAYED APPLES IN 1911.

Orchard.		Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	*Total* Fungous Troubles.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	*Total* Chewing Insects.
Andrews .	Unsprayed	14.7	2.9	0	0	19.5	37.1	9.8	3.2	12.8	25.8
" .	Sprayed ..	3.1	0.7	0	0	9.2	13.0	0.4	0.4	3.2	4.0
Clark	Unsprayed	0.1	0.1	0.2	3.2	3.4	7.0	10.8	0.6	12.8	24.2
"	Sprayed ..	0	0.2	0	0.9	0.9	2.0	1.9	0.7	3.1	5.7
Ives, 1st..	Unsprayed	19.2	2.7	0.3	0.1	0.7	23.0	16.5	3.8	7.0	27.3
" " ..	Sprayed ..	1.1	1.5	0.4	0.1	0.1	3.2	4.1	2.1	5.3	11.5
" 2d..	Unsprayed	2.2	0.4	0	0	0.7	3.3	8.2	9.4	3.8	21.4
" " .	Sprayed ..	0.4	0.6	0.1	0	0	1.1	0.5	0.2	2.1	2.8
Jones	Unsprayed	3.2	5.9	0.1	0	27.3	36.5	14.4	0.4	9.3	24.1
"	Sprayed ..	0.9	1.6	0.0	0	3.8	6.3	4.4	0.3	10.6	15.3
Smith	Unsprayed	0	0.6	0.3	2.9	2.1	5.9	6.9	0.3	9.0	16.2
"	Sprayed ..	0	0.3	0.1	0.2	0.1	0.7	1.8	0.2	3.3	5.3
Station ...	Unsprayed	10.7	4.8	0	0	10.0	25.5	9.5	0.7	5.5	15.7
" ...	Sprayed ..	0.4	1.4	0	0	1.6	3.4	2.4	0.1	4.1	6.6
Stevens ..	Unsprayed	3.5	1.6	0	1.5	23.5	30.1	4.3	3.0	10.5	17.8
" ..	Sprayed ..	0.3	0.8	0	0.1	8.8	10.0	1.0	0.5	5.3	6.8
Stoddard .	Unsprayed	2.6	2.3	0.1	5.7	21.8	32.5	26.6	0	25.7	52.3
" .	Sprayed ..	0.8	0.9	0.1	1.6	5.3	8.7	7.1	0.1	5.1	12.3

Results. Thomsen's lime-sulphur, made in 1910, caused considerable injury to the foliage (see Plate XX, b), while little or no injury was noticed from the other sprays. It also caused more russeting and scald on the fruit than any of the others. Bordeaux was next to it as regards these fruit injuries. There was also considerable russeting on the checks.

The Bordeaux treatment gave the highest percentage of perfect fruit, largely because it reduced to a minimum the fungous troubles, especially

* The percentages of fungi are somewhat higher on the sprayed apples than they would have been if all the treatments had contained efficient fungicides, since these totals include results where lead arsenate alone was used, and also all of the fungicides, poor as well as efficient. This is well illustrated in the case of sooty blotch in the Andrews orchard, where the average per cent. for all of the sprayings as given in the table was 9.2%, while the average for the efficient Bordeaux treatment in this orchard was only 0.9%.

fruit speck and sooty blotch, which were prominent troubles in this orchard. Sherwin-Williams lime-sulphur was second as regards perfect fruit, and while not quite as good as Bordeaux in preventing fungous troubles, was better than any of the other treatments, and caused less spray injury than the Bordeaux. The trees sprayed with lead arsenate alone had less fruit speck and sooty blotch than the check trees, thus seeming to indicate some fungicidal value for this insecticide.

In this orchard a total of 25.8%, or fully one-fourth of all the apples on the unsprayed trees, showed injury from chewing insects. Half of the damage was probably caused by the codling moth, though it is often difficult to trace the injury when slight. On the sprayed trees the injury from chewing insects was reduced to 4%. In this orchard the lead arsenate was fully as effective as an insecticide when added to Bordeaux mixture as when used alone or in connection with lime-sulphur.

Clark Orchard. *Conditions.* The trees sprayed in this orchard were very young Greenings, just coming into bearing, although some older Baldwins were also included in the treatments with lead arsenate. The orchard had been given a winter treatment by the owner. Only two sprayings were made, corresponding to the second and third treatments, on May 26 and June 16–17. The following sprays were tried: (1) Bordeaux mixture, 2–4–50, with 3 lbs. lead arsenate (Swift's); (2) Grasselli's lime-sulphur, 1½–50, with 3 lbs. lead arsenate (Swift's); (3) lead arsenate paste (Swift's), 3–50.

Results. Some, but not serious, foliage injury resulted from both the Bordeaux and Grasselli's lime-sulphur, the former causing more. The trees sprayed with Bordeaux also developed considerably more russeting of the fruit than any of the others, though the per cent. was not unusually high for this treatment.

The trees sprayed with Grasselli's lime-sulphur gave the highest percentage of perfect fruit, though this was but little higher than those sprayed with lead arsenate alone. Comparatively little injury from fungi (see Table IV), even on the checks, occurred in this orchard. The Greenings sprayed with Bordeaux, which gave the best fungicidal results, had no sooty blotch and only 0.1% scab, against 4.4% sooty blotch and 4.2% scab on the check trees. Considerable Baldwin spot developed on both the unsprayed Baldwins and those sprayed with lead arsenate.

The fruit on the unsprayed trees in this orchard showed an average of 24.2%, or about one-fourth, injured by chewing insects, but the treatment by spraying reduced this to 5.7%. Lead arsenate alone gave slightly better results than when combined with a fungicide, and the percentage of fruit injured by chewing insects was slightly greater where the lead arsenate was used with Bordeaux mixture than with lime-sulphur.

Ives (1st) Orchard. *Conditions.* This was a young orchard, about seven years old, of miscellaneous varieties, which were just coming into bearing, except the Spitzenburgs, which had borne at least one small crop. The trees had received attention as regards both winter and summer spraying in previous years, and this year had been given a spraying on the dormant trees. The apples from all the trees of the same variety and treatment were picked and counted together, as some trees had no apples, others a very few, and others a considerable number. Three applications (the first omitted in the case of lead arsenate alone) were given with each spray on the following dates: May 8, May 29, and June 19. The sprays (except Sulfocide, which contained Paris green, ¼ lb.–50, with the addition of lime) also contained Vreeland's dry lead arsenate at the rate of 1½ lbs. to 50 gallons of mixture in the second and third applications, and were as follows: (1) Bordeaux mixture, 1st, 4–4–50, 2d and 3d, 2–4–50; (2) Sherwin-Williams lime-sulphur, 1–50; (3) self-boiled lime-sulphur, 8–8–50; (4) Sulfocide, 1–300; (5) Atomic sulphur, 1st, 10 lbs. to 50 gallons, 2d and 3d, 12 lbs. to 50 gallons (brand used in 2d and 3d treatments contained lead arsenate added by manufacturer); (6) lead arsenate, Vreeland's dry, 1½ lbs. to 50 gallons.

Results. Some leaf burn resulted from the Sulfocide and more from the Bordeaux, which caused quite a few leaves to drop during the season. The Atomic sulphur produced the most scald, 7.8%, though there was almost as much from the Bordeaux and self-boiled lime-sulphur treatments. On the whole, more scald showed in this orchard than in any of the others. The Bordeaux produced far more russeting here than any of the other treatments. Though no Baldwins were among the varieties sprayed, the average per cent. of russeting of all the varieties treated with the Bordeaux was 12.3%, while that for the lead arsenate, which had the lowest percentage of russeting, was only 0.3%.

The lead arsenate gave the highest percentage of perfect fruit, while the Sherwin-Williams lime-sulphur was second, though only slightly better than two other treatments. The Bordeaux, on account of spray injury, gave the lowest percentage of perfect fruit, though it was considerably ahead of the average for the checks. Fungous troubles, except fruit speck, were not very abundant in this orchard. The Bordeaux gave the best record against these, having only 2% against 22.2%, the average for the checks. Sulfocide gave the poorest results against both fungi and insects, though, because there was little spray injury to the fruit, its percentage of perfect fruit was higher than that of the Bordeaux.

The average per cent. of fruit injury by chewing insects on all unsprayed trees in this orchard was 27.3, and on the sprayed trees, 11.5. With Sulfocide and Paris green, used here as recommended by the manufacturer, there was more injury by chewing insects than with any other combination used in the orchard. Bordeaux mixture gave results equal to commercial lime-sulphur when both were combined with lead arsenate, but the percentage of injured fruit was twice as high as obtained from lead arsenate alone. With self-boiled lime-sulphur the percentage was slightly lower than with commercial lime-sulphur. Atomic sulphur, with lead arsenate added by the manufacturer, was not as effective as lead arsenate alone.

Ives (2d) Orchard. *Conditions.* This was a mixed orchard of Baldwins and several other varieties, such as Russets, Greenings and Suttons, which had been in bearing several years. In previous years it had been well protected by both winter and summer spraying. The sprayings in this orchard were made entirely by Mr. Ives, upon suggestions given by the writers, as he wished to test the relative merits of various insecticides, and to determine how essential was the use of a fungicide. Only two summer sprayings were made, and these were rather too close together, being about ten days apart. The treatments were as follows: (1) Sherwin-Williams lime-sulphur, 1¼-50, with 1½ lbs. Vreeland's lead arsenate; (2) sulphur and lead arsenate (Sherwin-Williams), 6-3-50; (3) lead arsenate paste (Sherwin-Williams), 3-50; (4) lead arsenate, dry (Vreeland's), 1½-50; (5) Ortho-arsenite of zinc, ¾-50.

Results. Some little foliage injury resulted from the Sherwin-Williams lime-sulphur, but it was not at all serious. It also caused a little fruit scald. Very serious injury followed the second application of the Ortho-arsenite of zinc, for some unexplained reason (see Plate XX, a). This eventually caused from one-third to one-half of the leaves to drop, affecting some varieties more severely than others. This insecticide also caused more russeting of the fruit than any of the other treatments.

As the Baldwins were the only variety that set fruit on a sufficient number of trees, data were taken only for this variety. On the whole, there was very little difference due to the different treatments in the percentage of perfect fruits, as all ran high, the Vreeland's dry lead arsenate giving the best results. The average for all was 88.8%, as against 71.7% on the check apples, which, however, were all from one tree. The percentage of fungous injuries in this orchard was so low, being only 4.6%, including Baldwin spot, on the checks, that very little was gained by adding a fungicide to the insecticide, especially as spray injury was increased somewhat by this.

In this orchard the sprayed trees showed an average of only 2.8% of injury from chewing insects, while the unsprayed tree gave 21.4%. The lowest percentage came from the use of Ortho-arsenite of zinc, but on account of the leaf injury caused by this poison in the orchard it is not to be recommended until further tests have been made. Next, the dry lead arsenate (Vreeland's) gave the lowest percentage of injury, though the difference between this and lead arsenate added to sulphur and to commercial lime-sulphur was very slight.

Jones Orchard. *Conditions.* This orchard was about fifteen years old, and contained a variety of apples, but chiefly Baldwins, Greenings and Russets. It had never been sprayed before, except a few of the trees which were included in our experiments of last year. The trees received no winter treatment this year, but had the previous year. The orchard was situated on a hillside, and not having been cultivated recently, suffered severely from lack of moisture during the past dry years. As last year fungous troubles, except rot, which was bad, had not been serious, only two sprayings, corresponding to the second and third, were given on May 22 and June 16. The treatments were as follows: (1) Blanchard's lime-sulphur, 1¼-50, with 3 lbs. lead arsenate; (2) self-boiled lime-sulphur, 8-8-50, with 3 lbs. lead arsenate; (3) lead arsenate paste, 3-50.

Results. No very noticeable foliage injury resulted from any of the treatments. There was also very little russeting. A little more scald occurred on the trees sprayed with Blanchard's lime-sulphur than on those receiving the other treatments, but even this was not bad.

Blanchard's lime-sulphur gave the highest percentage of perfect fruit (with the self-boiled second), showing 74.4 as against only 39.5 on the check trees. There was considerable fruit speck, rot and sooty blotch, especially the last, on the unsprayed trees. The lead arsenate alone seemed to have considerable fungicidal value, when compared with the checks. Sooty blotch on an old Greening tree (see Table V) on a different part of the farm ran as high as 47.8%, showing how prevalent this trouble may become on neglected trees in a favorable season.

An average of 24.1% of injury by chewing insects was obtained from the unsprayed trees, and the average per cent., 15.3, from the sprayed trees, is greater than in most orchards. This is probably due to the fact that most of the trees bore small crops, and in such a case, other things being equal, a larger proportion of them are attacked by insects. Lead arsenate alone gave only slightly better results than when combined with commercial or self-boiled lime-sulphur. Bordeaux mixture was not used in this orchard.

Smith Orchard. *Conditions.* This orchard received a winter treatment in this and the previous year, but no recent summer treatment until this year. Since scab had been bad last year on the Fall Pippin and Early Harvest, these were selected to try the comparative value of Bordeaux and commercial lime-sulphur in preventing this trouble. Unfortunately for the experiment, scab in 1911 was much less abundant than the previous year, seeming not to develop from the numerous twig infections because of unfavorable conditions, though there was more than in most of the orchards under experimentation this year. Three sprayings were given, on May 5, on the unfolding leaves, May 23, just after the petals had fallen, and June 15. Lead arsenate (Sherwin-Williams paste), at the rate of 3 lbs. to 50 gallons, was added in both cases in the second and third sprayings. The Bordeaux was used at a strength of 4-4-50, 2-4-50, and 1-4-50 in the successive sprayings, while the Sherwin-Williams lime-sulphur was used at a strength of 1¼-50 in each spraying.

Results. No foliage injury resulted from the sprayings, except possibly a little from the Bordeaux on a Gilliflower tree, which was not in good shape from some other cause. The Bordeaux mixture produced a very extensive, though not a very serious russeting on the Early Harvest, while scarcely any showed on the Fall Pippin. The Sherwin-Williams lime-sulphur, while not producing russeting to any extent, did cause more scald than the Bordeaux.

On account of the russeting, which marred but did not seriously injure the fruit, the lime-sulphur, with 88%, and the checks, 74.6%, both gave a higher percentage of perfect fruit than the Bordeaux. The Bordeaux and lime-sulphur had practically the same percentage of fungous injury, 0.6%, while the checks had only 5.9%, showing that these troubles were not very common here this year, scab being the most abundant.

The unsprayed trees showed an average percentage of 16.2% injured by chewing insects, and 5.3% on the sprayed trees. With the Bordeaux, lead arsenate gave 6.7% fruit injured and only 4.2% with the commercial lime-sulphur. Lead arsenate alone was not used in this orchard.

Station Orchards. *Conditions.* The Station orchard on the Webb farm at Centerville was used only in an experimental way to test the different sprays on the foliage, and no data were gathered from the fruit, since the trees were of unknown varieties, some apparently seedlings, and scarcely any two alike. It was an old, entirely neglected orchard, but due to the thorough pruning, fertilization, spraying and cultivation it has had for the past two years, a decided change in its appearance has been made.

At the new Station farm at Mount Carmel there is a small orchard consisting largely of Baldwins and Greenings. It has been neglected in the past and apparently has not been given either winter or summer spraying. This year it was given a winter treatment by us for the San José scale. Two summer sprayings were also made, the first on May 22 to 23, and the second on June 15. As a number of the sprayed trees did not produce fruit, we give here only the treatments from which data were obtained. (1) Bordeaux mixture, 2–4–50, with 3 lbs. lead arsenate (Vreeland's); (2) Thomsen's lime-sulphur, 1¼–50, with 3 lbs. lead arsenate (Vreeland's); (3) sulphur and lead arsenate (Vreeland's), 6–3–50; (4) lead arsenate (Devoe & Raynolds' and Vreeland's).

Results. Bordeaux caused a little foliage injury, but comparatively few leaves dropped. The Thomsen lime-sulphur, however, caused a noticeable injury to the foliage, the same as in the Andrews orchard. This material in each case was taken from the same barrel put up by the manufacturer in 1910, and evidently was not of as high a standard as it should have been. No doubt this injurious character has been eliminated in their later products. In July a severe hail storm injured the young fruit so that at harvest time (see Plate XIX, a) a large percentage showed the effects by evident marks or scars. In our table all such fruit is counted as perfect, if not otherwise injured. The Bordeaux caused considerable russeting of the fruit, though not of a very serious nature. This, however, reduced the percentage of perfect fruit below that of any other treatment.

The Thomsen lime-sulphur gave the highest percentage of perfect fruit, 81.5, as against 55.2 on the checks. The Bordeaux proved the most efficient fungicide, showing only 2% fungous injury, as against 5.2% for the lime-sulphur and 25.5% for the check trees. Fruit speck, sooty blotch, and rot, in the order named, were the most prominent fungous troubles.

In the Station orchard the different varieties render the results scarcely comparable, though on the whole the sprayed fruit showed 6.6% injured by chewing insects, and the unsprayed, 15.7%. As in most orchards, lead arsenate alone gave better results against chewing insects than with the

TABLE V.—RESULTS OF APPLE SPRAYING EXPERIMENTS IN 1911.

Orchard.	Treatment.	Variety.	No. of Trees Sprayed.	No. of Trees Counted.	Total Apples Counted.	Perfect.	Russeted.	Scald.	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Lice.	Scale.
						%	%	%	%	%	%	%	%	%	%	%	%	%	%
ANDREWS.	Bordeaux	Baldwin	7	4	2675	77.0	15.3	0.9	0.3	0.7	0.4	0	0	0.9	0.2	0.6	2.1	0.3	1.7
	Lime-Sulphur (Sherwin-Williams)	"	8	4	2801	73.0	11.1	0.7	2.7	3.9	0.6	0	0	4.6	0.6	0.5	2.9	0.1	0.7
	Lime-Sulphur (Thomsen)	"	8	4	2282	59.0	21.2	1.4	0.9	2.7	0.7	0	0	13.2	0.5	0.2	3.2	0.6	0.2
	Sulphur and Ld. Ars.	"	7	4	2666	65.5	9.3	0.7	2.0	5.0	0.5	0	0	13.4	0.4	0.6	2.7	0.0	0.9
	Ld. Ars. (Ansbacher)	"	6	4	2367	64.4	11.7	0.4	2.8	1.1	1.7	0	0	14.8	0.3	0.1	4.3	0.4	0.3
	Lead Arsenate (Vreeland, dry)	"	9	4	2480	71.7	7.5	0.7	1.0	4.8	0.5	0	0	9.8	0.3	0.3	4.3	0.2	0.1
	Total, Sprayed	....	....	....	15271	68.8	12.5	0.8	1.7	3.1	0.7	0	0	9.2	0.4	0.4	3.2	0.3	0.7
	Checks	Baldwin	....	13	3968	27.9	16.5	0.8	3.6	14.7	2.9	0	0	19.5	9.8	3.2	12.8	0.5	0.2
CLARK.	Bordeaux	Greening	13	8	2216	72.5	15.1	0.1	0	0	0.2	0	0.1	0	3.5	0.4	2.3	2.3	3.6
	Lime-Sulphur (Grasselli)	Greening	15	8	1506	83.8	2.0	2.2	0.2	0	0.5	0.2	0.5	0	1.5	1.1	3.3	3.6	1.3
	Lead Arsenate (Swift)	Baldwin	12	4	1392	70.0	0.4	0.1	24.9	0	0.2	0	0	0	0.5	0.4	3.8	0	0
	" " "	Greening	16	5	1341	83.1	1.8	0.4	0.1	0.1	0.1	0	3.5	4.1	1.0	1.1	3.3	0	1.7
	Total, Sprayed	....	....	....	6455	76.8	6.1	0.7	5.4	0.0	0.2	0.0	0.9	0.9	1.9	0.7	3.1	1.6	1.9
	Checks	Baldwin	....	4	458	48.7	2.4	0.2	15.7	0	0	0	0	0.2	9.4	0.7	24.7	0	0
	"	Greening	....	6	1450	65.3	2.4	0.1	0.7	0.1	0.1	0.2	4.2	4.4	11.3	0.6	9.0	0.3	1.7
	Total, Checks	....	...	...	1908	61.3	2.4	0.2	4.3	0.1	0.1	0.2	3.2	3.4	10.8	0.6	12.8	0.2	1.3
IVES. 1st Orch.	Bordeaux	King	53	....	12	100	0	0	0	0	0	0	0	0	0	0	0	0	0
	"	Jonathan		...	473	61.1	16.1	14.8	0	0	0	0	0	1.7	3.0	1.7	2.1	2.3	0
	"	Russet		....	23	69.6	0	0	0	0	0	0	0	0	17.4	0	13.0	0	0
	"	Spitzenburg		....	763	68.8	9.7	1.8	0	0.8	2.9	0.3	0	0	5.8	5.9	5.6	0.4	0.3
	"	Sutton		....	400	75.0	14.0	0.5	0	0	0.5	0.3	0	0	5.5	2.0	3.5	0	0
	Total, Bordeaux	....	....	....	1671	68.3	12.3	5.1	0	0.4	1.4	0.2	0	0.5	5.0	3.6	4.2	0.8	0.1

TABLE V.—RESULTS OF APPLE SPRAYING EXPERIMENTS IN 1911—*Continued.*

Orchard.	Treatment.	Variety.	No. of Trees Sprayed.	No. of Trees Counted.	Total Apples Counted.	Perfect.	Russeted.	Scald.	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Lice.	Scale.
						%	%	%	%	%	%	%	%	%	%	%	%	%	%
IVES. 1st Orchard (cont'd.)	Lime-Sulphur (Sherwin-Williams)	King	56	....	26	84.6	0	0	0	0	3.8	0	0	0	0	0	11.5	0	0
	" "	Pound Sweet		....	119	64.7	0	2.5	0	0	10.1	0	0	0	13.4	2.5	10.9	0	0
	" "	Russet		....	31	74.2	0	6.5	0	0	0	3.2	0	0	0	0	6.5	9.7	0
	" "	Spitzenburg		....	311	75.2	6.8	3.9	0	0.6	0.3	0	0	0	6.1	0.6	6.4	0	0
	" "	Sutton		....	348	87.4	0.3	1.1	0	0.3	0.6	0.6	0	0	2.0	0	6.3	1.4	0
	Total, S. & W. L.-S.	....	....	....	835	79.0	2.6	2.5	0	0.4	1.9	0.4	0	0	5.0	0.6	7.2	1.0	0
	Self-boiled Lime-Sulphur	King	51	....	255	87.5	0	1.6	0	0.4	2.0	0	0	0	4.3	0.8	3.5	0	0
	" "	Pound Sweet		....	26	73.1	0	0	0	0	15.4	0	0	0	11.5	0	0	0	0
	" "	Russet		....	74	77.0	0	6.8	0	0	1.4	0	0	0	4.1	0	6.8	5.4	0
	" "	Spitzenburg		....	2933	76.5	2.5	5.8	0	1.3	1.2	0.4	0.0	0.0	3.9	3.1	5.3	0.7	0.0
	" "	Sutton		....	351	92.9	0.6	0.3	0	0	0.3	0.3	0	0	1.1	0	4.8	0	0
	Total, Self-boiled L.-S.	....	....	....	3639	78.8	2.1	4.9	0	1.1	1.3	0.4	0.0	0.0	3.7	2.6	5.1	0.7	0.0
	Sulfocide (Pratt)	Jonathan	38	....	372	66.4	3.8	2.2	0	7.8	0.8	1.1	0	0.8	8.1	1.6	8.9	0	0
	" "	King		....	99	77.8	0	0	0	0	5.1	0	0	0	6.1	3.0	9.1	0	0
	" "	Russet		....	20	75.0	0	0	0	0	5.0	0	0	0	20.0	0	0	0	0
	" "	Spitzenburg		....	596	69.3	2.5	1.0	0	2.7	4.0	0	0	0	9.1	5.5	8.1	0	0.2
	" "	Sutton		....	683	86.7	0.3	1.3	0	0	0.9	0.6	0	0	3.5	1.8	5.1	0	0
	Total, Sulfocide	....	....	....	1770	76.0	1.8	1.3	0	2.5	2.2	0.5	0	0.2	6.7	3.1	7.1	0	0.1
	Atomic Sulphur (Thomsen)	Jonathan	53	....	153	69.9	9.2	11.8	0	0.7	0	1.3	0	0	3.9	0	3.3	0	0
	" "	King		....	176	83.0	1.1	13.1	0	0	1.7	0.6	0	0	2.8	0.6	4.5	0	0
	" "	Pound Sweet		....	6	100.	0	0	0	0	0	0	0	0	0	0	0	0	0
	" "	Russet		....	104	85.6	0	6.7	0	0	0	1.0	0	0	1.0	0	5.8	0	0
	" "	Spitzenburg		....	1000	70.5	2.5	9.5	0	2.8	1.5	0.2	0	0	5.9	1.6	6.0	0.4	0
	" "	Sutton		....	632	90.3	0.5	2.8	0	0	0	1.1	0	0	1.4	0.3	3.3	0.3	0
	Total, Atomic Sulphur	....	....	....	2071	78.4	2.1	7.8	0	1.4	0.9	0.6	0	0	3.9	0.9	4.8	0.3	0

TABLE V.—RESULTS OF APPLE SPRAYING EXPERIMENTS IN 1911—*Continued.*

Orchard.	Treatment.	Variety.	No. of Trees Sprayed.	No. of Trees Counted.	Total Apples Counted.	Perfect.	Russeted.	Scald.	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Lice.	Scale.
						%	%	%	%	%	%	%	%	%	%	%	%	%	%
IVES. 1st Orchard (cont'd).	Lead Arsenate	Greening	34	....	323	91.3	0.6	0	0	0.6	1.9	0	0	0	1.5	0.6	3.4	0	0
	" "	Pound Sweet		....	165	77.0	0	1.2	0	0	6.1	0	0	0	3.6	1.2	10.9	0	0
	" "	Spitzenburg		....	144	79.9	1.4	1.4	0	3.5	2.1	1.4	0	0	1.4	2.1	7.6	0	0
	" "	Sutton		....	895	92.1	0.1	0.3	0	0	0.4	0.8	0	0.1	0.4	0.1	3.6	1.8	0.2
	Total, Lead Arsenate	....	....	....	1527	89.1	0.3	0.5	0	0.5	1.5	0.6	0	0.1	1.1	0.5	4.7	1.0	0.1
	Total, Sprayed	....	....	....	11513	78.2	3.3	4.1	0	1.1	1.5	0.4	0.0	0.1	4.1	2.1	5.3	0.6	0.1
	Checks	Greening	....	....	125	74.4	0	0	0.8	0.8	4.0	0	0	0	10.4	4.8	2.4	3.2	0
	"	Jonathan	....	....	328	40.9	4.0	1.2	0	42.7	0	0	0	1.2	8.2	2.4	4.0	0	0
	"	King	....	....	50	54.0	0	0	0	4.0	4.0	0	0	0	18.0	0	20.0	0	0
	"	Pound Sweet	....	....	27	40.7	0	0	0	0	25.9	0	0	0	29.6	0	3.7	0	0
	"	Russet	....	....	59	59.3	0	0	0	0	0	0	0	0	13.6	3.4	23.7	0	0
	"	Spitzenburg	....	....	1849	48.4	1.3	0.5	0	20.7	3.1	0.2	0.1	0.9	19.1	4.7	6.9	0.8	0.1
	"	Sutton	....	....	302	78.1	0	0	0	0.3	0.7	1.3	0	0	10.9	1.0	8.3	0	0
	Total, Checks	....	....	....	2740	52.2	1.4	0.5	0.0	19.2	2.7	0.3	0.1	0.7	16.5	3.8	7.0	0.7	0.0
IVES. 2d Orchard.	Lime-Sulphur (S. & W.) Lead Ars. (Vreel. dry)	Baldwin	60	....	1652	88.1	2.2	3.4	2.6	0.2	0.2	0	0	0	0.4	0.3	2.3	0.3	0.1
	Sulphur and Lead Arsenate (S. & W.)	"	15	....	409	89.2	2.9	1.2	2.4	0.2	0.5	0.2	0	0	1.0	0.2	1.7	0.5	0
	Lead Arsenate (S. & W.)	"	15	....	436	89.4	1.1	2.5	0.7	0.9	1.6	0	0	0	1.1	0	2.8	0	0
	Lead Arsenate (Vreeland, dry)	"	15	....	556	93.7	1.8	0	0.4	0.5	1.1	0	0	0	0.2	0.5	2.0	0	0
	Ortho-Arsenite of Zinc	"	15	....	624	85.7	5.6	1.1	4.3	0.6	0.3	0.2	0	0	0	0	1.6	0.8	0
	Total, Sprayed	....	....	....	3677	88.8	2.7	2.1	2.3	0.4	0.6	0.1	0	0	0.5	0.2	2.1	0.3	0.1
	Checks	Baldwin	....	1	449	71.7	1.3	0.7	1.3	2.2	0.4	0	0	0.7	8.2	9.4	3.8	0.4	0

TABLE V.—RESULTS OF APPLE SPRAYING EXPERIMENTS IN 1911—*Continued.*

Orchard.	Treatment.	Variety.	No. of Trees Sprayed.	No. of Trees Counted.	Total Apples Counted.	Perfect.	Russeted.	Scald.	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Lice.	Scale.
						%	%	%	%	%	%	%	%	%	%	%	%	%	%
Jones.	Lime-Sulphur (Blanchard)	Baldwin	6	1	313	77.0	0.6	3.8	1.0	0	3.2	0	0	0.6	3.5	0	9.9	1.3	0
	" "	Greening	3	2	323	70.6	0	0.3	0	0.3	2.2	0	0	0	5.3	0	9.9	9.3	2.2
	" "	Russet	3	1	182	76.9	0	3.8	0	1.1	1.1	0	0	1.6	1.6	0	13.2	1.1	0
	Total (Blanchard, L.-S.)		....	....	818	74.4	0.2	2.4	0.4	0.4	2.3	0	0	0.6	3.8	0	10.6	4.4	0.9
	Self-boiled Lime-Sulphur	Baldwin	4	2	1092	69.0	0.5	1.4	8.0	0.2	1.5	0	0	3.4	4.9	0.2	9.6	2.2	0.4
	" " "	Greening	2	2	369	72.1	0.3	2.2	0	1.6	0.8	0	0	2.2	4.9	1.6	10.6	4.3	0
	" " "	King	2	2	210	82.4	0.5	1.4	0	1.0	1.9	0	0	0.5	4.8	0.5	7.1	0	0
	" " "	Russet	2	2	633	64.9	0	2.2	0	0	1.6	0	0	3.3	4.9	0.5	18.0	6.0	0.2
	Total, Self-boiled L.-S.		....	....	2304	69.6	0.3	1.7	3.8	0.4	1.4	0	0	2.9	4.9	0.5	11.8	3.4	6.2
	Lead Arsenate	Baldwin	7	6	1765	71.6	1.0	1.4	3.8	1.7	1.7	0	0	3.0	4.5	0.2	10.8	1.1	0.1
	" "	Greening	6	2	316	72.5	0	0.3	0	0	3.2	0	0	1.9	8.2	0	9.2	4.7	0
	" "	Russet	3	2	770	46.1	0	0.9	0	1.7	0.8	0.1	0	12.3	1.8	0	6.9	41.2	0
	Total, Lead Arsenate		....	....	2851	64.8	0.6	1.1	2.3	1.5	1.6	0.0	0	5.4	4.2	0.1	9.5	12.3	0.1
	Total, Sprayed		....	....	5973	68.0	0.5	1.5	2.6	0.9	1.6	0.0	0	3.8	4.4	0.3	10.6	7.8	0.2
	Checks	Baldwin	....	1	251	31.9	3.2	0	11.6	6.0	6.8	0	0	4.8	20.3	0.4	17.1	0	0
	"	Greening	....	5	448	30.4	0.4	0	0	3.8	11.4	0	0	18.1	22.1	0.4	15.6	0.9	0
	"	" (old)	....	1	858	44.3	0.1	0.3	0.2	0.8	2.1	0	0	47.8	4.2	0.2	1.3	0	0
	"	King	....	3	266	30.8	1.1	0.8	0	9.0	9.0	0.4	0	10.2	31.6	0.8	14.7	0	0
	"	Russet	....	1	127	73.2	0	0	0	0	3.9	0	0	1.6	7.9	0	14.2	0	0
	Total, Checks		....	....	1950	39.5	0.7	0.2	1.6	3.2	5.9	0.1	0	27.3	14.4	0.4	9.3	0.2	0
Smith.	Bordeaux	E. Harvest	3	3	849	34.9	63.0	1.4	0	0	0.1	0	0	0	1.4	0	2.6	0	0.4
	"	F. Pippin	3	3	2158	80.7	0.5	0.4	0	0	0.1	0	0.6	0.1	1.9	0.5	5.4	7.5	2.5
	Total, Bordeaux		....	....	3007	67.8	21.4	0.7	0	0	0.1	0	0.4	0.1	1.8	0.3	4.6	5.4	1.9

TABLE V.—RESULTS OF APPLE SPRAYING EXPERIMENTS IN 1911—*Continued.*

Orchard.	Treatment.	Variety.	No. of Trees Sprayed.	No. of Trees Counted.	Total Apples Counted.	Perfect.	Russeted.	Scald.	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Lice.	Scale.
						%	%	%	%	%	%	%	%	%	%	%	%	%	%
Smith.	Lime-Sulphur (Sherwin-Williams)	E. Harvest	4	3	3682	88.4	1.6	5.5	0	0	0.4	0.1	0.0	0	1.4	0.0	2.5	0	0
	" "	F. Pippin	3	3	679	85.6	0	7.4	0	0	0.4	0	0.4	0.6	4.0	0	1.6	0	0
	Total, L.-S. (S.&W.)		....	....	4361	88.0	1.3	5.8	0	0	0.4	0.1	0.1	0.1	1.8	0.0	2.4	0	0
	Total, Sprayed		....	....	7368	79.7	8.2	3.7	0	0	0.3	0.1	0.2	0.1	1.8	0.2	3.3	2.2	0.8
	Checks	E. Harvest	....	3	3355	81.5	0	1.9	0	0	0.5	0.4	1.8	0	5.9	0	7.8	0	0.4
	"	F. Pippin	....	3	1620	60.4	0	1.2	0	0	0.7	0	5.1	6.4	8.8	0.8	11.4	0.6	7.3
	Total, Checks		....	....	4975	74.6	0	1.7	0	0	0.6	0.3	2.9	2.1	6.9	0.3	9.0	0.2	2.6
Station (Mount Carmel).	Bordeaux	Baldwin	1	1	1425	73.1	19.1	0.4	0.8	0.1	0.7	0	0	0.1	1.1	0.1	2.9	1.8	0.9
	"	Greening	3	1	670	68.7	15.7	0.4	0	0.1	4.2	0	0	0.1	6.4	0	1.6	4.3	2.4
	Total, Bordeaux		....	...	2095	71.6	18.0	0.4	0.6	0.1	1.8	0	0	0.1	2.9	0.1	2.5	2.6	1.4
	Lime-Sulphur (Thomsen)	Greening	3	2	888	81.5	0.3	0.8	0	0.5	1.1	0	0	3.6	2.0	0.1	3.3	6.8	0
	Sulphur and Lead Arsenate	Colvert	1	1	275	78.9	1.1	3.3	0	0	0	0	0	3.3	1.8	0	11.6	0	0
	" " "	F. Pippin	1	1	193	80.3	0	0	0	0	1.6	0	0	2.1	3.1	0	14.0	0	0
	" " "	Gravenstein	1	1	117	82.1	1.7	0	0	0	0	0	0	2.6	0	0	13.7	0	0
	Total, Sulphur and Lead Arsenate		....	....	585	80.0	0.9	1.5	0	0	0.5	0	0	2.7	1.9	0	12.8	0	0
	Lead Arsenate	Baldwin }	30	1	544	78.5	4.0	1.7	3.3	1.3	0.6	0	0	3.1	0.7	0.2	2.0	0.7	4.6
	" "	Greening }		1	140	79.3	0.7	0.7	0	1.4	3.6	0	0	1.4	5.7	0	6.4	1.4	0
	Total, Lead Arsenate		....	....	684	78.7	3.4	1.5	2.6	1.3	1.2	0	0	2.8	1.8	0.1	2.9	0.9	3.7
	Total, Sprayed		....	....	4252	76.0	9.6	0.8	0.7	0.4	1.4	0	0	1.6	2.4	0.1	4.1	2.8	1.3
	Checks	Baldwin	....	1	670	56.4	3.9	2.7	4.8	13.0	4.5	0	0	5.1	7.5	0	6.1	1.8	2.1
	"	Greening	....	1	246	52.0	0	0.8	0	4.5	5.7	0	0	23.6	15.0	2.4	3.7	2.0	0
	Total, Checks		....	....	916	55.2	2.8	2.2	3.5	10.7	4.8	0	0	10.0	9.5	0.7	5.5	1.9	1.5

TABLE V.—RESULTS OF APPLE SPRAYING EXPERIMENTS IN 1911—*Continued.*

Orchard.	Treatment.	Variety.	No. of Trees Sprayed.	No. of Trees Counted.	Total Apples Counted.	Perfect.	Russeted.	Scald.	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Lice.	Scale.
						%	%	%	%	%	%	%	%	%	%	%	%	%	%
STEVENS.	Bordeaux............	Baldwin.......	1	1	500	65.0	19.6	0.2	3.6	0.2	2.2	0	0	3.8	0.6	0	3.4	1.4	0.2
	"	E. Harvest.....	1	1	165	35.2	52.7	0	0	0	4.8	0	0	0	3.0	1.8	2.4	0	0
	"	Eng. Russet ...	1	1	742	91.0	0	0	0	0	0.3	0	0	0.5	0.8	0.1	3.6	3.6	0
	"	F. Pippin......	3	2	1062	85.2	0.2	0.2	0	1.3	2.4	0	1.5	2.0	0.1	1.9	4.0	0	1.4
	"	Greening	9	7	3035	80.1	7.6	0.4	0	0.1	0.3	0.0	0	3.8	0.1	0.3	5.4	1.1	1.0
	"	King..........	1	1	298	75.5	10.7	0.7	0	0.3	3.7	0	0	0.3	0.7	0.3	8.4	0	0
	"	R. Astrachan ..	2	1	322	74.5	11.8	0	0	0	2.5	0	0	0	5.6	0.3	5.3	0	0
	"	Rox. Russet ...	2	2	1231	83.3	0.2	0.1	0	0.2	0.6	0	0	2.2	0.6	0.4	11.4	1.4	0.1
	"	Sweet Apple...	2	1	391	66.0	22.8	0	0	0	0.8	0	0	0	7.7	0.8	2.0	0	0
	"	Y. Transparent.	1	1	277	20.9	74.0	0	0	0	0.4	0	0	0	2.2	0.7	1.8	0	0
	Total, Bordeaux....	....	....	....	8023	77.3	9.8	0.2	0.2	0.3	1.1	0.0	0.2	2.5	1.0	0.5	5.6	1.1	0.6
	Lime-Sulphur (Grasselli)..	Baldwin.......	6	4	1192	65.5	17.4	2.2	0.3	0.7	0.5	0.1	0	11.7	0.1	0	1.5	0	0.1
	" "	E. Harvest	1	1	294	84.7	0	0	0	0	0	0	0	0	4.4	0	10.9	0	0
	" "	Greening	7	4	1274	78.3	2.4	2.9	0	0.2	0	0	0	14.3	0.2	0.2	1.7	0.1	0
	Total, L.-S. Grasselli	....	....	....	2760	73.4	8.6	2.3	0.1	0.4	0.2	0.0	0	11.7	0.6	0.1	2.6	0.0	0.0
	Sulphur and Lead Arsenate..	Baldwin.......	1	1	419	68.3	6.4	1.4	0	0	0	0	0	19.8	0	0	4.1	0	0
	" "	Greening	6	3	886	66.6	0.2	0.2	0	0	0.5	0	0	30.5	0	0.2	2.5	0	0
	Total, Sulphur and Lead Arsenate	....	....	....	1305	67.1	2.2	0.6	0	0	0.3	0	0	27.0	0	0.2	3.0	0	0
	Total, Sprayed.......	....	....	....	12088	75.3	8.7	0.7	0.2	0.3	0.8	0.0	0.1	8.8	1.0	0.5	5.3	0.7	0.4
	Checks.............	Baldwin.......	....	2	580	34.8	5.7	0	0.2	5.0	2.1	0	0	33.6	4.7	2.9	13.3	0.2	0
	"	E. Harvest	....	1	889	77.1	0	0	0	0	0.6	0	3.0	7.3	4.6	0.2	7.3	0	0
	"	Eng. Russet ...	....	1	373	62.5	0	0	0	5.9	0.5	0	0	8.0	5.4	0.3	14.5	2.4	1.1
	"	F. Pippin......	....	2	624	49.8	0.2	0.5	0	6.7	4.5	0	6.1	19.2	0	5.3	9.5	0	1.6
	"	Greening.......	....	3	1150	22.7	0.1	0.7	0	0.6	0.6	0	0	62.3	4.2	1.9	8.0	4.3	0.3
	"	R. Astrachan ..	....	1	505	69.3	0	0	0	11.3	1.4	0.2	0.2	0	5.7	1.6	10.3	0	0
	"	Rox. Russet....	....	1	376	48.7	0	0	0	0.3	2.7	0	0	8.5	7.4	14.1	18.9	0	0.5
	Total, Checks......	....	....	....	4497	49.5	0.8	0.2	0.0	3.5	1.6	0.0	1.5	23.5	4.3	3.0	10.5	1.3	0.4

TABLE V.—RESULTS OF APPLE SPRAYING EXPERIMENTS IN 1911.—*Concluded.*

Orchard.	Treatment.	Variety.	No. of Trees Sprayed.	Total Trees Counted.	Total Apples Counted.	Perfect.	Russeted.	Scald.	Baldwin Spot.	Fruit Speck.	Rot.	Rust.	Scab.	Sooty Blotch.	Codling Moth.	Lesser Apple Worm.	Other Chewing Insects.	Lice.	Scale.
						%	%	%	%	%	%	%	%	%	%	%	%	%	%
STODDARD.	Bordeaux............	Baldwin.......	3	3	603	76.6	11.8	0	0	0.8	0.3	0	0	0	6.1	0	3.5	0.8	0
	"	Eng. Russet ...	1	1	340	88.2	0	0	0	0	0	0	0	0	5.6	0	4.4	1.8	0
	"	Greening	4	4	601	79.4	0	0	0	0	1.0	0	2.3	3.8	7.5	0	6.0	0	0
	"	King..........	1	1	108	74.1	0	0	0	2.8	0	0	0	0	7.4	0	13.0	3.7	0
	"	Rox. Russet ...	2	2	407	75.7	0	0	0	0.7	2.2	0	0	1.2	14.5	0	4.9	9.7	0
	"	Strawberry, etc.	7	1	412	72.8	0	0	0	4.1	1.5	0.2	8.5	0	3.9	1.0	8.0	0	0
	Total, Bordeaux....	....	....	....	2471	78.0	2.9	0	0	1.1	0.9	0.0	2.0	1.1	7.4	0.2	5.6	0.7	0
	Lime-Sulphur (Vreeland)..	Hubbardston ..	1	1	136	83.8	0	0	0	0	2.2	0.7	0	0	11.0	0	2.2	0	0
	" "	King..........	1	1	130	84.6	0	0	0	0	0.8	0	2.3	6.2	0	0	4.6	1.5	0
	" "	Mann	1	1	121	62.8	0	0	0	0	0.8	0	0	29.8	9.1	0	5.8	0	0
	Total, L.-S. (Vreeland).......	....	....	....	387	77.5	0	0	0	0	1.3	0.3	0.8	11.4	6.7	0	4.1	0.5	0
	Sulphur and Lead Ars.	Baldwin.......	3	1	212	80.2	0	0	0	0.5	0.9	0	0	11.8	5.7	0	0.9	0	0
	" "	Greening	3	3	441	73.9	2.5	0	0	0	0.5	0	1.8	9.5	6.3	0	5.4	0	0
	" "	Rox. Russet...	2	1	204	60.3	0	0	0	0	0.5	0	0	28.4	7.4	0	3.4	0	0
	Total, Sulphur and Lead Arsenate...	....		....	857	72.2	1.3	0	0	0.1	0.6	0	0.9	14.6	6.4	0	3.9	0	0
	Total, Sprayed.......	....	....	....	3715	76.6	2.2	0	0	0.8	0.9	0.1	1.6	5.3	7.1	0.1	5.1	0.5	0
	Checks.............	Baldwin.......	....	1	201	33.8	0	0	0	4.5	0	0	0	14.9	17.4	0	26.4	6.5	0
	"	Greening.......	....	2	501	21.6	0	0	0	3.2	3.2	0.2	12.8	33.1	23.8	0	21.2	0	0
	"	King..........	....	1	104	51.9	0	0	0	1.9	1.0	0	0	0	11.5	0	29.8	5.8	0
	"	Russet	...	2	315	12.7	0	0	0	0.6	2.9	0	0	15.2	41.9	0	31.1	6.3	0
	Total, Checks......	....	....	....	1121	24.1	0	0	0	2.6	2.3	0.1	5.7	21.8	26.6	0	25.7	3.5	0
ALL.	Bordeaux...........	All	....	....	22158	74.4	12.3	0.7	0.2	0.4	0.9	0.0	0.3	1.1	2.5	0.7	4.3	1.3	1.2
	Commercial Lime-Sul.	"	....	....	18290	78.0	6.5	2.8	0.8	1.1	0.6	0.1	0.1	4.6	1.5	0.3	3.3	1.0	0.3
	Self-boiled Lime-Sul.	"	....	....	5943	75.2	1.4	3.7	1.5	0.7	1.3	0.2	0.0	1.1	4.2	1.8	7.7	1.7	0.1
	*Sulfocide..........	"	....	...	1770	75.9	1.8	1.3	0	2.5	2.2	0.5	0	0.2	6.7	3.1	7.1	0	0.1
	*Atomic Sulphur.....	"	....	....	2071	78.4	2.1	7.8	0	1.4	0.9	0.6	0	0	3.9	0.9	4.8	0.3	0
	Sulphur and Lead Ars.	"	....	....	5822	70.0	5.2	0.7	1.1	2.3	0.5	0.0	0.1	14.6	1.4	0.3	3.9	0.1	0.4
	All Fungicides.......	"	....	....	56054	75.4	7.8	2.0	0.6	0.9	0.8	0.1	0.1	3.6	2.4	0.7	4.4	1.0	0.6
	All Lead Arsenates ..	"	....	....	14258	74.2	4.1	0.7	3.9	1.5	1.0	0.1	0.3	5.8	1.3	0.3	4.9	2.8	0.4
	All Checks..........	"	....	...	22524	51.1	3.6	0.7	1.3	6.5	2.1	0.1	1.5	13.3	10.1	2.0	10.6	0.8	0.9

* It should be remembered that these two fungicides were not so extensively tested and in only one orchard.

addition of a fungicide, though there was practically no difference between lime-sulphur and Bordeaux mixture. For some reason not easy to explain, fruit sprayed with lead arsenate and sulphur was scarcely better than that not sprayed, though all of these sprayed trees were early varieties, and had no checks of the same varieties.

Stevens Orchard. *Conditions.* Most of the trees in this orchard were at least fifteen years old and of miscellaneous varieties, that had not been sprayed recently, except possibly a winter treatment. As sooty blotch and scab had been quite troublesome previously, three summer sprayings were given, as follows: 1st, May 9; 2d, May 25; and 3d, June 19. The following treatments were tried: (1) Bordeaux mixture, 1st, 4-4-50; 2d, 2-4-50; 3d, 1-4-50; (2) Grasselli's lime-sulphur, 1¼-50; (3) sulphur and lead arsenate, 6-3-50. Swift's lead arsenate, 3-50, was used in the second and third sprayings of treatments Nos. 1 and 2, and of course in all three of treatment No. 3.

Results. There was no foliage injury with the sulphur and lead arsenate, and practically none with the Grasselli's lime-sulphur, and the little caused by the Bordeaux (mostly on Red Astrachan, Baldwin, and a sweet variety) did no particular harm. As usual, the Bordeaux caused more russeting, though not of a serious nature, than any of the other mixtures, being especially prominent on Yellow Transparent, Early Harvest, Baldwin, and a variety of sweet apple. The lime-sulphur seemed to cause considerable russeting of the Baldwin, but not of the other varieties, and it also produced more scald than the other sprays.

Despite the russeting caused by the Bordeaux, it gave the highest percentage of perfect fruit, 77.3, as compared with 49.5 on the checks. This was because it was much more effective in preventing fungous attacks, especially sooty blotch, which was quite prominent on some varieties. The unsprayed trees had 30.1% of the fruit attacked by fungi as compared with 4.1% for the Bordeaux and 12.3% for Grasselli's lime-sulphur. The sulphur and lead arsenate on the Baldwins and Greenings reduced the sooty blotch somewhat as compared with the checks of these two varieties, but not sufficiently to be considered a valuable fungicide.

In Mr. Stevens' orchard the sprayed fruit showed an average injury of 6.8% caused by chewing insects, while the unsprayed fruit showed 17.8% of injury. The percentage of injured fruit was more than twice as great from lead arsenate with Bordeaux mixture than from the same poison when used either with dry sulphur or with commercial lime-sulphur.

Stoddard Orchard. *Conditions.* The trees in this orchard were of miscellaneous varieties, varying from twenty-five to at least fifty years old. They had received no summer treatment previously, and on the whole suffered more injury from fungi and insects than any others under experimentation this year. Three treatments were given, on the following dates: 1st, May 8; 2d, May 29; and 3d, June 23. Vreeland's lead arsenate, 3-50, was used in the second and third sprayings of each treatment, and of course in all three of the one with sulphur and lead arsenate. As the material was not on hand, the first treatment with the

lime-sulphur had to be omitted. The treatments were as follows: (1) Bordeaux, 1st, 4-4-50, 2d and 3d, 1-4-50; (2) Vreeland's lime-sulphur, 1¼-50; (3) sulphur and lead arsenate, 6-3-50.

Results. No leaf injury occurred from any of the sprayings except a very little from the lime-sulphur on one tree of a fall variety. Practically no scald occurred from any of the treatments. About the only russeting was on the Baldwin, produced by the Bordeaux mixture, and this was not serious.

The Bordeaux and lime-sulphur gave practically the same percentage of perfect fruit, having about 78, as compared with 24.1 on the check trees. This difference of about 54% was the greatest obtained in favor of the sprayed trees in any of the orchards under experimentation this year. Sooty blotch and scab, on certain varieties, were the worst fungous troubles in this orchard.

The fruit in this orchard showed the most serious injury from chewing insects of any in the experiments. Codling moth was chiefly responsible, though there was a large amount of injury that could not definitely be attributed to codling moth. Lesser apple worm was noticeably absent. Though the percentage of fruit injured by chewing insects was higher, 12.3%, than in any other orchard except Mr. Jones' at Hamden, a much large percentage, 52.3%, was also obtained from the unsprayed trees. The latter, therefore, exhibited more than four times as much injury from the attacks of chewing insects as the former. In this orchard the lead arsenate, though not used alone, gave slightly better results in combination with dry sulphur than with commercial lime-sulphur, and in both cases better than when used with Bordeaux mixture.

PEACHES.

In 1911, spraying experiments with peaches were conducted in the orchards of W. A. Henry & Son, Wallingford; E. M. Ives, Meriden; and B. T. Jones, Hamden; and besides some miscellaneous tests were made on the very young trees at the Station farm at Centerville. At the Station farm, only self-boiled lime-sulphur and Atomic sulphur were used, on June 1 and June 21, both sprayings and both treatments containing lead arsenate. The former produced no injury, while the latter produced considerable leaf spotting and leaf fall, also some injury to the young twigs.

In the following paragraphs we give briefly the conditions and the more general results of these experiments, while in Table VI the details of the counts are given. In determining the results, any rot showing on a peach was counted, but if only two or three inconspicuous scab spots showed, the fruit was counted as perfect. In cases where the peaches showed both rot and scab, this has been indicated in the table in a separate column. Where the rot develops very extensively, it often entirely obscures the scab that may be present, so that the percentage of scab may be somewhat less than really occurred. Likewise, rot tends to obscure any insect injury, and as it often starts from such injury, this may explain why the sprayed peaches in the Jones orchard this year and last showed more insect injury than the unsprayed.

Henry Orchard. *Conditions.* This was a comparatively young orchard, being in bearing for the second or third year, and consisting of the several varieties mentioned in Table VI. The trees in the past had received excellent care, not only as regards sprayings, but as regards all other treatment. Only two summer sprayings were given here, to determine if these, under practical orchard conditions, would yield sufficient protection against scab and rot. The sprayings were made on June 8 and July 10. The treatments were as follows: (1) Grasselli's lime-sulphur, 1st, 1–150, and 2d, 1–300; (2) self-boiled lime-sulphur, 8–8–50; (3) Sulfocide, 1st, 1–500, and 2d, 1–600; (4) Atomic sulphur, 1st, 12–50, and 2d, 8–50. No poison was used in the Sulfocide because of sure spray injury. In the first spraying of both the self-boiled and Grasselli's lime-sulphur, 3 lbs. Swift's lead arsenate was added, and in the first spraying with Atomic sulphur the brand containing lead arsenate added by the manufacturer was used.

Results. The first treatment with Grasselli's lime-sulphur caused very considerable leaf injury and fall, and also some fruit fall. As the fruit was thus thinned about right for a dry season, this did not prove so serious as it would have otherwise. The Atomic sulphur also caused considerable leaf injury, but very little was caused by the Sulfocide, and practically none by the self-boiled lime-sulphur. On account of the injury, most of the treatments were weakened in the second spraying, and the lead arsenate omitted. It seems on the whole more probable that the injury was due to the presence of lead arsenate than to the strength of the mixtures used. No injury followed the second treatment.

The self-boiled, Grasselli's, and Atomic sulphur all gave about the same percentage, 87, of perfect fruit, which considerably exceeded that given by Sulfocide, 68%, and the checks, 52%. This was because these sprays were about equally efficient in preventing scab, which was the only abundant fungous trouble, averaging 40.5% on the checks. On the whole, the Waddell and Carman varieties showed the most scab.

Peaches are injured by attacks of the plum curculio (see Report for 1910, page 609), which is more serious in the Southern States than in Connecticut. In some orchards the peach sawfly and the canker worm defoliate the trees, and in certain seasons green fruit worms and rose chafers cause considerable injury. Wherever any of these insects are prominent and liable to do damage, the foliage should be sprayed with lead arsenate. None of these insects were prevalent in this orchard. The sprayed fruit showed on the average fully as much insect injury as that not sprayed.

Ives Orchard. *Conditions.* Most of the trees used in these experiments were Hieleys just coming into bearing. These set considerably less fruit than anticipated, because of late frosts, but the treatments were given, nevertheless, as planned, and what little fruit had matured on each tree was gathered and counted. The few trees of other varieties used were old and past their prime. All had received winter treatments this year and previously. Three summer sprayings were given, as follows: May 26, June 14, and July 14. The treatments were: (1) Sherwin-Williams lime-sulphur, 1st and 2d, 1–150; 3d, 1–250; (2) self-boiled lime-sulphur, 8–8–50; (3) Atomic sulphur, 1st and 2d, 12–50; 3d, 8–50. Lead arsenate was used only in the first spraying, 2–50 of Grasselli's in Nos. 1 and 2, and that added by the manufacturer in No. 3.

Results. No especial spray injury resulted in these experiments. Rot was present only to a very limited extent, and scab only fairly abundant. The three fungicides used seemed to be about equally efficient against the latter. The percentage of scab on all the sprayed peaches was 1.0%, as against 16.3% on all the unsprayed.

In this orchard the spraying with fungicides with an insecticide added in one treatment did not seem to lessen the slight injury from chewing insects.

Jones Orchard. *Conditions.* These were somewhat neglected trees that had been in bearing from six to eight years. They had been severely winter-injured in the past, and were now showing yellows or similar trouble on some of the trees. While the orchard contained a number of varieties, only the Champions were selected for experimentation, because these rotted the most readily. Half of the trees received a winter treatment, just as the buds began to swell, April 11, with Blanchard's lime-sulphur, 1–9, for the San José scale and leaf curl. Three summer sprayings were given, as follows: 1st, May 22 (husks shedding off the young fruit); 2d, June 15 (peaches one to one and one-half inches long); 3d, July 13 (peaches nearly full-grown). The treatments given were as follows: (1) Blanchard's lime-sulphur, 1st and 2d, 1–150; 3d, 1–250; no lead arsenate used; (2) self-boiled lime-sulphur, 8–8–50, with lead arsenate, 3–50, in the 1st and 2d; (3) self-boiled lime-sulphur, 8–8–50, no lead arsenate used; (4) Atomic sulphur, 1st and 2d, 12–50; 3d, 8–50; lead arsenate in 1st and 2d. Each treatment included trees that had and had not received winter spraying.

Results. A very slight spotting of the foliage was noticed after the second spraying with the commercial lime-sulphur, but this caused no leaf fall. (A spraying with another commercial lime-sulphur *containing lead arsenate* at about this time at the Henry orchard caused serious foliage injury.) With the Atomic sulphur, however, this injury, while not serious, was much more evident, and caused some leaf fall. The Atomic sulphur, also, and to a less degree, the self-boiled lime-sulphur, caused some fruit scald, a trouble exaggerated by the dry, hot weather. The addition of lead arsenate to the self-boiled lime-sulphur, while it

TABLE VI.—RESULTS OF PEACH SPRAYING EXPERIMENTS IN 1911.

Orchard.	Treatment.	Variety.	No. of trees counted.	Total Peaches counted.	Perfect. Per cent.	Scald. Per cent.	Rot. Per cent.	Rot and Scab. Per cent.	Scab. Per cent.	Chewing Insects. Per cent.
HENRY.	Grasselli Lime-Sulphur......	Belle of Georgia	3	450	89.3	1.8	0.2	0	0	8.7
	" " "	Carman........	1	156	85.3	0	0	0	1.3	13.5
	" " "	Elberta........	2	301	89.7	0	0	0	1.7	8.6
	" " "	Greensboro	1	284	95.1	0	0.7	0	4.2	0
	" " "	Waddell.......	2	320	76.6	0	0.3	0	11.3	11.9
		Total......	9	1511	87.4	0.5	0.3	0	3.6	8.2
	Self-boiled Lime-Sulphur.....	Belle of Georgia	3	454	84.4	0	0.4	0	0	15.2
	" " "	Carman	1	164	88.4	0	0	0	1.2	10.4
	" " "	Elberta	2	300	89.7	0	0	0	0	10.3
	" " "	Greensboro	2	405	96.3	0	0.2	0	1.5	2.0
	" " "	Waddell	3	749	81.3	0	0.7	0	4.5	13.5
		Total	11	2072	86.7	0	0.4	0	2.0	10.9
	Sulfocide	Belle of Georgia	3	445	62.7	0	0.7	0	31.2	5.4
	"	Carman........	1	152	67.8	0	0	0	20.4	11.8
	"	Elberta	2	311	81.0	0	0.3	0	10.6	8.0
	"	Greensboro	1	128	85.2	0	1.6	0	13.3	0
	"	Waddell	2	299	55.5	0	0.3	0	38.5	5.7
		Total	9	1335	68.1	0	0.5	0	25.1	6.3
	Atomic Sulphur	Belle of Georgia	3	447	90.4	0	0.4	0	0.2	8.9
	" "	Carman........	1	153	85.0	0	0	0	2.0	13.1
	" "	Elberta	2	307	87.9	0	0	0	0.3	11.7
	" "	Greensboro	1	151	97.4	0	0	0	2.0	0.7
	" "	Waddell.......	3	486	81.9	0.2	0.2	0	2.1	15.6
		Total	10	1544	87.4	0.1	0.2	0	1.2	11.2
	Total, Sprayed	....	39	6462	83.2	0.1	0.3	0	7.0	9.4
	Checks	Belle of Georgia	3	457	51.0	0	0.4	0	39.4	9.2
	"	Carman........	3	456	38.8	0	0.2	0	51.8	9.2
	"	Elberta	3	474	59.7	0	0	0	30.4	9.9
	"	Greensboro	3	323	74.6	0	0.3	0	23.8	1.2
	"	Waddell	3	559	43.5	0	0.7	0	50.6	5.2
		Total	15	2269	51.9	0	0.4	0	40.5	7.2
IVES.	Self-boiled Lime-Sulphur.....	Carman........	1	40	100.	0	0	0	0	...
	Checks	"	1	567	76.7	0	1.2	0	22.0	...
	Self-boiled Lime-Sulphur.....	Elberta	1	86	96.5	0	0	0	3.5	...
	Checks	"	1	112	63.4	0	0	0	36.6	...
	Sherwin-Williams Lime-Sulphur	Hieley.........	13	49	98.0	0	0	0	0	2.0
	Self-boiled Lime-Sulphur.....	"	25	165	93.9	0	0	0	0	6.1
	Atomic Sulphur	"	13	91	100.	0	0	0	0	0
	Checks	"	21	99	45.5	0	0	0	42.4	12.1
	Self-boiled Lime-Sulphur.....	Triumph	1	174	97.7	0	0.6	0	1.7	...
	Checks	"	1	582	91.8	0	6.0	0	2.2	...
	Total, Sprayed	....	54	605	97.0	0	0.1	0	1.0	...
	Total, Checks	....	24	1360	79.8	0	3.1	0	16.3	...

JONES.	Blanchard Lime-Sulphur, 1st treatm't	Champion	2	634	60.4	0.2	15.8	0.6	19.1	3.9
	" 1st and 2d treatment	"	2	386	90.2	0.3	2.3	0	3.1	4.1
	" 1st, 2d and 3d treatment	"	1	347	87.6	2.9	0.6	0	2.3	6.6
	" 2d and 3d treatment	"	4	524	87.6	0.8	3.8	0	1.7	6.2
	" 3d treatment	"	2	267	82.4	0	3.0	0	10.5	4.1
	Totals, Blanchard L.-S.	"	11	2158	79.4	0.7	6.4	0.2	8.2	5.0
	Self-boiled Lime-Sulphur with Lead Arsenate........	"	13	3274	86.9	3.4	3.9	0	0.6	5.1
	Self-boiled Lime-Sulphur without Lead Arsenate.....	"	10	1845	88.2	2.2	4.6	0	0.7	4.4
	Atomic Sulphur	"	14	2883	86.4	6.0	3.4	0	0.1	4.1
	Total, Sprayed	"	48	10160	85.4	3.3	4.4	0.0	2.1	4.6
	Checks	"	12	2602	63.5	0.0	12.3	1.2	19.8	3.2

did not cause any very evident leaf injury, did cause more fruit scald than where it was left out. The sprays, particularly with the addition of lead arsenate, seemed to heighten the color of the fruit. This was especially true of the Atomic sulphur, where the added color almost partook of the nature of an injury, due to numerous small reddish spots that were produced. It would seem from the results in this orchard that the presence of lead arsenate was responsible for most of the injury that resulted on peaches in the various experiments this year.

The winter treatment with commercial lime-sulphur reduced the leaf curl to practically nothing, though this trouble was not prominent this year even on unsprayed trees. A count of the 73 trees receiving this treatment showed only 30 leaves with the curl, or less than ½ leaf to a tree. Twelve trees not sprayed showed from 3 to 70 leaves with the curl, or an average of 22½ per tree. Last year's difference was considerably greater, the sprayed trees showing 1½ leaves with the curl, and the unsprayed, 132 per tree.

The trees having the winter treatment and three summer treatments did not show any less scab or rot than the trees having only the three summer treatments. The winter treatment, therefore, seems of no special value as far as these two troubles are concerned. With the commercial lime-sulphur the trees were so sprayed that some received one, some two, and others all three treatments, as indicated in the table. While the experiment was on too small a scale to show positively, still it agrees with our experiments of last year, and indicates 1st, that three summer treatments give the best fungicidal results; 2d, that two treatments in a dry year may also give good results; 3d, that if one of the three treatments is omitted, it should be the first; 4th, that one treatment only, given at the time of either the first or the third, is likely to be of little value.

The three different sprays showed about the same value in preventing scab and rot when used in three applications. The total percentage of scab and rot on all the sprayed fruit was 6.5, as against 33.3 for all the checks. Rot would have been worse had the weather been a little more favorable for it earlier, but this trouble did not start to any extent on either the sprayed or the unsprayed trees until about half the fruit had been gathered.

The self-boiled lime-sulphur used without lead arsenate gave a lower percentage of insect injury than where it was added in the first two sprayings. On the whole, the checks also had a somewhat lower percentage than the sprayed trees. These results seem to indicate that an insecticide gives little protection to the fruit against insect injury.

PEARS AND QUINCES.

Our spraying experiments with pears and quinces were rather limited, being carried on with a few trees each at the Clark and Ives farms. No special data, as in the case of apples and peaches, were gathered, but the general benefits and injuries of the spraying were noted. Experiments by Thaxter long ago showed that scab of pear and leaf blight of quince could be readily controlled by the general Bordeaux treatments. Our experiments were largely to determine whether some of the other sprays had any advantage over the Bordeaux.

Fungi and Insects. The pear and quince have several fungous troubles in common, and the same as those of the apple, described in our previous report; namely, black rot, brown rot, more or less common to both, and sooty blotch on pear and fruit spot on quince, the two latter of comparatively little importance. The most serious diseases of the pear in this State, outside of the bacterial blight, are scab (*Fusicladium pyrinum*, see Plate XXI, a), leaf spot (*Septoria pyricola*) and leaf and fruit blight (*Entomosporium maculatum*). This latter is even a more serious trouble of the quince (see Plate XXI, b), while rust (*Roestelia aurantiaca*) is another common trouble in certain places.

The insects found on pear and quince are also very similar to those on the apple; namely, bud moth, codling moth, and fall webworm. Leaf blister mite, pear psylla, and San José scale are not affected by arsenical poisons, though the lime-sulphur should have a tendency to keep them down. Possibly the quince curculio may be repelled in a measure by lime-sulphur preparations, but arsenical poisons are not effective against it, and when it is particularly destructive the jarring method is usually employed.

Pears. At the Clark farm one tree each of eight different varieties of pears were sprayed on May 26 and and June 16, as follows: (1) Bordeaux, 2-4-50, with three pounds lead arsenate; (2) Grasselli's lime-sulphur, 1¼-50, with three pounds lead arsenate; (3) Swift's lead arsenate, 3-50. At the second spraying, it was seen that the lead arsenate alone had caused no injury to the foliage. The Bordeaux had caused a slight injury, while the lime-sulphur had caused a little more, some varieties suffering more than others. The trees did not fruit very heavily, and those that did showed no scab either on the sprayed or unsprayed trees. There was a little russeting on a few of the pears sprayed with the Bordeaux.

At Mr. Ives' the Flemish Beauty pear, by far the worst variety to scab, and often worthless because of it, was sprayed with 4-4-50 Bordeaux before blossoming, and twice afterwards with the 1-4-50, and a fourth treatment was given on July 16, with self-boiled lime-sulphur. None of these sprayings caused any noticeable injury. The fruit was slightly russeted, but this possibly may have been natural, as it did not mar the appearance of the fruit. Practically no scab showed on the sprayed fruit.

Quinces. Two bushes at the Clark farm were sprayed at the same time as the pears, one with Bordeaux and the other with Grasselli's lime-sulphur. No particular injury was noticed from either of these sprayings, and no fungi showed on either the sprayed bushes or the check, except a little black rot on the fruit at the end of the season.

At the Ives farm, six quince bushes just coming into bearing were sprayed with self-boiled lime-sulphur on May 26, June 14, and July 14, using lead arsenate in the first spraying. Mr. Ives also had sprayed these bushes earlier with Bordeaux. No injury was noticed from any of these sprayings. No fungi appeared on the sprayed or check bushes, except a little rust, which was almost as abundant on the sprayed as on the unsprayed bushes.

RECOMMENDATIONS. Since pears are not generally seriously injured by fungi or insects in this State, they frequently require no protection by spraying. Bordeaux has proved a very effective spray in the past, and as we saw no special advantage from the other sprays tried, we are still inclined to recommend it, especially when used

against pear scab. However, we believe that less leaf injury will result if the weaker solution, 1-4-50, is used after the first treatment. Therefore we recommend the same strengths, and number and times of treatment with Bordeaux, as for apples (see page 370).

We would also recommend the same treatment for the quince, since it is even less liable than the apple to suffer injury from Bordeaux on either leaves or fruit. In cases where the quinces tend to rot in the fall, starting at the blossom end through the evident opening in the calyx, it may be well to give a fourth spraying with weak Bordeaux about a month after the third, or about the middle of July. The bushes should also be kept pruned of all dead branches, as these carry over the black rot fungus. To protect the quinces from rust evidently requires that they be coated continually with a spray from the time the leaves unfold to the middle of July, taking special care to protect the young fruit and branches, where this trouble develops most frequently.

CHERRIES AND PLUMS.

While quite a number of cherry and plum trees were sprayed the past year, the experiments were more to test the general effects of the sprays on the foliage, etc., than to determine the exact numerical results in lessening fungous and insect troubles of the fruit. The experiments were thus somewhat preliminary in nature, but we give here such results as were obtained. The experiments were made in the orchards of the late F. W. Gray of Watertown; W. A. Henry & Son, Wallingford; and E. M. Ives, Meriden. Each of these orchards had been infested in the past by a different fungous trouble as mentioned later.

Fungi and Insects. The fungous and insect troubles of cherries and plums, because of their close botanical relationship, are practically the same. In this State, the most troublesome fungous pests are brown rot of the fruit, anthracnose of the leaves, and black knot of the stems. The brown rot is the same as that on peaches, which we described in our report last year. On cherries and plums it often starts from insect punctures, especially those made by the curculio, as shown in Plate XXIII, b. The sweet cherries, as Governor Wood, etc., are much more subject to rot than the sour cherries, as Early Richmond, etc. With the plums, the Japanese, as a rule, suffer most from rot, though some of the varieties of the American group also rot badly.

The anthracnose (*Cylindrosporium Padi*) forms small purplish spots on the upper sides of the leaves, while the mass of spores

ooze out on the under surface, often showing as minute, slightly tinted, agglutinated globules. The infected tissues, especially in the plum, often fall out, giving a shot-hole appearance to the leaf. The leaves, if badly infected, turn yellow and drop prematurely, especially toward the end of the season. Certain varieties of cherries seem to be especially subject to this trouble.

Black knot (*Plowrightia morbosa,* see Plate XXII) shows in early spring as slight swellings on the smaller branches and twigs. These soon crack open, and rapidly enlarge, and by the first of June in this region they develop an olive-green surface growth of the summer spore stage. This is gradually superseded during July by the appearance of the winter spore receptacles. In the meantime, the knots have enlarged to several times the diameter of the twig for a length of from three to six inches. They usually encircle the stem nearly, but not entirely, and so do not completely cut off the food supply from the parts above. When fully enlarged, the winter stage completely coats the knots with a black layer of closely placed, minute papillæ. It is within these papillar receptacles that the winter spores are finally developed. Some of these spores are matured by the first of December, and by April or May they are ready for general reinfection of the young twigs.

Both plums and cherries are injured by the plum curculio, which has been mentioned under peaches. The cherry is also attacked by the cherry fruit fly (*Rhagoletis cingulata* Loew.), which, like its close relative, the apple maggot, lays an egg beneath the skin of the fruit. The larva hatching from it feeds inside on the pulp, entirely out of reach of sprays. Certain chewing insects, like canker worms and sawflies, may be controlled by the use of lead arsenate.

Gray Orchard. *Black Knot.* This was a small orchard of sour Montmorency cherries just coming into bearing. They had been badly infected for the last few years with black knot, and while this had all been cut out in 1910, there was still a good deal present in 1911, when our experiments began. The trees had received a winter treatment with lime-sulphur for the San José scale, but had received no previous summer treatments. The experiments here were largely for the prevention of black knot. Three sprayings were given, as follows: 1st, May 19; 2d, June 2; 3d, July 11. Two sprays only were used: (1) Atomic sulphur, 12-50, with lead arsenate in the first and second applications, and 10-50, without lead arsenate, in the third; (2) self-boiled lime-sulphur, 8-8-50, with lead arsenate in the first treatment only.

Twenty-six trees were included in each treatment, and others were reserved for checks. The fruit ripened, and was picked between the second and third sprayings. As it was a sour variety, and the season was quite dry, there was practically no rot, even on the check trees. The crop, however, was light, because late frost had injured the blossoms. No anthracnose showed on the leaves of the sprayed or unsprayed trees during the season. No injury showed on the leaves of any of the sprayed trees after any of the treatments.

The black knot was not cut out this year from any of the trees until after the third treatment in July. At this time all of the knots were removed from seven trees in each of the treated lots and the checks. These showed an average of sixty-two knots on each tree sprayed with self-boiled lime-sulphur, fifty-two on each sprayed with Atomic sulphur, and forty-five on each check tree. Of course the spraying would have no effect this year on the number of knots, as these came from infections before the treatment was begun, but these figures show that the sprayed trees were infected as badly, if not worse, than the check trees. The effect of the treatment, however, was decidedly manifested in preventing the fruiting stages from developing on the knots, as shown in Plate XXII. On June 2, the time of the second spraying, the olive-green summer spore stage was just beginning to develop prominently on the surface of the knots. On July 11, when the winter receptacles had begun to form quite generally, while the spray had not materially stopped the growth of the knots in size, it had very largely prevented the formation of either of the spore stages on the exterior of these knots (compare No. 1 with No. 2 in Plate XXII). The following table shows the condition of the knots on this date, as regards the development of the fruiting stages:

Treatment.	No Fruiting Stage.	Summer Stage.	Winter Stage.	Not Fruiting.
Atomic Sulphur	222	105	23	63%
Self-boiled Lime-Sulphur	153	118	75	44%
Checks—no treatment	0	24	230	0%

This table does not show the total effect of the sprays, since many of the knots were producing the fruiting stage only on a portion of the knot, evidently where the spray had not thoroughly protected it. This protection seems to have been permanent, since knots examined in August and again in December and in April of the next year still remained in about the same condition, while the unsprayed knots had continued to develop. While it may seem curious that the spray should prevent the development of the fruiting stages of the knot, especially the more protected winter stage, and still not prevent to a very great extent the enlargement of the knots, this appears to have been accomplished by the searing over of the surface of the knots by a sort of corky development of plant tissues, while the mycelium of the fungus within was protected from any injury. From what could be seen of the development, it appeared that the winter spore receptacles developed only on those sprayed knots, or on portions of them, where the summer spore stage had not been prevented in its development.

The table shows that the Atomic sulphur was more effective in preventing the fruiting of the knots than the self-boiled lime-sulphur. While the former appears to be a somewhat better fungicide, its more efficient results here were apparently in part due to the weak condition of the self-boiled lime-sulphur, as this was made up only in half-barrel lots, so that the heat from the slaking lime did not bring much sulphur into solution. If made up in two or three barrel lots at a time, we believe it would have shown equal fungicidal value.

To determine the real value of the experiments, they should be continued for another year, and will be if arrangements can be made with those who now have the orchard in charge. Present results, however, seem to show that thorough spraying with an efficient fungicide, combined with winter pruning of the knots, should keep this trouble under control.

Henry Orchard. *Anthracnose.* In this orchard, which included a variety of plums and sweet and sour cherries which were just coming into bearing, there had been some previous trouble from anthracnose, which caused premature defoliation. This year Mr. Henry had given the trees a winter treatment and one summer treatment, about May 26, with home-made lime-sulphur, testing about 25°, and then diluted to about 1-60. This strength caused a little shot-hole injury to the plum leaves, but apparently little injury to the cherries. On June 8, a few of the trees were sprayed with Atomic sulphur, 12-50, containing lead arsenate, and a larger number with self-boiled lime-sulphur without lead arsenate. During the first week in July, Mr. Henry also made a second spraying with self-boiled lime-sulphur on part of those that had received this spray previously, so that these received three summer treatments. No very evident injury resulted from the later sprayings made by us or Mr. Henry.

As the season was dry, there was practically no rot either on the sprayed or unsprayed trees. No black knot was seen on this orchard. We did not have a chance to examine the orchard after the middle of August, at which time apparently no anthracnose showed, though there was some shot-hole injury. Mr. Henry states that some anthracnose showed later on both the sprayed or unsprayed trees, but that he did not make any particular observations to determine the difference, if any, due to the spraying. While the experiments did not positively prove the value of spraying against anthracnose, they show that the self-boiled lime-sulphur is a fairly safe fungicide for such treatment so far as spray injury is concerned.

Ives Orchard. *Brown Rot.* These experiments were on a few cherry (Coe's Seedling, Bigarreau, and Oxheart) and plum trees (Satsuma and Abundance), which had been subject to rather serious rotting in previous years. The kind and strength of treatments and dates of spraying were exactly the same as those for the peaches at the same place (see page 393), except that only the first two sprayings were made on the cherries, as they ripened before the third was made. Sherwin-Williams lime-sulphur, self-boiled lime-sulphur, and Atomic sulphur were the sprays used.

No spray injury was noticed except a little shot-hole on the leaves of the Coe's Seedling, and apparently also on the plums, from the Sherwin-Williams lime-sulphur. The plums had been so severely winter-injured at the base of the trees several years previously that the severe dry weather caused all the fruit to drop before ripening. This dry weather also prevented any extensive rotting of the cherries, even on the check trees, such as ordinarily occurs. However, counts were made at the picking time, June 30, with the following results:

Treatment.	Variety.	Total No. Cherries.	Perfect.	Rot.	Insects.	Per cent. Perfect.
Sherwin-Williams L.-S.	Coe's Seedling	267	250	3	14	93.6%
Atomic Sulphur....	Coe's Seedling	394	380	8	6	96.4%
Self-boiled L.-S. ...	Coe's Seedling	351	333	9	9	94.9%
" "	Bigarreau	1176	1028	122	26	87.4%
" "	White Oxheart ...	1097	1017	7	73	92.7%
Total Sprayed......		3285	3008	149	128	91.6%
Checks	Coe's Seedling	437	387	32	18	88.6%
"	Bigarreau	646	516	107	23	79.9%
"	White Oxheart ...	541	448	34	59	82.8%
Total Checks......		1624	1351	173	100	83.2%

From the preceding table it will be seen that the sprayed cherries gave 91.6% perfect fruit, as against 83.2% on the unsprayed. This increase was partly due to decrease of rot, and to a less extent to a decrease of insect injury. With a wet season at harvest time, no doubt, the difference due to rot would have been considerably greater. When picked, the cherries sprayed with self-boiled lime-sulphur, and to a less degree with Atomic sulphur, showed more or less adhering sediment, as the last spraying had been made only a week before, with no intervening rains. The sediment largely wore off in handling, did not affect the taste, and was not especially objected to by the buyers.

The spraying helped to keep the fruit longer, as showed by tests made with a box each taken from sprayed and check trees of the Coe's Seedling. These boxes were examined every other day, and all rotten cherries removed. The keeping quality was unusually good for both the sprayed and the check fruit, because of the dry weather at this time. At the end of the sixth day after picking, the box from the tree sprayed with Atomic sulphur showed that only 26% had rotted, while the box from the check had 57% rotted. At the end of the sixteenth day, the former showed 45% rotted, and the latter 87%.

The Bigarreau cherries failed to set well, many dropping off before maturing, and the Oxheart showed a tendency to crack open. Neither of these troubles was lessened by the spraying. The former trouble was apparently due to imperfect pollenization, and the latter was evidently characteristic of the variety, aggravated by certain weather conditions. This cracking opens the way for rot, and so sprayed cherries, even if cracked as badly, should suffer less from rot.

RECOMMENDATIONS. From these experiments, we make the following suggestions for spraying cherries and plums in this State, until further knowledge is gained.

(1) If the trees suffer from black knot, the knots should be cut off thoroughly by the first of April and destroyed. If the trees need spraying for San José scale, the treatment should be made with commercial lime-sulphur 1-8, in April, just before the buds begin to swell, as this may help to kill the spores of the black knot, and also will take care of any leaf curl or plum pocket that may appear.

(2) As certain varieties of cherries and plums, especially the latter, are as sensitive to spray injury as the peach, it is best to use only self-boiled lime-sulphur, 8-8-50, for summer spraying. If commercial lime-sulphur is used, it should not be stronger than 1-150, and without poison.

(3) As a rule, three summer treatments are desirable, and these may be given somewhat according to the fungous troubles to be combatted, and the time of ripening of the fruit. As a rule, the first treatment should be given on the leaves as soon as they reach maturity, somewhere near the middle of May (the earlier the better, for black knot and anthracnose). The second should be made on the young fruit from the first to the middle of June, according to its size and the time of its ripening. The third should be made usually a week or ten days before the fruit ripens. This will vary from the latter part of June, for cherries, to about the middle of July, for most of the plums. With early ripening fruit, the second and third sprayings thus come close together, before picking, when used against brown rot. If anthracnose or black knot are the chief troubles, it may be well to defer the third treatment until just after the cherry harvest. As the cherries and plums are smooth fruits, the spraying may be made within a week or ten days of picking time, especially if rainy, since the sediment does not adhere to these so readily as to the hairy peaches.

(4) If it is desired to protect the foliage and fruit against insects, lead arsenate, 3-50, may be added to self-boiled lime-sulphur in the first, and also in the second spraying, if the latter is made at least three weeks before the fruit ripens. It is still a question just how much this will do toward lessening wormy fruit.

CURRANTS.

The chief fungous trouble of currants in this State is anthracnose of the leaves (*Gloeosporium Ribis*), which produces small purplish spots on the upper surface, and causes premature defoliation (see Plate XXIV, a). The powdery mildew also attacks the foliage and young branches of certain varieties. Both these troubles yield to treatment with fungicides, when properly applied.

Of the insect troubles, the imported currant worm (*Pteronus ribesi* Scop.) is the most common and wide-spread. The adult is a four-winged fly, which lays its eggs on the under side of the lower leaves of the gooseberry and currant during April and May. The eggs hatch in a week or ten days, and the larvæ usually begin to feed by the second week in May, becoming full-grown about June 1. They then pupate, in earthen cells in the ground, the adults emerging before July, when the females lay eggs for a second brood. A spray of lead arsenate, or dusting with fresh hellebore, will easily control this insect, which is shown on Plate XXIV, b.

Our experiments with currants were not extensive enough to make any very general recommendations. They were carried on at the Gray place in connection with the experiments with cherries merely to test the effect on the currant leaves of the sprays used there. The sprays and times of treatment were the same as those given for the cherries; namely, three sprayings, made May 19, June 2, and July 11, with (1) self-boiled lime-sulphur, 8-8-50, with lead arsenate, 3-50 in the first spraying only; (2) Atomic sulphur, first and second treatment, 12-50, with lead arsenate; third treatment, 10-50, with no lead arsenate.

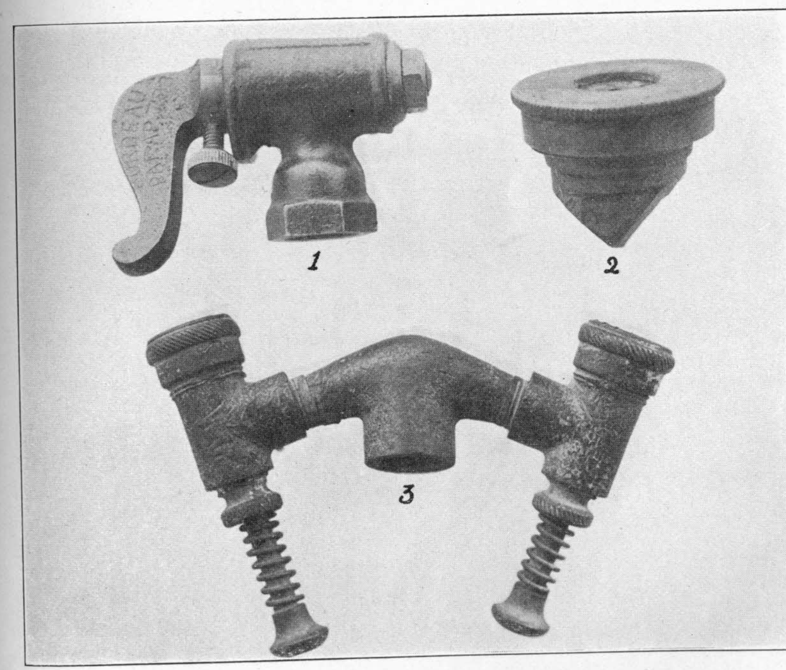
The only injury that resulted was an evident scorch on scattered clusters of leaves on the row of currants sprayed with Atomic sulphur, appearing some time after the second treatment. A similar scorch, but much less abundant, showed on the row sprayed with self-boiled lime-sulphur. Appearances seemed to indicate that the hot, dry weather at that time was at least partially responsible for the trouble. Gooseberries throughout the State baked on the bushes because of this hot period.

No anthracnose or insect injury appeared on the sprayed bushes. However, only a little anthracnose and a few leaves eaten by the imported currant worm were seen on the unsprayed rows. It is doubtful if either of the sprays used there have any advantage over Bordeaux. It might, however, be desirable to use the weak Bordeaux, 1-4-50, for the second and third treatments where leaf injury is likely to occur if the full strength is used.

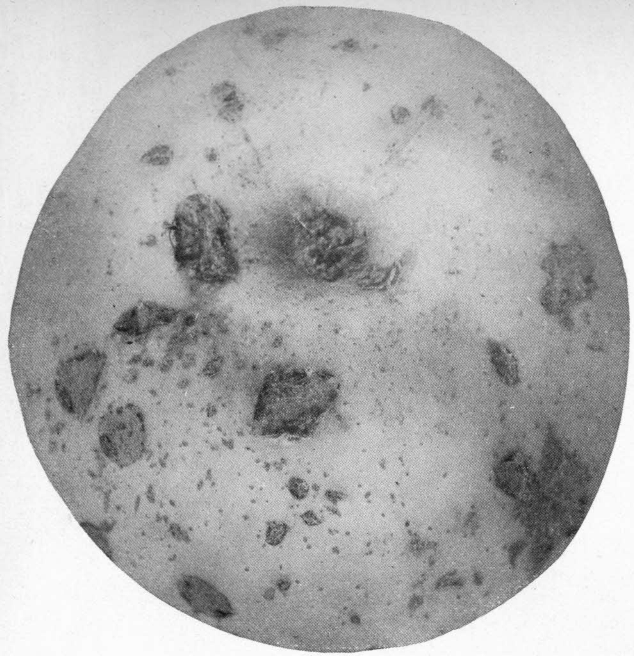
a Gasoline engine sprayer used in Henry orchard.

b. Horizontal pump sprayer used in Ives orchard.

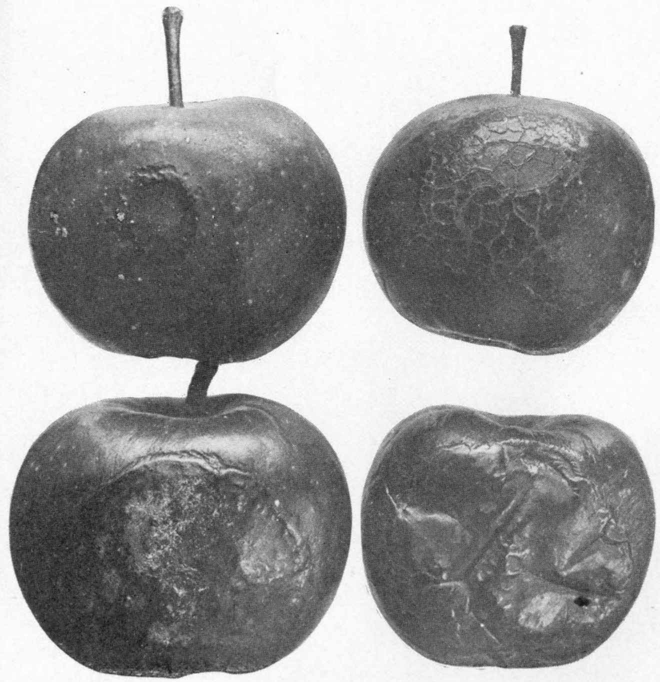
a. Mounted half barrel sprayer used in Jones orchard.



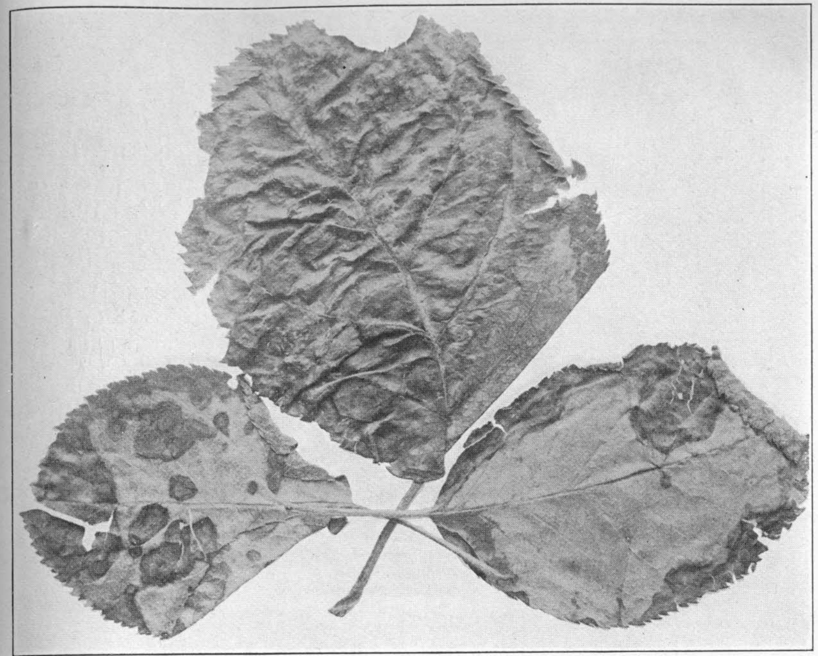
b. Types of nozzles: 1. Bordeaux; 2. Disc; 3. Double Vermorel.



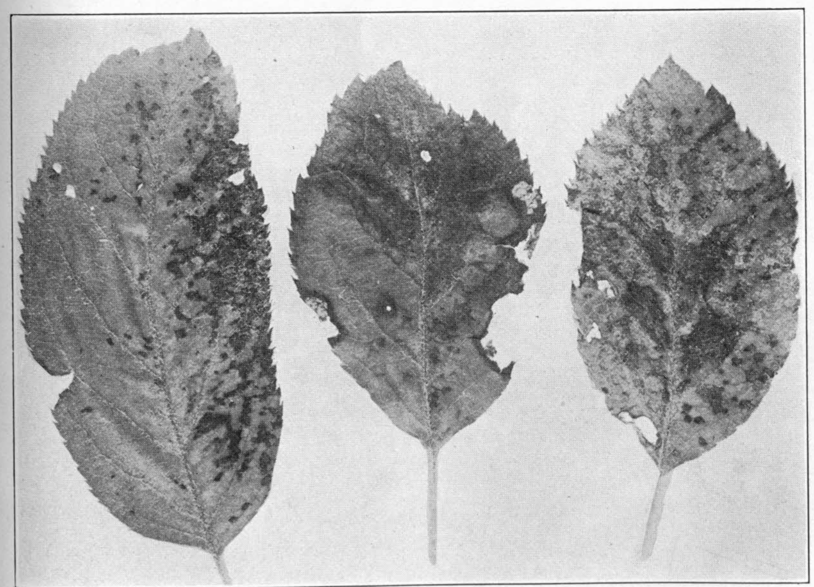
a. Apple showing hail injury.



b. Apples showing scald injury.

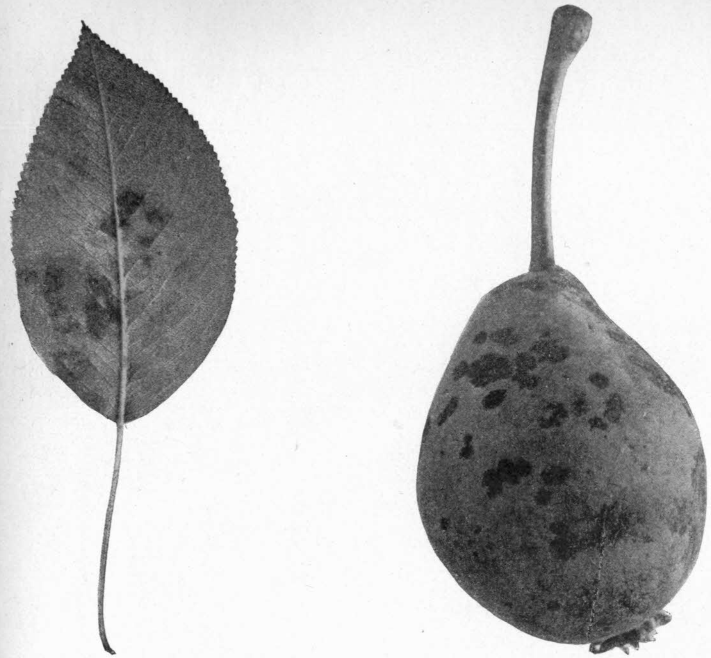


a. Ortho-arsenite of zinc injury on apple leaves.

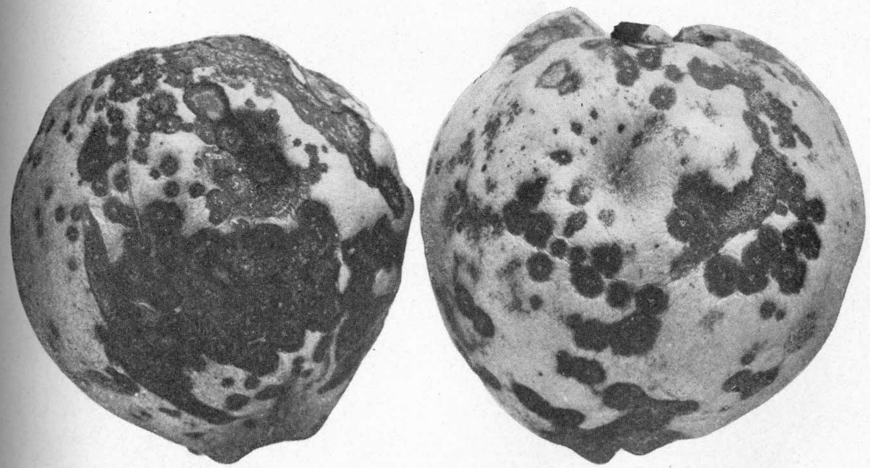


b. Lime and sulphur (Thomsen) injury on apple leaves.

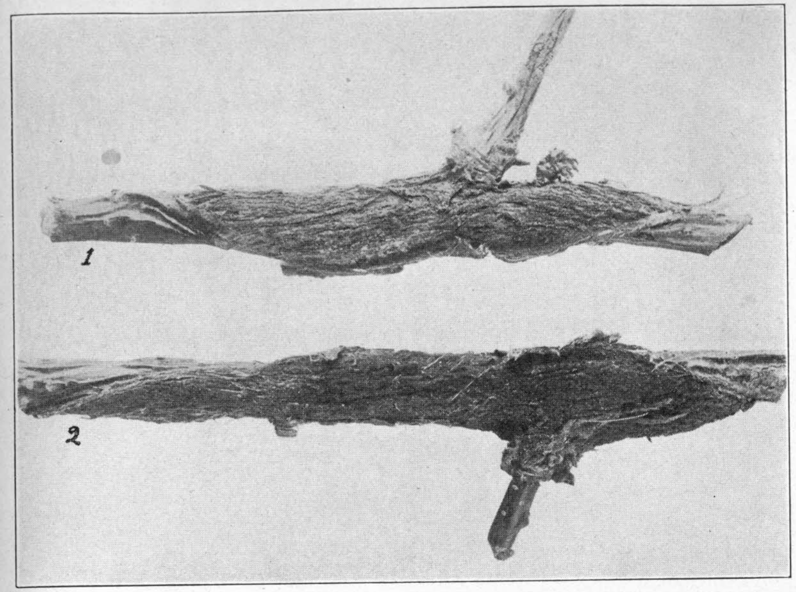
PLATE XXI.



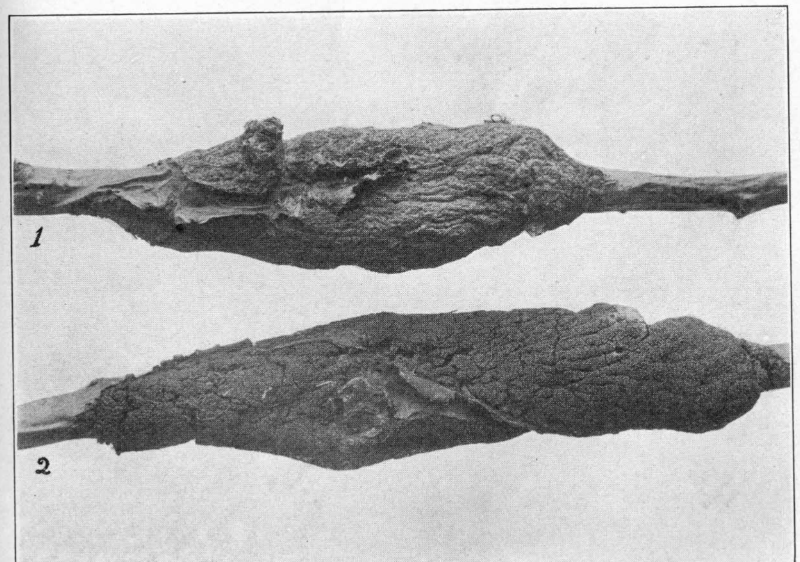
a. Pear scab on leaf and fruit.



b. Quince fruit blight.

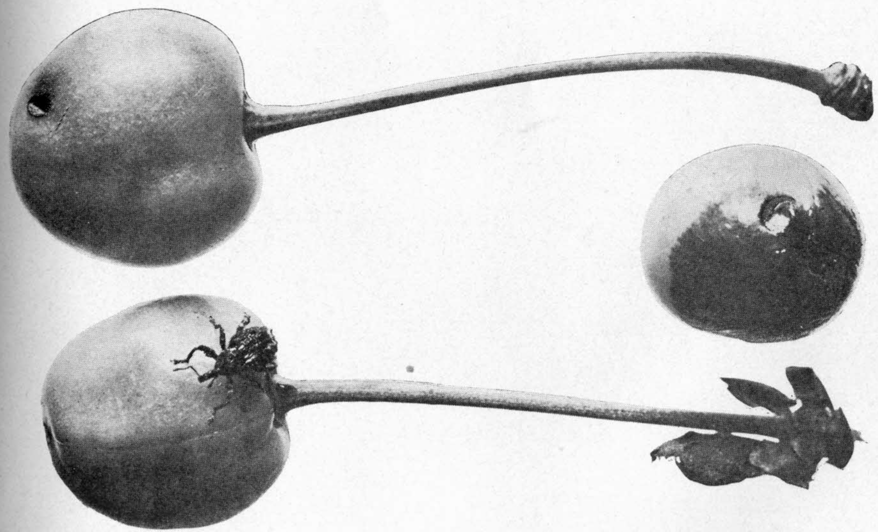


a. Development of Black Knot on sprayed (1) and unsprayed (2) branches, June 2. (2) shows summer stage.



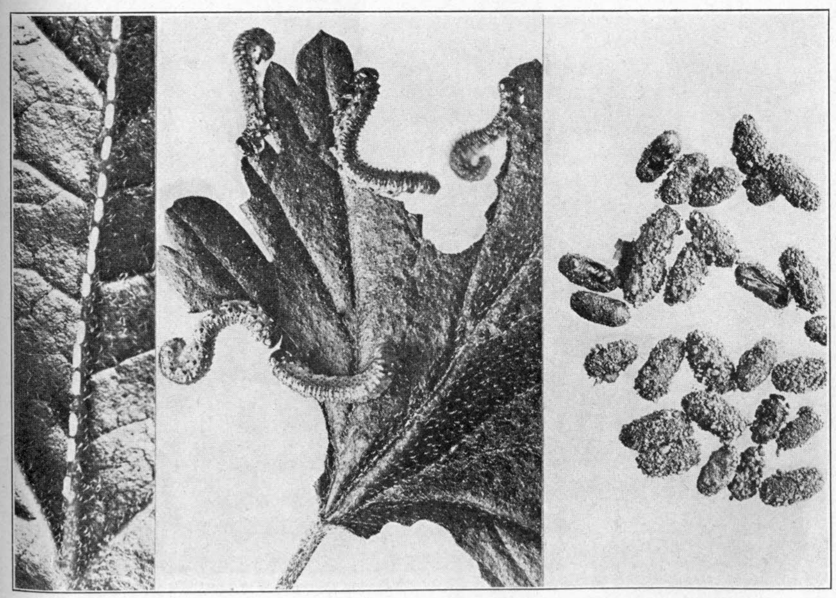
b. Development of Black Knot on sprayed (1) and unsprayed (2) branches, Dec. 4. (2) shows winter stage.

a. Brown rot of cherries.



b. Curculio, its injury and resulting brown rot.

a. Anthracnose of currant.



b. Imported currant-worm, eggs, larvæ, cocoons.

PART VI.

INHERITANCE IN CORN.

By H. K. HAYES.

Introduction

For the last six years this Station has been studying the inheritance of corn characters, and in 1911 a technical bulletin was published on the subject. The purpose of this paper is to state as clearly as possible some of our results which have practical value to corn growers and breeders in two different particulars.

First, a large number of corn varieties are grown in Connecticut and often several of them on the same farm. In spite of usual precautions, slight accidental crossings between varieties take place which cause serious embarrassment to growers of seed corn and plague everyone who wants to raise corn which is uniform in appearance. In the following pages is stated what can be done to detect and cull out the accidental hybrid seed.

Second, many more or less successful attempts have been and are being made to develop new hybrid varieties which shall combine desirable qualities from both parents. Accurate knowledge of the way in which these desirable qualities are inherited will simplify operations and prevent disappointment.

The Formation of the Seed

Following the general rule, seed corn can only be produced by a union of male and female elements. The tassels and silks of corn, which are the male and female reproductive organs, are borne on widely separated parts of the plant. Each thread of silk grows from a spot on the cob where the kernel is to be and where the female cells are produced. The office of the silk is to collect the pollen grains which are formed in the tassel. A mature pollen grain falling on a mature silk germinates and sends out a tube which, guided by the silk, reaches the ovary. Through this tube two male cells pass, and on reaching the female cells, unite with them. One unites with the egg cell to form the embryo or undeveloped plant and the other fuses with a second female cell to form the endosperm of the seed. This endosperm is the surrounding tissue in which the food material is stored. The embryo of the corn seed is the germ or chit, the rest of the seed within the outer covering is the endosperm.

The fusion of the cells just described, called fertilization, is at once followed by rapid growth and the production of a seed. When the pollen comes from the same plant which bears the silk, there is "self-fertilization;" when it comes from another plant of the same variety there is "cross-fertilization;" when from another variety there results "hybridization." As a commercial variety of corn is generally composed of many types in a complex hybrid condition, due to constant inter-crossing, there is no exact distinction between "cross-fertilization" and "hybridization" as applied to corn.

The Law of Heredity

The transmission from one generation to another of the prominent features, such as sweet, dent and flint characters, color of seeds, etc., which distinguish varieties of corn, follows what is known as Mendel's Law of Heredity, which may be illustrated from his own work with peas. For this discussion Darbishire's book, "Breeding and the Mendelian Discovery," has been freely used.

The edible pea may be divided into two classes, the tall and the dwarf. One difference between them is in the length of the internodes, i. e., the sections of the stem between two nodes or joints where the leaves are attached. This causes the tallness or the shortness of the whole plant.

Moreover, the pea is a normally self-fertilized plant, i. e., seed is formed by the union of male and female cells of *the same plant*.

This seed, if from a tall race, will produce nothing but tall plants, and if from a dwarf plant will yield dwarfs only.

Now, if a cross is made between a tall and a dwarf race by applying the pollen of one variety to the stigma or female receptive organ of another variety, and the seeds produced by this "cross" are sown, nothing but tall plants will appear. These are no shorter than the pure tall plants and in many cases they are

somewhat taller because of the increased vigor due to crossing two pure races.

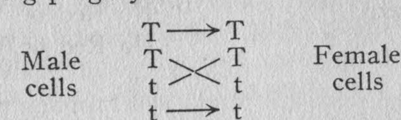
When we sow the seed from the above hybrid generation we obtain tall and dwarf plants in the ratio of about three tall to one dwarf in every four. These dwarfs, if self-fertilized, will all breed true as to height in later generations, but while some of the tall plants will breed true others will again give tall and dwarf plants in the ratio of three to one.

These facts are easily explained by the present Mendelian theory, which is not essentially different from Mendel's interpretation. A plant or animal does not transmit its characters in a bunch as it were, as if the entire organism were the unit, but its various characters are inherited separately.

Each reproductive cell, whether in pollen or ovule of the tall pea, contains a factor, structure or unit quality of tallness which we may represent by T. A union of male and female cells of tall peas will be a union of reproductive cells, all of which contain T, and a tall race will result. Each such reproductive cell of the dwarf pea lacks the structure or factor which produces the tall race. This lack may be represented by t, and from their fusion only dwarfs result.

But when the tall and dwarf races are crossed, each seed is the result of a union of reproductive cells, the one from the tall race containing T and the one from the dwarf race containing t. But the tall character in this generation is "dominant;" i. e., it conceals or masks the other. Such characters as tallness and dwarfness are said to be contrasted or allelomorphic pairs, and as only tall plants are produced when tall and dwarf are crossed, the tall character is said to be a *dominant* one and the dwarf character a *recessive* condition.

Now, if all the seeds of this hybrid are planted and their blossoms self-fertilized, we may explain the conditions as follows: Half of the male cells are supposed to contain only T, the factor for tallness, and half only t, the factor for dwarfness. The same is true of the female cells. We may represent the situation and the resulting progeny thus:



From the diagram it appears that one-quarter of the resulting seeds have received T from both pollen and ovule, or (T + T). They can produce only tall progeny. One-quarter have received t from both, or (t + t) and can produce only dwarf progeny. The remaining half of the seeds are like those from which they themselves were grown, i. e., they are formed by a union of cells, one of which contains T and the other t, or (T + t). But when the dominant factor T is received from only one reproductive cell the plant when grown is a tall one and can not be distinguished from the pure tall race.

The only method of distinguishing between the pure tall and hybrid tall plants is by breeding from them. The pure tall plants will, of course, give only tall progeny, while the hybrid tall plants will again give both tall and dwarf plants.

The first important fact which this illustrates is that the external appearance of a plant is not a correct criterion of its breeding qualities, but that the contents of the reproductive cells are the important feature, and that in most cases the only way of determining these contents is to breed from them.

We should also note that only one of the factors of a contrasted pair is found in a single reproductive cell. Thus, in the case above described no reproductive cell consisted of a mixture of the factors for both tall and dwarf plants but contained either the one or the other.

The fact that there is often a dominance of one condition over another in the first hybrid generation of a cross is of especial importance to the corn growers of Connecticut. A partial report of this matter was given in 1907 by East.

Dominance of Characters in Corn Breeding

After crossing, the characters here given behave in the following manner:

Flint or Dent	is	dominant	to	Sweet.
Yellow	"	"	"	No Yellow or White.
Purple	"	"	"	No Purple or White.
Red Pericarp	"	"	"	No Red or White.
Red Cob	"	"	"	No Red or White.

Flint or Dent—Sweet Crosses

If a sweet corn is used as the female parent and is crossed with a starchy corn, either a flint or a dent, there result hybrid seeds which cannot be distinguished from seeds of the starchy parent. This result is due to the fact that the endosperm of corn is hybridized as well as the embryo. (See The Formation of the Seed.)

A microscopic study of the starch grains of sweet corn shows them to be small, angular and abortive, while those of a flint or dent are much larger and are circular in outline. Something is evidently introduced by the pollen of the starchy corn which enables the sweet variety to proceed in its starch development and form seeds which are not visibly different from the starchy parent.

If, on the other hand, starchy corn, flint or dent, is used as the female parent and is pollinated with sweet corn pollen, no immediate effect is apparent. The starchy corn already contains the dominant factor and masks or hides the presence of the sweet character which is recessive.

The practical use of these facts is as follows:

No extreme care need be used in isolating sweet corn plots from field corn, as any crossing on the sweet corn shows in the first year, and at harvest the hard starchy kernels can be discarded. The sweet kernels, those with a wrinkled appearance, when grown will always produce sweet corn.

But, on the other hand, as there is no immediate visible change when field corn is pollinated with sweet corn pollen, there is no method of detecting and rejecting the hybrid kernels. The field corn seed should always therefore be saved from that part of the field which is farthest from the sweet corn plot.

Sometimes seeds of a semi-starchy nature appear in sweet corn varieties. In a study of the inheritance of starchy-sweet crosses a few ears of this nature were met with. Semi-starchy seeds have also been mentioned as occurring in a number of pure sweet races by Halsted of New Jersey. To determine the inheritance of this peculiarity, the most starchy and most sweet kernels were selected from a self-fertilized semi-starchy ear. The result of two years' selection of the most wrinkled kernels for planting produced ears nearly all of which were of a pure sweet nature. No ears have as yet been produced of a pure starchy nature.

Such semi-starchy ears are often encountered by sweet corn canning factories and give much trouble. Selection of the most wrinkled seeds for planting will assist in eliminating the semi-starchy types.

Yellow—White Crosses

Our results indicate that in many cases there are two separately inherited characters for yellow color in corn, either of which can produce this color. This fact, although of great scientific importance, does not materially change the methods of producing pure seed of either the yellow or white variety. The color which produces the yellow varieties of corn is an endosperm character. When white corn is crossed with pollen from a yellow variety the resulting progeny always has a yellow color, although it is sometimes lighter than the pure yellow. If the white corn plot is not completely isolated from the yellow variety some hybrid seeds will be produced. On saving the white corn seed, those seeds which are hybrid can be detected by their yellow color and removed, with the assurance that when nothing but white seed is planted the seed is pure for this character.

When yellow is the female parent and is crossed with white corn the resulting seed is yellow. In some crosses the hybrid seeds are light yellow, but, on the other hand, some hybrid yellow-white seeds are dark yellow, so it is impossible to separate the pure yellow from the hybrid yellow seed except by breeding. Therefore, yellow corn, when intended for seed, must be grown at a considerable distance from white varieties.

Intentional crossing of two varieties is usually done with the idea of obtaining an improved variety by combining the desirable qualities of both parents. Suppose a white corn with a large stalk has been crossed with a yellow variety with a good ear and that a type has been produced with both these characters (large stalk and good ears), but the ears are composed of such a heterogeneous mixture of yellow and white seeds that they have no value as seed corn. The problem is to obtain ears which will produce either all white or all yellow seeds. The easiest method is to select only pure white seeds for planting, which in turn will produce only white corn. If a yellow variety is desired it can be most easily produced by planting all yellow seeds and self-fertilizing a number of ears, i. e., the pollination of the silks of a plant by its own pollen grains. This is most easily performed as follows:

Just before the silk appears a bag should be placed over the ear and another over the tassel. About five days later, when the silk is well showing, the stalk should be bent over and the tassel bag carefully removed. This will contain a certain amount of yellow dust or pollen which should be carefully dusted over the silks, and the ear again covered. After maturity, these hand-fertilized ears should be harvested and examined. All ears which contain only yellow seeds will produce only yellow progeny. It is necessary to self-fertilize a large number of ears so that several pure ears may be allowed to cross naturally the following season in order not to obtain evil effects from inbreeding.

Purple—White Crosses

Only a few races of purple corn are grown in Connecticut, of which Black Mexican sweet is the best known example, although a purple pop variety is sometimes seen in the market. This purple color is due to a dye which is present in a single row of cells, known as the aleurone layer, which is found just underneath the pericarp or outer hull of the seed. As this layer is a part of the endosperm, there is an immediate effect when non-purple races are crossed with purple varieties. The conditions, however, are different than in the crosses previously mentioned.

From an analysis of crosses between Black Mexican sweet and several non-purple races the following facts have been established. The purple color is due to at least two separately inherited factors found in the reproductive cells, both of which must be present in order to produce a purple condition. By crossing a white race which we found to contain one of these factors with another white race which contained the other factor, purple seeds were obtained. In one cross there was no visible effect in some kernels when a non-purple race was crossed with pollen from a purple variety. This we explain by the presence of something in this race which inhibited the production of purple. These facts, however, will not be further discussed here.

When pure seed of a purple race is desired, it is necessary that it be isolated from other corn plots. Of course, when Black

Mexican sweet is fertilized with pollen from starchy races, either dent, flint, or pop, those seeds which are of a hybrid nature will be of a hard starchy condition and can therefore be rejected.

Non-purple races, of either flint, dent, pop, or sweet, from which seed is saved, should not be grown near a purple variety, as there is no surety that hybrid seeds can be rejected. All kernels showing any purple color will be found to be hybrids and by rejecting these the greater part of the hybrid seeds can be removed.

Red Pericarp—White Pericarp Crosses

The pericarp of corn is the outer hull. It is in this portion of the seed that the red color of the common red races of corn is found. If a paper bag be placed upon an ear before silking time and be removed after the silks have fully developed, thus leaving it unfertilized, the places on the ear where the seeds would have been formed, had pollination taken place, will be found to consist almost entirely of this outer hull or pericarp. This portion of the seed is therefore just as much a part of the mother plant as its tassels or silks and is not immediately affected by pollination. For this reason an ear has either a red pericarp color on all of its seeds or on none of them.

If a seed is soaked for a short time in water this outer hull may be easily removed. This red color conceals all other colors which may be present in the seed. Thus, an ear of corn may contain both yellow and white, or purple seeds, or any of these colors in a pure condition, yet if the red pericarp is present these facts are obscured. Thus we are further impressed with the fact that all of the characters so far discussed are separately inherited.

If a red pericarp corn is crossed with a non-colored race, no matter which is the female parent, there will be no immediate visible effect. If these hybrid seeds are planted, the crop for the following season will consist of all red pericarp ears. If these ears are self-fertilized and grown, red and non-red pericarp ears will be received in the ratio of three to one.

Besides this solid red pericarp there are mosaic red, commonly called "Bloody Butcher," varieties. This mosaic red is inherited as a pattern color. In common with many variegated races of

plants this condition does not breed true but always gives some non-colored and, in some cases, some deep red progeny. There is also a pericarp color which varies in intensity due to light conditions. If the ear is stripped of its husks before maturity all seeds are partially covered with red, in other cases the red color is only seen as a slight blush on some seeds near the tip of the ear. This color is inherited in the same manner as the deep red pericarp color.

As there is no method of detecting a cross between red and non-red races, seed of either sort should only be grown in isolated plots at some distance from the other variety.

Red Cob—White Cob Crosses

The directions for selecting exhibition corn, issued by the extension department of the Massachusetts Agricultural College, state that white corn usually has white cobs, that red cobs in yellow corn are preferred, while a variation in cob color shows a mixture and poor breeding.

It is not believed that the color of the cob is of any practical importance, although for the sake of a uniform appearance a "mixture" is not advisable. In a study of a cross between a red pericarp, red cobbed variety, and a race which lacked these colors, the pericarp and cob colors were coupled in inheritance, i. e., when separation took place all red cobs had red pericarps and all white cobs had white pericarps. In other cases no coupling has been observed and each character is separately inherited.

The cob color behaves exactly similar to the pericarp color in crosses. Red is dominant to white and in the second generation there are, on the average, three red cobs to one white.

In case of a mixture of red and white cobs, or pericarp colors, pure races for either the one or the other can be most quickly got by self-fertilizing a number of ears, as explained under the heading Yellow-White Crosses. All non-colored self-fertilized ears for either cob or pericarp will give non-colored progeny. Of the self fertilized red ears, one-third will breed true and two-thirds will again give a mixture. The breeding nature of these can be tested by growing about ten hills of each and noting results. The remainder of the seeds from each ear should be reserved and all ears which, by test, give only red-eared progeny can be used to multiply the variety the following year.

Summary of Crosses Showing Dominance

In the preceding discussion we have considered the appearance of crosses, the production of seed of pure varieties, and the inheritance of characters.

Summing up these results, we find that when a white corn is crossed with a yellow variety the resulting seeds are always yellow. Likewise when sweet corn is pollinated with starchy races (dent, flint, or pop) the resulting seeds are always of a starchy appearance. Pure seeds for the characters, sweetness, or white color can therefore be told by inspection. When ears show a mixture of yellow and white or starchy and sweet seeds we may be sure that the white seeds and the sweet seeds are pure for these respective characters. Thus no extreme isolation from other varieties of either sweet or white corn seed plots need be practiced, as the crossed seeds can be detected and eliminated. Seed plots in all other cases must be isolated from other varieties.

In case a mixture has been received of yellow and white seeds and a yellow race is desired, this can be obtained by planting yellow seeds and self-fertilizing a number of ears, as we know that all self-fertilized ears which contain only yellow seeds will thereafter give yellow progeny.

When a variety produces some colored and some non-colored ears for either cob or pericarp colors, there is no surety that either selected color will breed true. As a larger part of the seeds of an ear is normally "cross-fertilized" there is a small chance of receiving either a red or white ear in which some seeds will not be fertilized with pollen from a plant bearing an opposite color and, when planted, give a mixture. Pure varieties can be most quickly obtained by self-fertilizing a number of ears as previously explained under the heading "Red Cob-White Cob Crosses."

It is always necessary to self-fertilize a number of ears so that several pure ears may be allowed to cross naturally the following season.

When attempting to produce an improved variety by crossing two types, each of which contains a desirable character, the aim of the breeder is to combine both desirable characters in one variety. As we have learned, each character is generally separately inherited, although some cases of coupling have been reported in which two or more characters are inherited together. The method of inheritance of any character can be determined by crossing a variety which contains this character with another in which it is either absent or is present in a modified condition and by studying the appearance of this character in later generations. The knowledge of the manner in which each character is inherited enables the breeder to combine desirable features of one variety with those of another.

When the parents differ by two separately inherited characters we may illustrate the results as follows:

Suppose one parent is a yellow sweet corn in which there is only one inherited factor for the yellow color and the other parent is a white flint corn. As we have seen, yellow is dominant to white, and flint or starchiness is dominant to sweetness. Since these are endosperm characters, the immediate cross of the above parents will be a yellow flint corn. But the following generation, if self-fertilized, will consist of ears containing four sorts of seeds in the ratio of nine yellow starchy, three white starchy, three yellow sweet and one white sweet. The yellow starchy corn is produced when the factors for yellow and starchiness are both present. As both are dominant factors, only a part of the nine yellow starchy seeds will breed true. Theoretically, one out of every nine will give ears containing only yellow starchy seeds, two will breed true for the yellow color but will be hybrid for the starchy character, two others will breed true for the starchy condition but will give both yellow and white seeds, and four will again produce ears containing all four sorts of seeds.

Of the three white starchy seeds, all will breed true to the white color, but only one of every three will give pure starchy ears. Likewise, of the three yellow sweet seeds, all will give sweet progeny, but only one out of every three will give pure yellow ears. The white sweet seeds will all breed true, giving only white sweet progeny.

Our parent varieties were yellow sweet and white flint. From crossing these varieties two new sorts have therefore been produced, namely, white sweet and yellow flint. This cross illustrates what we mean by a recombination of characters.

Inheritance of Characters Which do not Show Dominance

From the viewpoint of the improvement of corn by a cross between two varieties, each of which contains some desirable character, the phenomenon of dominance is of little importance. The result desired is to obtain a race which contains both beneficial characters.

The following crosses conform to the essential feature of Mendel's law, i. e., the separation of characters in the reproductive cells of hybrids and their chance recombination—although the conditions are of a complex nature.

After crossing, the characters given below do not show dominance. The first hybrid generation is intermediate in appearance and the second hybrid generation gives both intermediate and parent types.

Crosses between Flint and Dent races.

Crosses between races which differ in row numbers.
Crosses between races which differ in height of plants.
Crosses between races which differ in length of ears.
Crosses between races which differ in size of seeds.

Crosses between Flint and Dent

Flint corn has hard, smooth and oval grains generally nearly as broad as long, while dent corn is indented on the top and the length of the seeds is much greater than their breadth. The characteristic difference between flint and dent is due to the amount and position of horny starch in the endosperm. Flint seeds have the embryo and soft starch surrounded by the horny starch. In dent races the soft starch extends from the center to the cap, the sides of the seed being composed of horny starch.

There is no immediate visible effect when dent and flint races are crossed, the character being inherited as a plant character. For this reason seed of either sort must be produced in isolated plots. Frequently an ear from a flint-dent cross contains both indented and flinty seeds, yet selection of either kind for planting gives like results. An ear which contains both flint and dent seeds is generally a hybrid.

The first generation of a cross between a flint and dent is of a uniform nature and intermediate in appearance. Sometimes this generation is more like the flint parent, sometimes more like dent

in appearance and in other cases strictly intermediate. Self-fertilized ears of this generation produce a wide range of variation the following season, a few ears resembling flint, others resembling dent, and the greater part again of an intermediate nature. Self-fertilized ears either of the pure dent or pure flint type produce pure races when grown, but the intermediates again show wide variabilities. In this cross there is often difficulty in separating pure dent or pure flint from intermediates, by inspection. As in some previous cases, the only sure method of determining the breeding nature of an ear is by growing it and examining its progeny.

Crosses between Races which Differ in Row Numbers

There is a wide range of row classes in corn. The most common flint races are eight-rowed sorts and some dent races produce as high as thirty-six rows. This character is quite markedly affected by conditions; thus, an eight-rowed flint frequently produces some twelve-rowed ears. A sixteen-rowed selection which has been inbred for a number of years has a normal fluctuation of from twelve to twenty rows with a mean value of sixteen rows. In pure races these fluctuations, due to environmental or physiological conditions, are non-inherited.

Crosses between races which differ in row numbers are of an intermediate nature in the first generation, the range of classes being somewhat larger in the second generation than in the first. Some of these second generation plants breed comparatively true, although the greater part again break up the following year.

There must be several inherited factors for row classes in corn, as different varieties breed true to different row classes. The row classes of most commercial varieties of corn can be changed by selection and either increased or decreased. This is due to the fact that corn is naturally cross pollinated, and a commercial variety really consists of a complex hybrid condition.

Crosses Between Races which Differ in Height of Plants

Plant height is a complex character and, without doubt, due to many inherited factors. Our reasons for this belief are the large number of known varieties which differ from each other in plant height. In common with other size characters, environmental conditions have the power to greatly modify the height of plants. The fluctuations within a pure race are very large and make the analysis of the inheritance of such characters almost impossible. Some of our experimental races have been constantly inbred for a period of six years and are very uniform in appearance. Under ordinary field conditions, the difference in height of different plants of such pure races is often as great as two and a half feet.

Two crosses have been studied between races which differ in plant height, both giving similar results. One was a dent-flint cross and the other a cross between Tom Thumb pop and Black Mexican sweet. The results were as follows: The first generation of the cross proved to be as uniform as either parent and was somewhat larger than the average of the parents. This increased height over the average of the parents is due to increased vigor and not to dominance.

Self-fertilized ears of this first generation, when grown, produced a wide range of variability for plant height, embracing the range of both parent forms. Of course, it is not to be expected that many of these forms will breed true the following year, yet selection of forms like either parent will doubtless give an approach toward the parental condition.

Length of Ears and Size of Seeds

Only one cross between races which differ in ear length has been carefully studied. This was between Tom Thumb pop, with an ear length of from five to eight centimeters, and Black Mexican sweet, with an ear length of from thirteen to twenty-one centimeters. The first generation of this cross had a range of variation of nine to fifteen centimeters. This generation was no more variable than the parent races, and was of an intermediate ear length, although somewhat larger than the average of the parents. The second generation was very variable and produced some ears which closely approached the parental forms in length.

The above cross was also used to study the inheritance of weight of seeds. The size of the seeds is determined in a large measure by the pericarp, which is a mother plant character. For this study, twenty-five seeds were weighed from each ear. The first generation was intermediate in weight of seeds and no more variable than the parent forms. The second generation presented a wide range of variation. Some short ears produced large seeds, while some long ears produced small seeds.

Summary of Crosses not Showing Dominance

The preceding crosses do not show the phenomenon of dominance, yet all behave in a similar manner. The first generation of these crosses is of an intermediate appearance and the second generation has a range of variation from one parent form to the other. Some of these second generation forms will breed true, but it is impossible to determine, by inspection, which these are. The only method of determining the breeding nature of these second generation forms is by row tests.

Abnormalities

There are a number of abnormalities of corn which are often found in commercial races. These appear to be of two sorts; first, those which are produced by some unusual environmental condition and are non-inherited, and second, inherited abnormalities. Of these two classes the heritable one is of interest to the commercial grower or seedsman because it is important to know the quickest method of getting rid of these abnormalities if they appear.

The following abnormalities have been found to be inherited:

- Dwarf forms.
- Divided ears.
- Irregularity of rows of seeds.

Dwarf Forms

Dwarfs have appeared several times in our cultures, and in all cases but one in strains which have been inbred for one or more seasons. Inbreeding, as used here, means the pollinating of the silks of a plant by its own pollen grains.

In one instance, some dwarf plants appeared in a commercial culture of Stowell's Evergreen Sweet. A normal plant from this culture was inbred and gave both dwarf and normal plants the following season. A cross was made between a normal plant and a race in which dwarfs had never appeared, which, when grown, gave only normal plants, two of which were self-fertilized. One of these ears produced only normal plants, and the other gave both normal and dwarf forms.

Several attempts to self-fertilize such dwarfs have proved unsuccessful and in one case when a few mature seeds were produced they failed to germinate. Emerson of Nebraska succeeded in self-fertilizing some similar dwarfs which appeared in his cultures and when grown only dwarfs were produced.

It seems very probable that we are dealing with a condition in which normal plants are dominant to dwarfs, as is the case of the tall and dwarf peas. The dwarfs which have appeared in our corn cultures, unlike dwarf peas, are absolutely valueless. The low per cent. of seeds which germinate from strains which produce some dwarfs points to the fact that in some cases such abnormalities have not been able to develop.

If dwarfs appear in an otherwise valuable strain they can be most quickly eliminated as follows: By hand pollinating a large number of ears we may expect to receive one out of every three which will give only normal plants. The hand pollinated ears should be tested by planting a part of each and reserving the remainder of the seeds. The seed from all ears which in this test gives only normal plants may be used to develop the strain the following season. Such a method should not be used unless the strain is a valuable one.

Divided Ears

A desirable ear of corn should be cylindrical in form and should not have too large a cob, i. e., the proportion of shelled corn to cob should be large.

There are several classes of abnormalities which show different degrees of division of the cob. A form with a monstrous, flattened, and in extreme cases a divided tip, is frequently seen in races which have a large number of rows, such as dents and pops. At our State Fair this year, one entry for the best six-ear lot of yellow dent corn contained one such ear. Such an ear produces a large proportion of cob which is valueless and also an ear which is hard to shell.

The above abnormality belongs to the inherited class, although environment has the effect of retarding or accelerating its manifestation. One of our inbred races of dent produces, on the average, about two-thirds of its progeny with a flattened ear and one-third with both a flattened ear and a divided tip. A cross between this strain and a strain with a flattened cob gave, in the first generation, about the same per cent. of divided tip ears as is produced by the divided tip parent.

Divided tip is dominant in crosses to normal tip, but the dominance is not complete. In such cases there is the added difficulty of not being able to tell the recessive form from the dominant by inspection. Flattened cobs have proved dominant in crosses over cylindrical cobs.

There are different degrees of cob division and in the extreme case the cob is grooved and only four rows are produced. Although we have not found this four-rowed condition to be inherited, there is no doubt of the fact that the tendency to division is sometimes inherited. We have often found the same plant producing one ear which is four-rowed and another with eight rows. When the tendency to division is an inherited character an inspection of the eight-rowed ear showed a tendency towards row splitting at the butt of the cob. In some cases we found this character to be non-inherited. Any row culture producing over five per cent. of such ears should probably be discarded.

Irregularity of Rows of Seeds

The greater part of the ears of our commercial varieties of corn have regular rows. Sometimes, as we have noted, two or more rows are dropped from a part of the ear, but even then the rows of seeds are regular and straight.

Nearly all varieties produce some ears which show irregular rows, the kernels being packed closely together on the ear, making it almost impossible to count the row number. Such irregular ears are undesirable, the seeds presenting differences of size and shape which are not conducive to even dropping by cornplanters. Regular-rowed ears also present a more attractive appearance.

Country Gentleman sweet corn is an irregular-rowed variety which proves that in some cases irregularity of rows is an inherited character. Irregular-rowed ears have often appeared in our cultures and proved to be non-inherited, in all but one case. A self-fertilized, irregular-rowed ear of a white flint strain produced thirty-three normal and fifteen irregular ears, while a normal self-fertilized ear produced one hundred and twenty-five normal and five irregular ears. One of these five irregular ears was self-fertilized, and the following year produced fifty-six regular ears and one irregular ear. A regular-rowed ear from the irregular-rowed strain produced seventy-nine regular and twenty-nine irregular-rowed.

The manner of the inheritance of this character cannot be definitely stated, yet the character is an inherited one. Any commercial row culture which contains much over five per cent. of irregular ears should be discarded to eliminate the undesirable character.

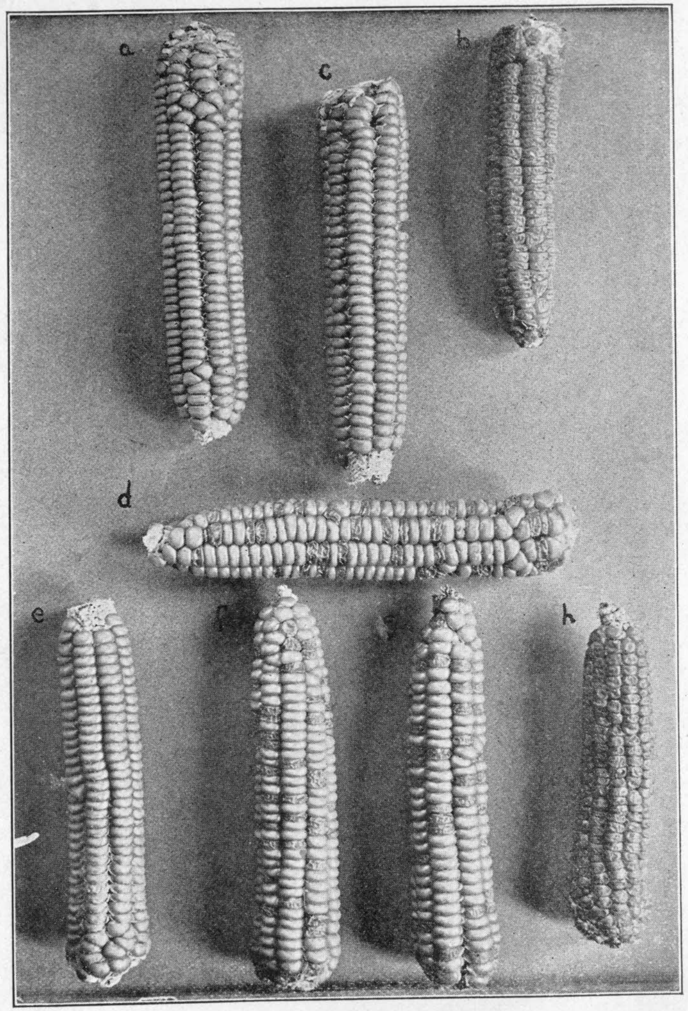
Summary of Results

Corn is a normally cross-fertilized plant, and for this reason a commercial variety is composed of many types. Any variety can be made more uniform by selection. The benefit of selection seems chiefly due to the elimination of the poorer types, leaving only the better sorts.

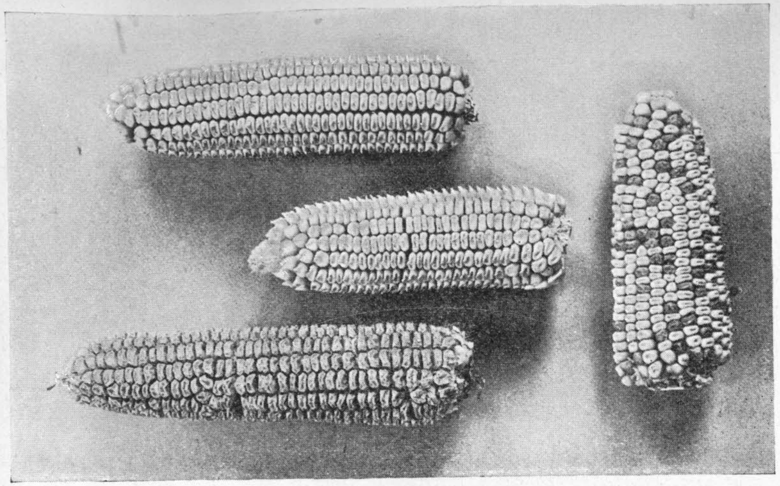
The improvement of corn by selection has been thoroughly discussed in previous bulletins and will be only briefly mentioned here. Bulletin 152 gives directions for producing a breeding plot in which each row is grown from a single ear. Each row is then harvested separately, the yield and appearance determining the value of the selection. Such commercial row cultures have been and will continue to be of great value. We should not, however, expect too much from such a method. The increased yields which have been received by such methods are believed to be due to the elimination of undesirable types of which the preceding abnormalities are examples. Row cultures are of inestimable value in such work.

In Bulletin 168 we discussed corn breeding methods and came to the conclusion that the growing of first generation hybrids would prove beneficial and materially increase corn yields. Some varieties will doubtless prove more beneficial for this work than others; however, all investigators agree that crosses between highly selected sorts will prove most valuable.

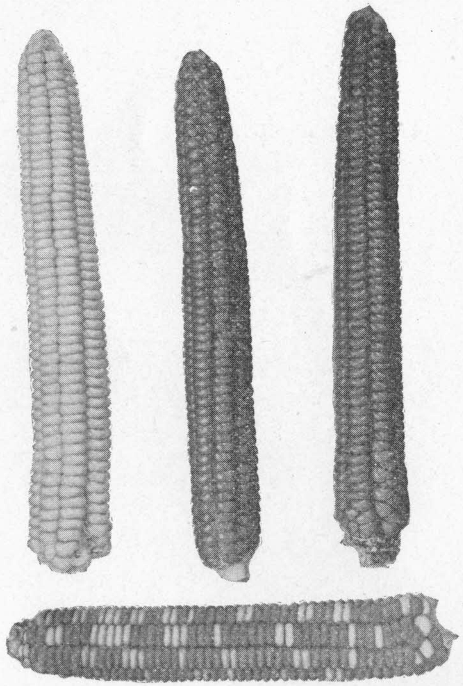
It is hoped that the corn growers of Connecticut will not discard this article because of its technical nature and the difficulty of understanding this class of results. The subject of the inheritance of plant characters is a complex one, yet the seedsman or farmer who applies the known principles of inheritance and breeding to his own work will certainly receive a benefit thereby.



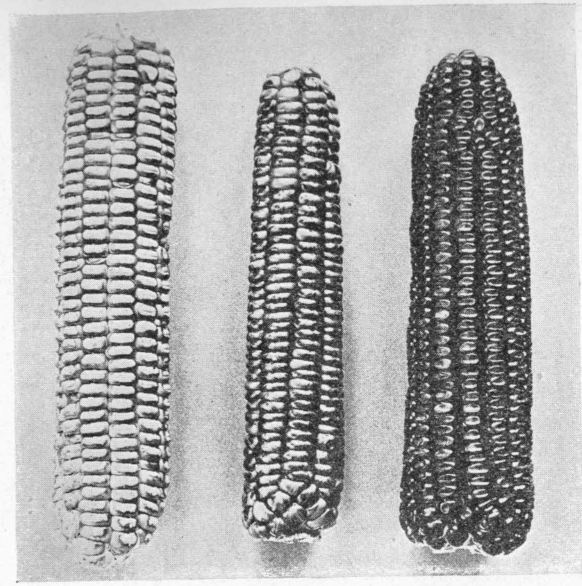
a, Rhode Island white flint (starchy parent); *b,* Early Crosby (sweet parent); *c,* result of immediate cross of *a* and *b,* showing dominance of the flint type; *d,* result of planting seeds of *c.* The result of planting starchy seeds of *d* is shown by *e, f, g.* The result of planting sweet seeds is shown by *h.*



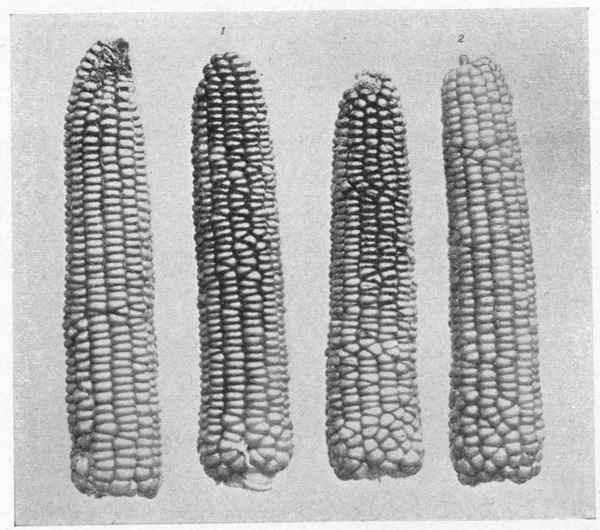
a, At left, upper ear, Illinois low protein dent. Middle ear, immediate result of cross between low protein dent and Stowell's Evergreen sweet, and lower ear, Stowell's Evergreen sweet. At right, result of planting seeds of the hybrid ear.



b, At left, Rhode Island white flint; at right, Longfellow yellow flint; in center, immediate result of cross between yellow and white flint, showing dominance of the yellow color. Lower ear is a self-fertilized ear grown from hybrid seeds of central ear.

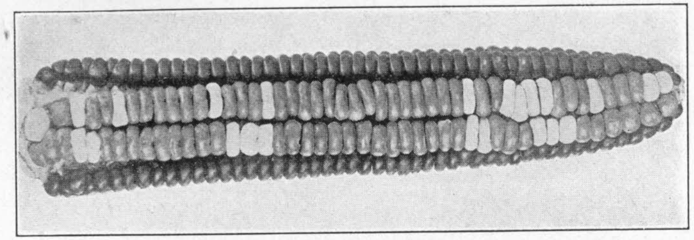


a, At left, the color which develops in sunlight; in center, variegated color which does not breed true; at right, common red pericarp.

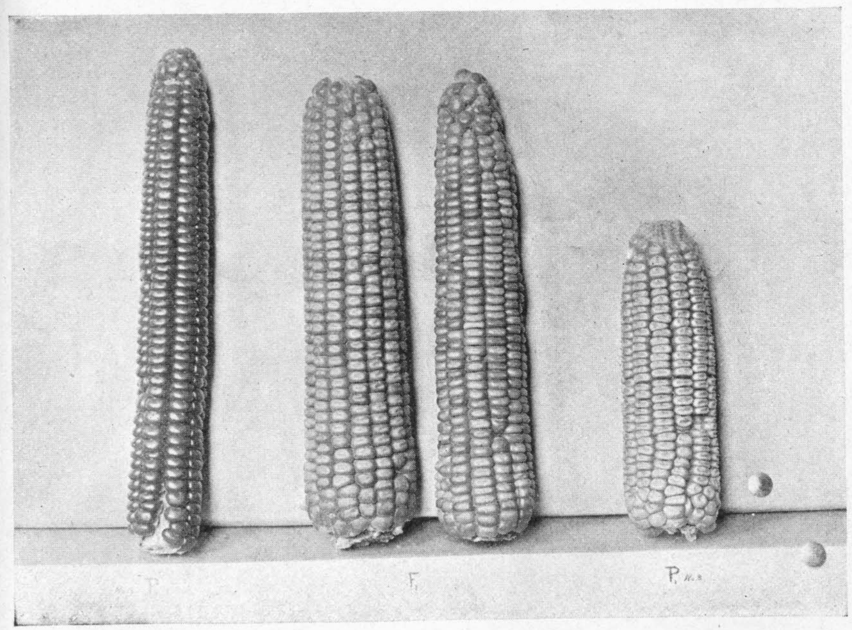


b, The second generation of a cross between the pericarp color which develops in the light and a white pericarp variety, giving, on the average, 3 colored ears to 1 white. The non-colored ear, if self-fertilized, will breed true. One out of every three, on the average, of self-fertilized colored ears will breed true.

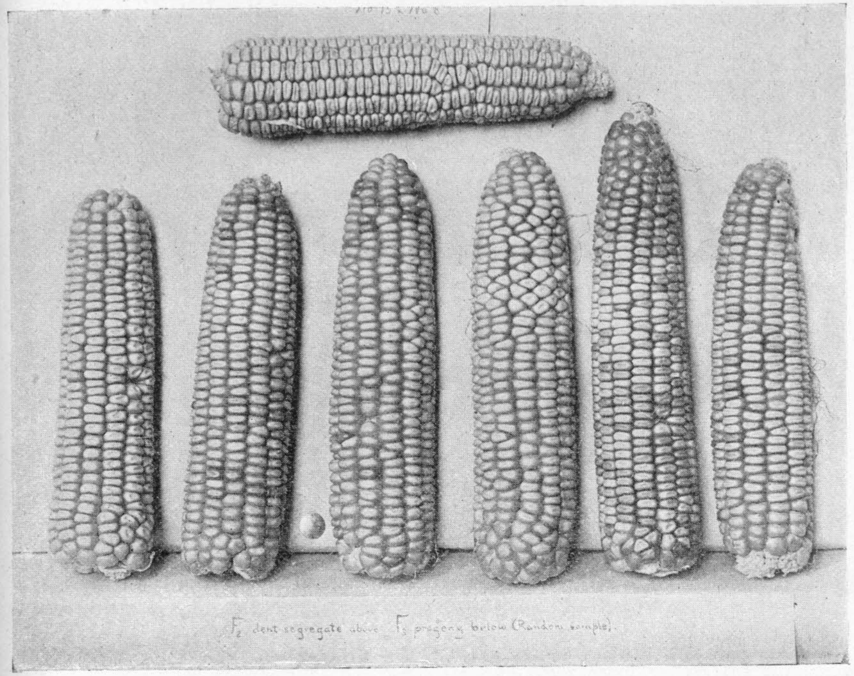
PLATE XXVIII.



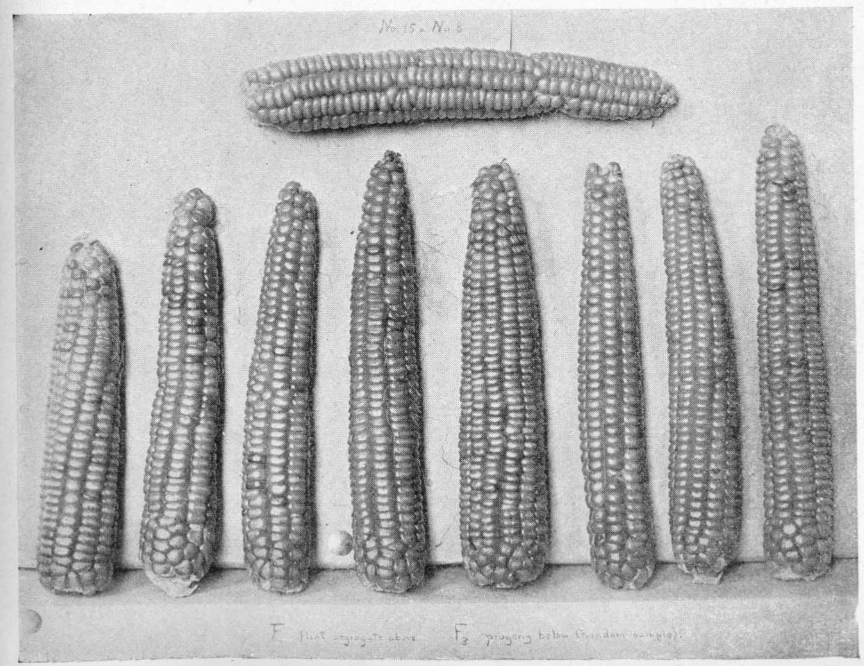
a, The first generation of a cross between a red and white pericarp, showing dominance of the red pericarp. The pericarp has been removed from two rows of seeds, showing a mixture of yellow and white endosperm colors.



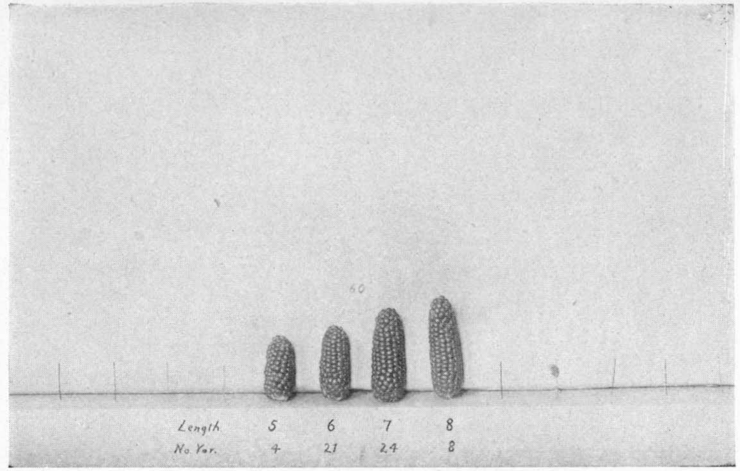
b, At left, Longfellow flint; at right, Illinois high-protein dent; in center, result of growing a cross between them.



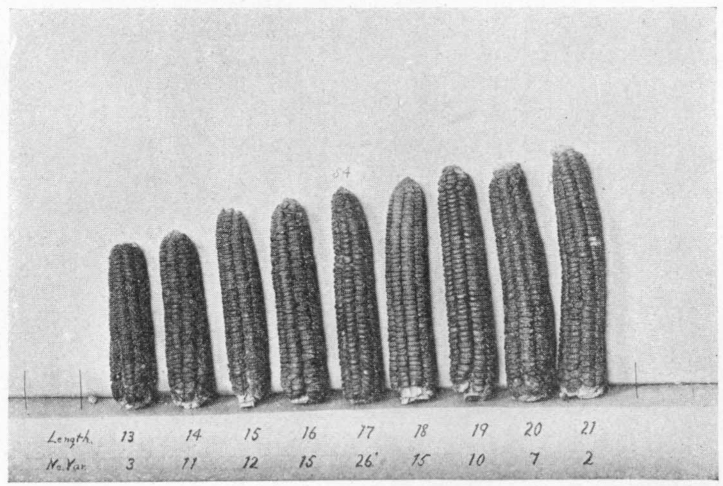
a, The ear above is a self-fertilized dent ear, received from growing the hybrid shown in Plate IV, *b* (frequency about 1 in 10). Random sample of its progeny below.



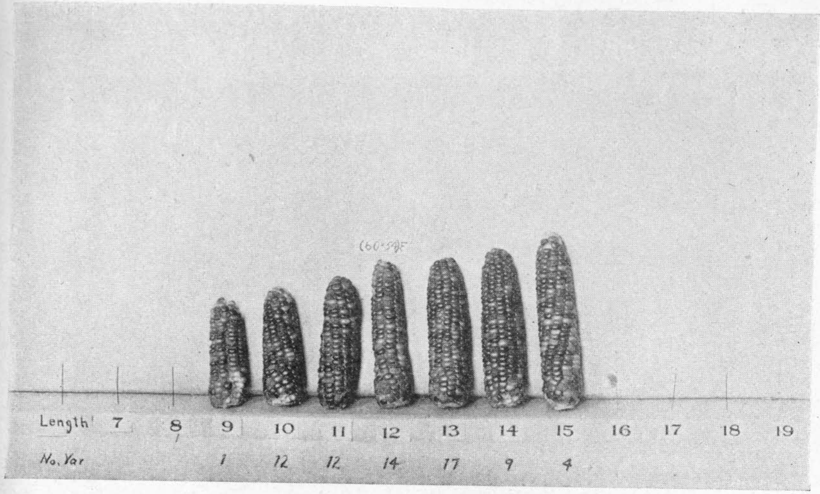
b, The ear above is a self-fertilized flint ear, received from growing the hybrid shown in Plate IV, *b* (frequency about 1 in 16). Random sample of its progeny below.



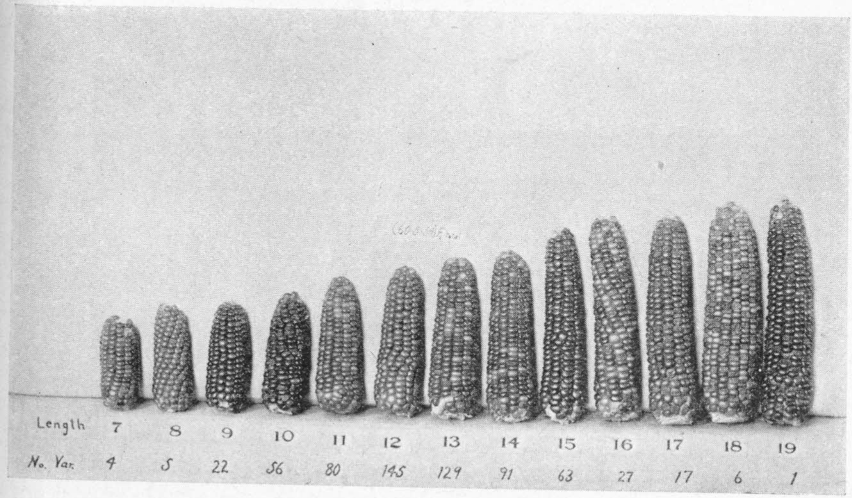
a, Tom Thumb pop, showing variation in length of ear. Length is given in even centimeters and the number of individuals in each class is given below (one-sixth of natural size).



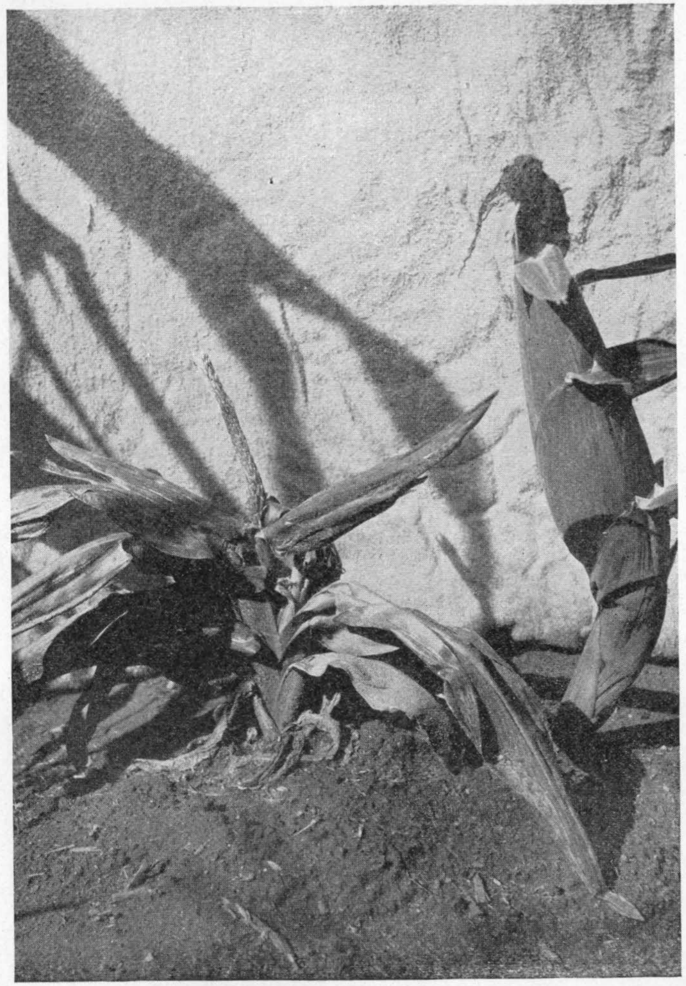
b, Black Mexican sweet, showing variation in length of ear (one-sixth of natural size).



a, Variation in length of ear of the first generation of a cross between Tom Thumb and Black Mexican (one-sixth of natural size).



b, Variation in length of ear of second generation of cross between Tom Thumb and Black Mexican (one-sixth natural size).



A dwarf, appearing in a commercial culture of Stowell's Evergreen sweet, compared with a normal ear of the latter.

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