FARMERS' BULLETIN 1101
UNITED STATES DEPARTMENT OF AGRICULTURE

The ARGENTINE ANT as a HOUSEHOLD PEST

FROM TEXAS TO THE ATLANTIC, in scattered localities, the Argentine ant, in dark brown hordes, attacks gardens, ruining orchard and truck crops, and swarms into the houses, making conditions in some cases so unbearable that their inhabitants leave.

The pest is carried by rail in foodstuffs, and since its original introduction, presumably from Brazil, it has been distributed about the country until infestations occur throughout the South, with a separate group of infestations in California. It may also be carried by floods, such as take place in the Mississippi Valley, the ants forming themselves into a compact ball which floats to safety.

In the warm spring weather the Argentine ant is particularly annoying in households, and thorough methods for its control should be undertaken at that time. On page 6 will be found a formula for a tree-banding mixture that will protect the trees of the nurseryman and orange grower. Various methods for isolating food in the house and a satisfactory ant poison to be used as a protection within doors and without are also described.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief
Washington, D. C. March, 1920

THE ARGENTINE ANT[1] AS A HOUSEHOLD PEST.

E. R. BARBER,
Scientific Assistant, Southern Field Crop Insect Investigations.

CONTENTS.

A PEST BOTH IN THE HOUSEHOLD AND ON THE FARM.

ANTS are common and annoyance from them is by no means unknown, yet the Argentine ant has distinguished itself by greatly exceeding other species in its injury. Other ants may make themselves troublesome, but the Argentine ant goes so far as to cause homes to be vacated in an infested neighborhood. It becomes important in agriculture as well, damaging fruit and other crops by its propagation of scale insects.

The worker ants are most commonly seen. Small in size and dark brown in color, they are able to invade practically every part of ordinary dwellings, stores, etc. The Argentine ant is almost omnivorous, eating most cooked foods and a considerable percentage of the raw foods found in the average pantry. It has a marked preference for some things, such as sugar, sirup, honey, jams, cakes, candies, pies, fruit, and meats of all kinds. Even refrigerators and ice boxes are readily invaded, the low temperatures having no deterrent effect. It is a common occurrence for Argentine ants to find their way into bedchambers, and while they do not possess a sting they can cause considerable pain with their mandibles. There have been many reports of babies being attacked by them in such numbers as to cause serious results; several of these reports have been verified.

With conditions made almost intolerable in badly infested places, it is not uncommon to find empty, unrentable houses. Realty values accordingly drop.

[1] *Iridomyrmex humilis* Mayr.

IMPORTANCE IN AGRICULTURE.

The nurseryman, the trucker, and the orange grower are greatly molested by this pest, owing to the fondness of the ant for the honeydew excreted by aphids and scale insects. The workers take the best possible care of these honeydew-yielding species, and protect them from their natural enemies, frequently building shelters over them, and as the host plants grow, carry the young scales and aphids and place them on the young tender growth, where they may more easily sap the juices of the plants.

In corn, cotton, and sugar-cane fields, the Argentine ant when present is constantly attending the aphids and mealybugs, increasing the numbers of these species to an alarming degree, much to the detriment of the plants. The writer estimates that a considerable loss of sugar results from the attendance of the Argentine ant on the sugar-cane mealybug.

NESTING HABITS.

Argentine ants are extremely social among their own kind, the individuals never having been observed to quarrel with one another, nor one colony with another. Workers may be carried for miles and placed with others of their kind and no apparent demonstrations of like or dislike are exhibited. The newcomers appear to enter into the colony spirit and are soon lost to the view of an observer. Any small nest will contain several queens which live together amicably.

The summer nest may be located anywhere—under sidewalks, under the sills of houses, in brick piles, stone piles, under a piece of board or a piece of tin, in an old tin can—in fact, in any place convenient to the food supply. In the winter months there is a tendency to concentrate into larger colonies, and they seek warm, dry, secure nesting places in which to hibernate. These desirable places are not plentiful, and where one is located the ants from some distance will seek its shelter. The winter is the most hazardous period of the year, for should a nest by any chance be flooded during a cold spell, when the ants are dormant, the chances of survival of the colony would be extremely slight. Usually throughout the latter part of December, January, and February (at New Orleans) these large colonies are found. They sometimes reach very extensive proportions and may contain several hundred queens and countless workers and immature stages. These colonies are usually located at the base of large trees on high, well-drained spots of ground, in manure piles, or in any other piles of decomposing rubbish where heat is generated. A warm day will make them particularly active, and they will form trails in all directions from these winter nests to food supplies. They may be observed traversing the trunks of trees every warm winter day, and from the trees trails are made to near-by houses, where they cause considerable annoyance.

With the advent of warm spring weather the breaking up of the large colonies occurs. This is the time of the year that food is very scarce, and at this season the ants are particularly aggressive and troublesome in the houses.

SCATTERED FROM TEXAS TO THE ATLANTIC, WITH INFESTATIONS IN CALIFORNIA.

Introduced years ago, probably on coffee ships landing at New Orleans from Brazil, the Argentine ant has been carried about the country in foodstuffs, until it now occurs in scattered localities throughout the South, the present northern limit being Nashville, Tenn. The farthest infestation in the East is Wilmington, N. C., while in the West it is found in several cities of central Texas, including Dallas, Fort Worth, and Houston. There is also a separate group of infestations in California.

HOW NEW TERRITORY IS GAINED.

Inspections indicate that when carried long distances the ants were more likely taken through on carload lots of foodstuffs which were rushed to their destination than along with smaller consignments. Arriving with the large shipments, they probably gained a foothold in the wholesale districts of such cities as Memphis and Atlanta, and from these centers were disseminated with small shipments to the surrounding towns.

There is also a normal extension of the territory occupied by the Argentine ant. This is 300 to 400 feet per year, and depends on the food supply and the abundance of other ants, the Argentine species waging a continuous warfare on native ants until the latter are entirely killed out.

To establish an infestation it should be noted that it is necessary for a gravid queen (egg-laying female) to be present. It is quite possible that into almost every town and city in the southern States there has been introduced at one time or another a number of workers, but as these are incapable of reproduction a colony has not become established.

THE NEST FLOODED, A COLONY MAY FORM A COMPACT BALL AND FLOAT AWAY.

Though the principal method of infesting new teritory is by rail, the Argentine ants are occasionally transported by high water. They are carried in lumber, rotting trees, uprooted shrubs, fruit, vegetables, etc., which may be swept from one location to another by a swollen stream. Even without such means of riding to safety, a flooded colony may not suffer extinction by drowning. The species has a remarkable habit of self-preservation in times of floods, for when rising water floods a nest, and no other way of escape is presented, the ants may cluster together and form a compact ball. The immature stages cluster at the center of this mass, while the queens and workers form the outer portion. As the ball enlarges by the addition of other workers which have been struggling alone in the water it gradually revolves. It is kept revolving slowly by the outside workers continually striving to reach the top of the ball, thus permitting air to reach the interior. The ants in these balls disperse when they come into contact with a secure resting place, but they may float about on still water for hours.

VARIOUS FORMS.

As with other ants, there are several distinct forms in a colony. The queen is a sexually perfect female, capable of depositing eggs. In one colony a number of queens may be present. The males or drones have apparently only the function of fertilizing the queens. The workers, foragers of the colony, are imperfect females with no reproductive functions. Besides these adult forms, there are usually eggs and other immature stages in a nest. (Fig. 1.)

CONTROL.

NATURAL CONTROL NOT EFFECTIVE.

Though sudden heavy rains, especially when combined with low temperatures in winter, reduce the numbers of the Argentine ant, it has been found that it is only a question of months before the normal infestation is regained. Other forms of natural control are of still less importance.

HOW TO KEEP ANTS FROM TREES.

Woglum and Neuls [1] recommend the following tree-banding mixture for keeping the ants from crawling up trees:

Finely powdered flowers of sulphur __________ part by weight __	1
Commercial tree-banding sticky material ______ parts by weight __	6

The two ingredients are mixed together thoroughly with a wooden paddle until of a uniform color and consistency. The tree trunk should first be coated with melted paraffin, which will harden almost immediately. The mixture just

[1] Woglum, R. S., and Neuls, J. D. The Common Mealybug and Its Control in California. U. S. Dept. Agr. Farmers' Bul. 862. 1917.

referred to should then be applied over the paraffin in a band about 5 inches wide and about one-fourth inch thick.

Before the band is applied the tree should be pruned so that the lowest branch is fully a foot above the ground, and all rubbish should be removed from beneath the tree and the soil cultivated to destroy all grass and weeds.

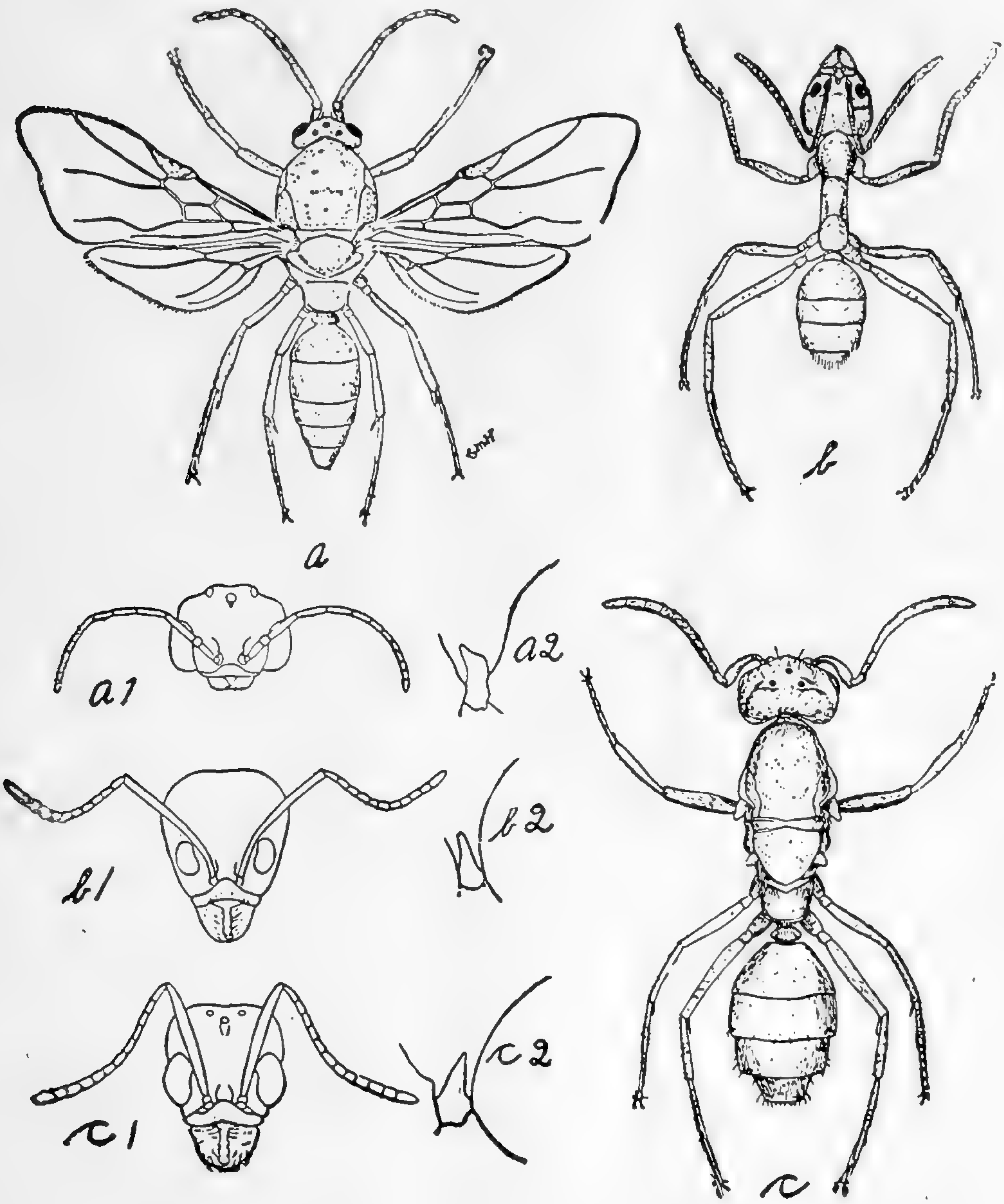

FIG. 1.—The Argentine ant, adult forms: *a*, Adult male; *a1*, head of male; *a2*, petiole of male; *b*, worker; *b1*, head of worker; *b2*, petiole of worker; *c*, fertile queen; *c1*, head of queen; *c2*, petiole of queen. All greatly enlarged. (Newell and Barber.)

HOW TO KEEP ANTS FROM TABLES, ETC., IN AN INFESTED HOUSE.

Perhaps the most effective and durable barrier which can be used indoors is a bichlorid-of-mercury tape or band. Tape is soaked in a saturated solution of bichlorid of mercury and then hung up to dry. It is then placed around the legs of tables, safes, etc., and if it is kept dry will last from six months to a year. Common lampwick one-half an inch wide is ideal for this purpose. After it has been treated in a saturated solution of bichlorid of mercury and dried, pieces are wrapped around the leg of the piece of furniture to be isolated and ends lapped over tightly and pinned. The tape can be readily renewed by another soaking in bichlorid of mercury and repinned in place.

Twenty-five per cent of bichlorid of mercury mixed in shellac may be painted around the legs of furniture, and when dry it will be quite as satisfactory as the tape.

Extreme caution is advised in handling bichlorid of mercury, as there is always an element of danger in using this poison. In recent years the sale of this drug to the layman has been practically discontinued.

A simple and efficient though perhaps unsightly barrier may be made by placing the legs of furniture in saucers and putting a generous supply of moth balls in each saucer. The moth balls will slowly volatilize, and it is necessary to add more from time to time, but the ants will not cross the barrier thus formed.

Coal oil placed in saucers in which the legs of furniture rest will repel the ant, but the odor of the oil is disagreeable to most persons.

STRONG ANT POISONS.

Many and varied experiments have proved that it is futile to try to exterminate Argentine ants with a poison which kills rapidly. A few workers may be killed, but the masses of ants will quickly recognize the source of fatality and avoid the "doctored" food. The few workers killed in this way will have no effect in reducing the numbers. None of this poison will reach the queens in the nest, and it has been found that it is essential to kill off the queens in order to prevent further multiplication of the pest.

Such poisons are, however, satisfactory for quickly ridding a house of ants, though the relief obtained is not permanent. Strong antimony or arsenical sirups, a number of which are sold by druggists in infested territory, are used for this purpose. They are usually placed about the infested house in small dishes, a few drops to a dish. Though the ants feed on such a sirup at first, they soon realize that it is harmful and vacate the building for a few weeks.

A SIRUP MADE ACCORDING TO A SPECIAL FORMULA MOST SATISFACTORY.

A weakly poisoned sirup, on the other hand, may be continually attended, the workers carrying it to the nest and feeding it to the queen and the larvæ, eventually exterminating the entire colony. A special poisoned sirup[1] has been devised. It is prepared as follows:

Granulated sugar	pounds	9
Water	pints	9
Tartaric acid (crystallized)	grams	6
Benzoate of soda	grams	8.4
Boil slowly for 30 minutes. Allow to cool.		
Dissolve sodium arsenite (C. P.)	grams	15
In hot water	pint	½
Cool. Add poison solution to sirup and stir well. Add to the poisoned sirup:		
Honey	pounds	1¼
Mix thoroughly.		

APPLICATION OF THE SIRUP.

On account of the ants continuing to feed on a weakly poisoned sirup, it is desirable to place it in cans or paraffined paper bags *outside* of the infested house. The ants will be attracted away from the house by the sirup on the outside, not temporarily driven away through fear as they are by a strongly poisoned sirup within the house. Within a day or so after the sirup is put out no ants should be found in the house.

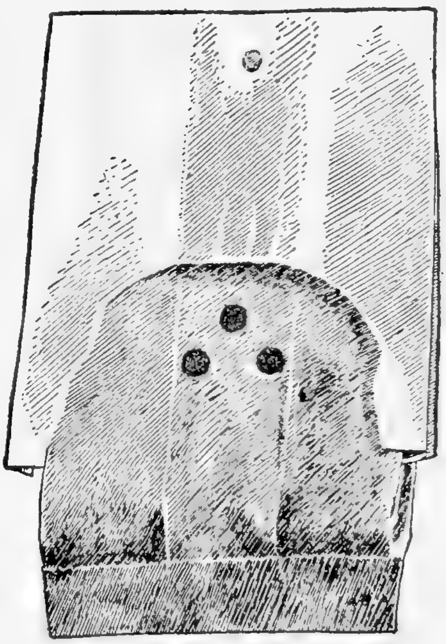

FIG. 2.—Paraffined paper bags arranged as a container for ant-poison sirup. The apron has been cut away to show entrance holes. Such bags are nailed to trees.

It may happen from time to time that some of the cans will be found deserted. This is often because the ants are attracted by other food, especially the honeydew given off by aphids and mealybugs. During the middle of the summer it is very hard to attract them away from this honeydew, which is their natural food, and for this reason it is desirable to poison them during the cooler months of the year, especially during early spring, when there are fewer insects to supply them with a food substance which is more attractive than the purest sirup. Houses, however, may be freed from ants during midsummer by the use of the sirup made according to the formula given above.

The paraffin-covered paper bag shown in figure 2 is undoubtedly the cheapest container. It can be made in large quantities at a cost of about $5 per thousand. Small 1-pound bags used in grocery stores are obtained, and two or three holes about one-fourth inch in diame-

[1] Accuracy in the use of the specified ingredients and weights is necessary if successful results are to be secured.

ter are cut through each folded bag with a leather-punch or similar instrument. This provides each bag with two or three holes on each side for the entrance of the ants. Being opened, the bags are dipped in a pan of molten paraffin and set aside to dry. The paraffin, forming a waterproof surface, materially lengthens the life of the bag, which is protected from the entrance of water through the holes by part of another (2-pound) paraffined bag which covers the first one like a canopy. In use, each bag is provided with a small quantity of poisoned sirup and a piece of sponge, the protecting outer piece of bag is drawn over it, and the ends of both are folded over at the top and tacked to a tree. On account of the bag coming together at the top it is very narrow at the point where the entrance holes are made; consequently very small pieces of sponge are required. The bags have been known to last for long periods, but the larger percentage of them last only about two or three months. They can not be recharged.

Fig. 3.—Tin can container for ant-poison sirups used in outdoor experiment.

The tin can snown in figure 3 is the most satisfactory container. Any sized can may be used, but the handiest size is the one-half pound baking-powder can. The can must have a friction cover, and of course it must hold water. If the can is indented deeply on the two opposite sides (as illustrated in the drawing, fig. 3) and the cover replaced, it will be observable that there is ample space between the top of the can and the cover for the entrance of the ants, and the can, if kept in an upright position, will be weatherproof. About a gill of the sirup will be sufficient for several months, but in heavy infestations it is better to put 2 gills in each can. It is very advisable to place a fairly large piece of sponge in the can. The sponge will float on the sirup and allow the ants to feed in large numbers. A piece of wire about 6 inches long may be bent for a handle, a hook inward at each end being made. The hooks may be attached under the lid of the can where it projects over the part that has been indented. This forms a handle by which the cans may be hung on trees, fences, walls of houses, etc. The ants prefer to climb for their food, and it is well to hang the cans near ant trails going up trees, walls, etc. It is advisable to hang the cans in the shade to prevent the evaporation of the sirup, for though it has been proved that evaporation does not affect this sirup to a marked extent, it is well to avoid raising the solid contents of the liquid. Eight to ten of these cans should be sufficient to place around an ordinary city house and lot. If the grounds are large and if many trees are present, more cans should be placed out.

From the results so far obtained, the careful preparation of the poisoned sirup can not be too highly emphasized. Very accurate balances are necessary for the weighing out of the poison and the tartaric acid. This is especially true when small quantities of the sirup are prepared.

PLANS FOR MUNICIPAL CONTROL WORK.

In effecting control in towns and cities it is first necessary to ascertain the extent of the infestation. This should be mapped out so that workmen in distributing the cans will be able to refer to the map to insure the covering of the entire territory. Cans may be obtained at wholesale at about $16 per thousand.[1] About 10 pounds of "grass" sponges will be required per 1,000 cans. These will cost about 75 cents per pound. The sponges should be thoroughly washed and dried before use. When wet they may be easily torn into pieces about 2 by 2 inches. Using 1 gill of sirup per can, 200 pounds of granulated sugar will be required per 1,000 cans. The cost of the sodium arsenite is about 80 cents per pound, and 1 pound will be sufficient for 1,500 cans. Tartaric acid (crystallized) costs about 70 cents a pound, which will be enough for 4,500 cans. From 60 to 100 cans will be required per block, depending on the size of the block. The late fall, winter, and spring are the most desirable times in which to do this work, as in these seasons the natural food is least plentiful and the ants most hungry. Two men should be able to prepare the sirup, wash and tear up the sponges, and charge about 2,000 cans per day and distribute about 1,000 cans per day.

TRAPPING ANTS.

By taking advantage of their winter colonizing habits the ants may be attracted in large numbers to specially prepared trap boxes, which may be fumigated when large numbers have gathered in these boxes for winter nesting. The boxes should be filled with decaying vegetation, the heat generated making them very attractive as hibernating quarters. Carbon disulphid was found to be the best and most economical fumigant for use in the trap boxes. It is hardly necessary to state that this method of control is not applicable to city conditions, where dry nesting quarters are very plentiful and the ants do not colonize to any great extent.

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[1] The cost figures given in this paragraph are approximately normal. Present war prices are probably higher for each item.

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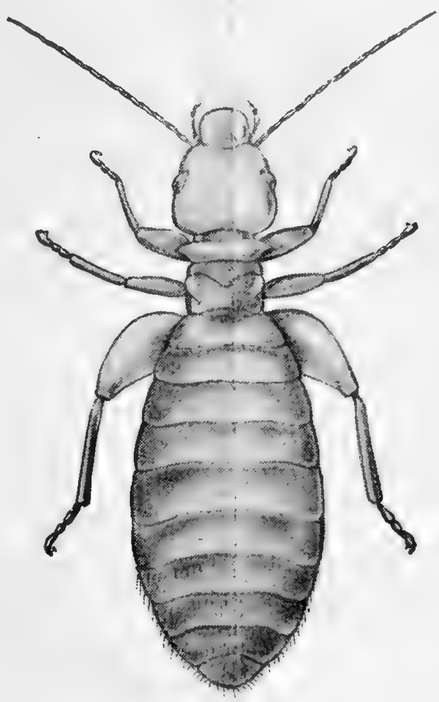
BOOK-LICE OR PSOCIDS

ANNOYING HOUSEHOLD PESTS

E. A. BACK

Entomologist in Charge of Stored Product and
Household Insect Investigations



Adult book-louse, about fifty times natural size.

FARMERS' BULLETIN 1104

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. February, 1920

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BOOK-LICE, OR PSOCIDS, are the tiny white or grayish-white insects, scarcely as long as the width of an ordinary pinhead, and often much smaller, that scurry across the pages when old, musty books are opened.

They appear in houses in greatest numbers during late summer and early fall, and are more abundant in damp, well-shaded rooms not in general use, and in houses long closed. Very few are found in bright, sunny, dry rooms in constant use.

Book-lice run in a halting fashion over everything in the house. They feed on all sorts of vegetable and animal matter. It is not often that they become abundant, and when they do, they attract attention more by their annoying presence than by the actual damage caused. They injure man in no way and are therefore unlike the true lice.

Unless they are present in annoying numbers, it is probably not worth while to worry about book-lice, for many exist out of doors and can get in through cracks and through the mesh of ordinary screens. With the coming of cold weather, or in late fall and winter, book-lice die off, but may leave behind eggs that will hatch the following spring. Control measures, discussed on page 4, should be resorted to when book-lice become unusually abundant.

BOOK-LICE[1] OR PSOCIDS.

THEIR HABITS AND WHERE THEY THRIVE.

DWELLING HOUSES, libraries, museums, military barracks, storerooms, barns, and other buildings often harbor diminutive insects known as book-lice, or psocids. Although many of these doubtless enter from outside, those that become numerous enough to annoy occupants can live and multiply wholly within doors.

Book-lice are found in all sorts of places, such as the trunks and foliage of trees, on fences, in woodpiles, and in refuse of all sorts: in fact, upon practically anything that has been left undisturbed for any length of time during warm and moist weather.

The book-lice that occur in houses have no wings and are seldom one-sixteenth of an inch long, often much smaller. Their shape and appearance are shown by the figure on the title-page. They are pale colored, almost white when young, but as they grow older are darkened somewhat by the food they have eaten, for this shows through their more or less translucent bodies. When old, musty books are opened suddenly, the book-lice may be seen scurrying across the pages in a halting and uncertain fashion, and frequently they are noticed upon door screens, window panes, furniture, books, and photographs, or upon almost any object in the room.

Book-lice do not attack man as do the true lice, and are, therefore, harmless to the occupants of a home. They are called book-lice

[1] Insects of the order Corrodentia and family Psocidae.

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merely because they are often seen on books, and because they have some resemblance to chicken lice. Usually they attract attention more because of their annoying presence than on account of the actual damage they do. Ordinarily they are not regarded as injurious pests, yet they have jaws with which, in spite of their delicate structure, they can gnaw. They feed upon decaying timbers, feathers, straw, and hair, and upon flour, meal, and other farinaceous substances, and even dust. They eat the starchy paste in book bindings, wall paper, and photographs. Indeed, they are general feeders upon dead and decaying animal and vegetable matter.

Book-lice thrive best in closed rooms that are warm and damp. Seldom are they noticed in light, airy rooms in constant use, but more often are found in numbers in darkened, damp parlors kept closed except on special occasions, and in houses that have been closed all summer. They die off during cold weather, but may leave behind them eggs which hatch the following spring to furnish the infestation for the succeeding year. Ordinarily they do not become abundant enough to attract attention until late summer or early fall.

CONDITIONS FAVORABLE TO THEIR INCREASE.

As stated, book-lice are not especially injurious in dwelling houses, barracks, or factories. It is only when materials which they are capable of injuring, or in which they can breed, are left undisturbed for long periods that they are likely to increase to such an extent as to cause serious damage or annoyance. Occasionally they multiply excessively in some available food supply, and swarm over a house to the consternation of the housekeeper, but fortunately such instances are rare. Upholstered furniture and mattresses stuffed with straw, husks, hair, feathers, or moss are specially favorable places for their multiplication, and in the worst cases of infestation on record, the psocids have come from such sources. They have been found in myriads in straw in barns and stables, in the straw coverings of wine bottles in cellars, and in rooms in which tow used in the manufacture of upholstered furniture is kept.

One record on file indicates the usual history of infestation. In a new house kept by very neat occupants, a mattress of hair and corn husks which had been purchased not more than six months before was found in a badly infested condition after the house had been closed about six weeks.

It was so covered with psocids that a pin could not be stuck into the mattress without piercing an insect. The side of the sheet next to the mattress was likewise covered, and a further search showed the walls and the entire house to be swarming with the tiny pests. A sweep of the hand over the walls would gather them by the thousands. Bureau drawers were swarming with them, and they were on every object and in everything. The mattress was found to contain millions of them, and seemed to be the source of the supply.

In a second case, newly purchased upholstered furniture became a distributing point. When such excessive outbreaks of the pests occur in newly purchased mattresses and furniture, the cause beyond doubt is the use at the factory of unsterilized stuffings.

HOW TO CONTROL BOOK-LICE IN HOUSES.

Where only a few book-lice are present, a thorough cleaning, airing, and drying of the room is all that is needed, provided the source of infestation is within the room itself. As many as possible of the objects in the room should be removed and thoroughly sunned on a bright day. The room should be heated to a temperature of 120° to 140° F. for several hours. Psocids are soft-bodied insects, and succumb to a prolonged drying due to heat. Where rooms are located on the ground floor in loosely constructed buildings in shaded and damp situations, as are many summer cottages, so many psocids come in from the outside that almost no treatment will entirely rid a room of them.

When book-lice swarm in alarming numbers over and throughout a room the breeding places should be located at once. If the source is old straw or husk fillings of mattresses, these should be removed and burned wherever possible. Thorough fumigation with the fumes of sulphur,[1] 1 pound of sulphur being burned for each 1,000 cubic feet of space, is effective. Where other pests are present, such as bedbugs, and where the bleaching effects of the fumes can be disregarded, as in barracks, 5 pounds of sulphur will prove effective. During fumigation the rooms should be kept closed as tightly as possible, and after five or six hours opened from without and thoroughly aired. Fumigation with hydrocyanic-acid gas is very effective, but dangerous in the hands of inexperienced persons. (See Farmers' Bulletin 699.)

Closets, boxes, trunks, and sometimes even entire rooms, where infested objects are kept near the floor, can be fumigated satisfactorily with carbon disulphid. (See Farmers' Bulletin 799.) In addition to cleanliness and plenty of sunlight, heat or fumigation, wherever it can be applied, will yield the best results, if the source of infestation has been removed.

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[1] Before resorting to sulphur fumigation the householder should be warned that sulphur fumes can unite with moisture in the air to form sulphuric acid, thus having a bleaching effect upon wall paper and other articles, as well as tarnishing metals of all sorts. The damper the house, the greater the bleaching. In houses thoroughly dried by heat very little bleaching occurs. *Householders possessing homes furnished with rare or valuable articles should never use sulphur.*

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FARMERS' BULLETIN - 1110

UNITED STATES DEPARTMENT OF AGRICULTURE

LICE, MITES AND CLEANLINESS

THIS BULLETIN has been written briefly and in simple terms for the beginner, and especially for members of the Boys' and Girls' Poultry Clubs. For additional and more complete information on the subject the reader should ask for Farmers' Bulletin 801, "Mites and Lice on Poultry." This may be obtained in many cases from club leaders or will be supplied free of charge on application to the U. S. Department of Agriculture, Washington, D. C.

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief
Washington, D. C. September, 1920

LICE, MITES, AND CLEANLINESS.

J. W. Kinghorne and D. M. Green,
Animal Husbandry Division.[1]

CONTENTS.

LICE and mites are common pests that usually can be found wherever poultry is kept. They are a source of continuous annoyance, and if present in large numbers cause slow or stunted growth as well as death in young chicks, and reduce flesh and egg production in mature birds. For this reason every boy and girl must keep the fowls as well as the poultry houses, nests, brood coops, etc., free from lice, mites, and other vermin, if he or she is to succeed with poultry or poultry-club work.

KINDS OF LICE.

More than 40 distinct species of lice infest the different varieties of domestic poultry. Seven species are commonly found on hens and chickens, 4 or 5 on pigeons, 2 or 3 each on ducks and geese, 3 on turkeys, and several each on guinea fowl and peafowl. The kinds most common on hens and chickens, however, are usually classed in three groups, known as body lice, head lice, and feather lice. They intermingle to a considerable extent, and their habits are very similar, but all are a pest and an annoyance to the fowls and should be destroyed.

[1] Much of the information given in this bulletin is drawn from Farmers' Bulletin 801, "Mites and Lice on Poultry," by F. C. Bishopp and H. P. Wood, of the Bureau of Entomology.

These different species of lice never leave the bodies or feathers of the fowls. They differ somewhat in size and appearance, but all are fitted with peculiarly arranged legs which permit them to move about rapidly through the feathers. They have sharp, strong, biting mouths, but unlike the red and gray mites are not fitted for sucking blood; instead, they feed on portions of the feathers and on scales from the skin.

BODY LICE.

The body louse is much larger than the red or gray mite, and is straw or pale yellow in color. It lives and breeds entirely on the body of the fowl, centering its activities on those sections that are not closely feathered, although it may sometimes be found on the head, neck, or other parts of the body. It is usually found in greatest numbers under the wings and around the vent, and oftentimes the skin of the fowl where the lice are thickest will appear red and rough, and quite often scabs and blood clots may be seen. These are evidence of long irritation, preventing normal growth and development in chicks, and causing sickness and loss of vigor in mature fowls.

Body lice deposit their eggs in clusters on the web part of the feather close to the quill. On mature fowls they are to be found in greatest numbers on the small, short feathers below the vent. On chicks the eggs are often deposited on the soft, downy feathers about the head and throat. The eggs hatch in about a week, and the lice reach their full size in about 20 days; therefore, if the lice are not killed, the fowls become alive with them in a very short time.

FEATHER LICE.

Feather lice are the species most commonly found on poultry, but are probably the least important, for the reason that they stay on the feathers the greater part of the time and feed on the feathers and scales along the quill rather than on the skin or body of the fowl. They are smaller than the body lice but otherwise resemble them somewhat in appearance. They can be detected easily, however, upon parting the feathers on the back or breast, where usually they can be found clinging to the web and shaft of the feather. Feather lice infest mature fowls and are seldom found on young chicks.

HOW TO GET RID OF BODY AND FEATHER LICE.

Inasmuch as poultry lice stay on the fowls nearly all the time, the only effective treatments are those which are applied directly to the birds.

Sodium fluorid, a powder which can be purchased at most drug stores, is the most effective remedy, being exceedingly poisonous to all kinds of poultry lice. It should be applied by placing a small amount of the powder (as much as can be held between the thumb and finger) among the feathers next to the skin on the head, neck, back, under the wings, on the breast, below the vent, and at the base of the tail.

Not more than 12 small pinches should be put on one fowl at a time, as too much is injurious. One pound of powdered sodium fluorid applied in this manner will treat 100 fowls and is very effective. It is usually advisable to treat fowls in the spring just before the brooding season, which will help to keep the young chicks free from vermin. Sodium fluorid if inhaled is very irritating to either fowls or human beings. If too much is inhaled by fowls or chicks it will be fatal. Therefore, precaution should be taken in treating fowls to see that it is not inhaled or allowed to get into any cuts or wounds in the flesh.

Blue ointment is another effective remedy. In using it apply a small portion (a piece about the size of a pea) with the fingers around the vent only of the fowl, and not on the body or under the wings. Care should be taken not to get any of the ointment into the vent, as it is poisonous and injurious. If mercurial ointment (a similar preparation) is used instead of blue ointment, it should be diluted with one-half the quantity of vaseline or lard.

Lice powders of various kinds are also on the market (they can usually be purchased at stores and poultry-supply houses) and may be used oftentimes with good results. These lice powders should be dusted well into the feathers (see illustration on front cover), working the powder in with the fingers, especially under the wings and around the vent, to make sure it reaches the skin. If all the lice are not killed by the first treatment the fowls should be dusted again in a week or ten days and as often afterwards as found necessary.

HEAD LICE.

Head lice, so called because of their habits, are found on the heads of both chicks and mature fowls, but most often on young chicks. They are longer and more slender than body lice, and dark brown in color. They are almost always in greatest number on the top of the head, around the ears, and underneath the bill, and are usually found with their heads close against the skin of the chicks, the body extending outward. Head lice confine their attacks principally to the head of the chick or fowl and are very injurious. They breed rapidly and pass from the mother hen to young chicks and from one chick to another, which makes it necessary to watch the flock carefully in order to keep the chickens free from these pests.

To kill head lice on chicks, a very small portion of melted lard or vaseline should be applied to the top of the head, under the wings,

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and around the vent. Care should be taken not to get too much grease on the chick, as that might prove fatal. These head lice are very injurious and chicks should be examined often for them and be treated at once whenever the lice are found.

POULTRY MITES.

Of all parasites affecting poultry it is probable that ordinary poultry mites are the most troublesome and destructive unless kept under control. Unlike the lice, poultry mites are bloodsucking parasites and live entirely on the blood of the fowl. They are very small and are gray in color. However, after they have been on the body of the fowl and filled themselves with blood they look red and are called red mites. When they are not filled with blood they look gray and are called gray mites. They do not stay on the fowl's body all the time, like lice, but during the day hide away in cracks and crevices, behind boards that are near the roosts, in the cracks of brood coops, and in other places. At night when the fowls and chicks go to roost the mites come out of their hiding places, crawl on to the birds, and suck the blood from their bodies. The irritation and loss of blood cause mature fowls to become pale in comb and wattles and poor in flesh; sitting hens may desert their nests and spoil their eggs, if they do not die on the nests, and chickens become weak and droopy and in many instances die from the attacks.

These mites are very small and sometimes hide themselves away so completely that the boy or girl may think the houses, coops, etc., are free from them unless a careful search is made. Knowing their hiding places, however, every club member should look for them very carefully every ten days or two weeks, especially during the summer, when they breed most rapidly, and if any signs of their presence are found, begin at once to get rid of them.

Since poultry mites hide away in cracks and crevices during the day, the first thing that should be done to get rid of them is to give the poultry houses, roosts, nests, etc., a good cleaning. After the cleaning, spray thoroughly with kerosene, crude oil, or some heavy coal-tar preparation, making sure that the spray reaches all the cracks and crevices and every other place where the mites may be hiding. The heavy coal-tar preparations are most effective and last longest. They can be purchased at most drug stores, with full directions for mixing and use. It is necessary to spray thoroughly and often, especially during warm weather, if the mites are to be kept from annoying the fowls.

"STICK-TIGHT" FLEAS.

In many of the Southern and Southwestern States fowls and chicks are often infested by a species of flea commonly known as the "stick-tight" flea, taking the name from its habit of sticking to one place on the bird instead of moving about like lice and mites. They are usually found in clusters on the comb and wattles and around the eyes. Chicks when infested often die quickly. Old fowls, while usually stronger and more resistant, will cease laying, or nearly so, and sometimes die as a result of the attacks of these fleas.

"Stick-tight" fleas breed in cracks and crevices of the floors of brood coops and poultry houses, also in dry animal or vegetable refuse,

FIG. 1.—Boy club member spraying his brood coop to kill the poultry mites.

but will not breed in damp or wet places. Therefore to get rid of them it is necessary to clean and spray the houses and runs thoroughly as well as to treat the birds. Grease the comb and wattles of the fowls and chicks with a preparation of kerosene and lard (1 part kerosene to 3 parts of lard), being very careful not to use too much of the mixture or get any of it in the birds' eyes or on other places where it is not necessary, as it may cause injury if used too freely. Clean and spray the coops and houses thoroughly the same as for poultry mites; also wet or spray the yards or runs, especially any dry soil about the poultry houses, such as dirt floors or ground underneath a board floor, with a solution of salt and water, which helps to keep the ground moist and prevents the fleas from breeding.

POULTRY TICKS, OR "BLUE BUGS."

Poultry ticks, or "blue bugs," are common in the Southern States and are very injurious to poultry and pigeons. Their habits are very similar to those of the little red and gray mites in that the adult bugs crawl on the bodies of the birds and feed at night only and during the day hide in cracks and crevices about the poultry house. The young ticks hatch and remain on the bodies of the fowls for from 3 to 10 days, when they leave. After that, they attack the chicks and fowls only when they have gone to roost at night. These "blue bugs" are about the size of a bedbug and much more harmful than either lice or mites.

Ticks, or "blue bugs," are much harder to kill than either lice or mites, ordinary lice powders or insecticides having little effect upon them. If the poultry house or coops become infested, remove the birds to temporary quarters for a period of 10 days, during which time the young ticks on the birds become filled with blood and fall off, when the birds should be at once removed. In the meantime thoroughly clean the poultry house by removing all nest boxes and nesting material, roosts, and other loose objects, and spray liberally with crude petroleum or kerosene or wood preservative. In spraying, make sure that the spray reaches all places where the bugs may be in hiding. Brood coops or temporary quarters, such as crates, etc., that may be infested, may be disinfected by scalding thoroughly with boiling water. For additional information the reader is referred to Farmers' Bulletin 1070, "The Fowl Tick," which treats of this pest more fully.

CHIGGERS, OR "RED BUGS."

Chiggers, "red bugs," or harvest mites are also quite troublesome in the Southern and Central States. They breed in the tall grass and are usually most plentiful in low-lying land. They attack fowls and chicks that are on range, attaching to the skin, causing an intense itching. Abscesses a third of an inch in diameter, surrounded by an area of inflammation, often may be found where clusters of these "red bugs" are feeding, and as a result the birds refuse to eat, become weak and droopy and soon die from hunger and exhaustion.

Fowls or chicks that have been attacked by chiggers, or "red bugs," if discovered before abscesses are formed on the skin, should have the inflamed parts treated with sulphur ointment, or a mixture of 1 part kerosene with 3 parts melted lard. If pus has already formed in the sore, remove the scab and wash the sore with a 4 per cent solution of carbolic acid and water. In sections where "red bugs" are plentiful, if fowls and chicks have free range, the grass should be kept short to prevent the bugs from breeding; also dust the birds occasionally with flowers of sulphur, rubbing it well into the feathers. Club members should also hatch their chickens as early in the season as possible, so that when the hot weather comes on, when these bugs are most troublesome, the chicks will be old enough to resist their attacks.

DUST BATH.

It is always advisable to provide a good dust bath in which the fowls and chickens can dust themselves whenever they wish, as in doing so they help to keep the lice under control and in some instances almost free themselves from them.

WHITEWASH.

Whitewash is also effective in killing mites and other vermin and may be used freely in spraying the houses, brood coops, roosts, etc. In badly infested places it is advisable to clean and spray, as already described, and in about 48 hours follow with a good spray or coating of whitewash. An effective whitewash for this purpose is made as follows:

Slake half a peck of lime and dilute it with 20 gallons of water; add 1 pound of salt previously dissolved in water; to this mixture add 2 quarts of crude carbolic acid. Apply with a spray pump or brush. This mixture if properly put on not only kills the mites but destroys all eggs, and will make the house, or any building where it is used, fresh and clean.

CLEANLINESS.

Cleanliness is of the greatest importance in keeping lice and mites, fleas, and other insects under control, and should have the closest attention of every boy and girl. The poultry houses, roosts, dropping boards, brood coops, and all other places that the fowls or chickens occupy should be kept clean. An abundance of light and fresh air should also be provided. While these things can not be depended on to keep away lice and mites, yet they make it easier to determine when the pests are present and help to keep the fowls healthy and vigorous, making them better able to withstand and to fight off the attacks of lice and mites. Sick or diseased fowls are always the first victims of these parasites, which makes it important that the fowls be kept healthy.

FARMERS' BULLETINS SPECIALLY USEFUL FOR MEMBERS OF BOYS' AND GIRLS' POULTRY CLUBS.

1105. Care of Mature Fowls.
1106. Incubation of Hens' Eggs.
1107. Brood Coops and Appliances.
1108. Care of Baby Chicks.
1109. Preserving Eggs.
1111. Management of Growing Chicks.
1112. Culling for Eggs and Market.
1113. Poultry Houses.
1114. Common Poultry Diseases.
1115. Selection and Preparation of Fowls for Exhibition.
1116. Selection and Care of Poultry Breeding Stock.

OTHER FARMERS' BULLETINS ON POULTRY RAISING.

287. Poultry Management.
528. Hints to Poultry Raisers.
574. Poultry House Construction.
585. Natural and Artificial Incubation of Hens' Eggs.
624. Natural and Artificial Brooding of Chickens.
682. A Simple Trap Nest for Poultry.
656. The Community Egg Circle.
684. Squab Raising.
697. Duck Raising.
767. Goose Raising.
791. Turkey Raising.
801. Mites and Lice on Poultry.
806. Standard Varieties of Chickens: I. The American Class.
830. Shipping Eggs by Parcel Post.
849. Capons and Caponizing.
858. The Guinea Fowl.
889. Back-Yard Poultry Keeping.
898. Standard Varieties of Chickens: II. The Mediterranean and Continental Classes.
957. Important Poultry Diseases.
1040. Illustrated Poultry Primer.
1052. Standard Varieties of Chickens: III. The Asiatic, English, and French Classes.
1067. Feeding Hens for Egg Production.

Bureau of Chemistry Circular 61, revised, How to Kill and Bleed Market Poultry.

For copies of these bulletins or further information on poultry raising, write to your poultry-club leader, or to the Animal Husbandry Division, Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.

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CONTROL OF APHIDS INJURIOUS TO ORCHARD FRUITS, CURRANT, GOOSEBERRY AND GRAPE

A. L. QUAINTANCE
Entomologist in Charge
and
A. C. BAKER
Entomologist, Deciduous Fruit Insect Investigations

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UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

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APHIDS are small, delicate, winged or wingless insects which feed upon plant juices, draining them from the foliage, fruit, twigs, or roots, through a beak pushed into the plant tissues.

Many kinds injure orchard fruits, currant, gooseberry, and grape. The most important are discussed in this bulletin.

Contact sprays, such as kerosene emulsion, soap washes, nicotine solutions, etc., must be used to kill aphids. Directions for preparing and applying them will be found on pages 39–45.

Stomach poisons, such as arsenate of lead, Paris green, and other arsenicals, are of no use against aphids.

Species which winter in the egg stage on the plants to be protected may be sprayed early in the spring as the buds are expanding, to kill the first brood and insure against injury later in the season.

Leaf-curling species, especially, should be treated with this bud spray in years when they are expected to be abundant. They can not be reached satisfactorily after the leaves have unfolded and the aphids have begun to be troublesome.

Those species which do not curl the leaves may be controlled readily by sprays when they are noted as becoming numerous.

Annual bud spraying in the case of the apple appears to be good orchard practice and, continued for a series of years, doubtless would prove profitable.

CONTROL OF APHIDS INJURIOUS TO ORCHARD FRUITS, CURRANT, GOOSEBERRY, AND GRAPE.[1]

A. L. QUAINTANCE, *Entomologist in Charge*, and A. C. BAKER, *Entomologist*, *Deciduous Fruit Insect Investigations.*

CONTENTS.

THE control of aphids, or plant-lice, is an ever recurring problem to the grower of orchard and bush fruits. Although cereal and forage crops furnish perhaps the most striking examples of the destruction wrought by aphids, practically no crop is free from attack by one or more of these small and delicate insects. During the past decade especially, aphid injury to orchard fruits, particularly the apple, has been on the increase.

The present bulletin treats of the aphids injurious to fruit and foliage of apple, quince, pear, plum, cherry, peach, currant, gooseberry, and grape. Forty-one species of aphids in all are discussed. The more important forms affecting a given fruit are considered first, and then follows a brief account of species known to infest the plant locally or occasionally, and which growers should be able to distinguish from the more destructive species. In their life history aphids are peculiar in many respects, and each species occurs in several different forms; for this reason a short account of aphids in general is given for the information of readers not familiar with these facts. Remedial measures are described at the close of the bulletin, since similar treatments are applicable, with some variations, for the control of all the species considered.

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[1] Since the well-known grape phylloxera [*Phylloxera vitifoliae* (Fitch)] is injurious principally to the roots and requires control measures radically different from those employed against foliage-inhabiting aphids, it is mentioned only incidentally in this bulletin, although its galls on grape leaves are illustrated (fig. 27, p. 36).

NOTE.—This bulletin is of interest to orchardists, vineyardists, and growers of currants and gooseberries in all parts of the United States.

APHIDS IN GENERAL.

Aphids, or insects of the family Aphididae, have a development which is remarkable in several ways. Eggs laid in the autumn hatch in the spring about the time when vegetation revives. From these winter eggs is produced a generation of females, usually wingless, which reproduce without the intervention of males (agamic reproduction), many species giving birth to living young. The adult aphids of this first generation are termed stem-mothers. The offspring of the stem-mothers (second generation) may be winged or wingless, or both forms may occur. They reproduce without the intervention of males, some species being oviparous, or egg laying, and depositing eggs which do not require fertilization for development, while others are viviparous—that is, they bring forth young alive, the eggs developing and hatching within the body of the parent.

A succession of generations may be produced in this way until the approach of autumn, when the true sexes appear and the females deposit eggs; or a species perhaps may be more or less biennial, some individuals producing true sexes only every second year. In still other species, the true sexes of which are at present unknown, reproduction without the intervention of males continues for a series of years.

The same species of aphid usually exhibits several forms, as wingless agamic females, winged agamic females, and the true sexual forms. In the last the male may be winged and the female wingless, or both sexes may be wingless. The different generations of a given species may vary more or less in appearance, and in some instances this is the case to such an extent that they appear to belong to distinct species.

Aphids feed upon sap which is sucked up through a beak pushed down into the tissues of the plant. Their presence on plants frequently is indicated by a curled and distorted condition of foliage, though this is not always so. When the insects are abundant the drain upon the plant is very great, interfering with its proper growth and development, and in extreme cases causing the death of infested parts. The leaves and shoots of plants infested by aphids are frequently seen to be covered with a black substance, as if dusted with soot. This is due to a black fungus which grows on the "honeydew" excreted by the aphids and is not especially injurious, though often objectionable as marring the appearance of the plants and fruit. Honeydew may be produced in such quantities as to coat the leaves and is attractive to various species of ants and wasps, which are

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DESCRIPTION OF PLATE I.

THE ROSY APPLE APHIS: *A*, Infested leaves and young apples, showing characteristic curling of the leaves; *B*, apples at later stage dwarfed and distorted by earlier attack of the aphids; *C*, mature aphid of first generation, pink variety; *D*, winged spring migrants going from apple to narrow-leaved plantain (*E*); *E*, narrow-leaved plantain infested by summer wingless generations; *F*, mature wingless summer aphid on plantain; *G*, fall migrants and males flying from plantain back to apple in fall; *H*, fall migrants and males alighting on apple leaves, the former giving birth to sexual females; *I*, a fall migrant; *J*, male; *K*, sexual female and eggs, the latter yellow at first, later turn black; *L*, twig showing the eggs in winter.

THE ROSY APPLE APHIS.

often seen attending the aphids or frequenting plants infested by them. The ants of themselves are not usually the cause of trouble but merely denote the presence of the aphids.

Since frequent reference must be made in the following pages to the different stages and forms of aphids, information concerning these is presented in summary form as far as present purposes require:

Winter eggs.—These are small, oval, and blackish, and occur on the twigs, around buds, under scales of bark, or elsewhere on the shoots or branches of the winter host plant.

Stem-mothers.—The aphids hatching from the winter eggs. They are the progenitors of the numerous generations which follow during the succeeding spring, summer, and fall.

Wingless viviparous females.—Wingless aphids which give birth to living young without the intervention of males.

Winged viviparous females or migrants.—Winged aphids which give birth to living young without the intervention of males and which migrate to other plants, establishing new colonies. *Spring migrants* and *fall migrants* are often to be distinguished.

The true sexes.—Males and sexual females are usually developed in the fall from the viviparous forms, the female depositing eggs to carry the species over the winter.

APPLE APHIDS.

Three or four species of aphids commonly attack the fruit and foliage of the apple, while a few more, which at present are of minor importance, are known to infest this plant. The important species to be considered are the rosy aphis, the green apple aphis, the woolly apple aphis, the apple-grain aphis, and the clover aphis.

THE ROSY APHIS.[1]

The rosy aphis infests especially the foliage surrounding the blossom or fruit clusters, and causes the leaves to curl badly. (Pl. I, A; illustration on title page.) The insects when abundant also infest the fruit stalks and newly set fruit. The little apples on the infested fruit spurs often fail to thin out, remain small, and as the season progresses become knotty and distorted according to the degree of infestation. (Pl. I, B.) In the fall these "aphis apples" (fig. 1) may be much in evidence, especially on the lower parts of the tree, during worst aphid seasons amounting to from 15 to 30 per cent of the crop. This species is very generally present in the apple-growing portions of the country and is at present the most important aphid pest attacking the foliage and fruit of this crop. On very young trees the feeding habits differ somewhat in that in addition to the foliage the aphids may attack the young shoots, causing these as they grow to become curled and twisted (fig. 2), resulting in permanent deformities which in pruning must be cut out in order that a properly formed tree may be produced.

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[1] *Anuraphis roseus* Baker.

The rosy apple aphis is easily distinguished from the other forms inhabiting the apple by its color. This varies from light salmon pink to deep purple or grayish black. (Pl. I, C.) The young stem-

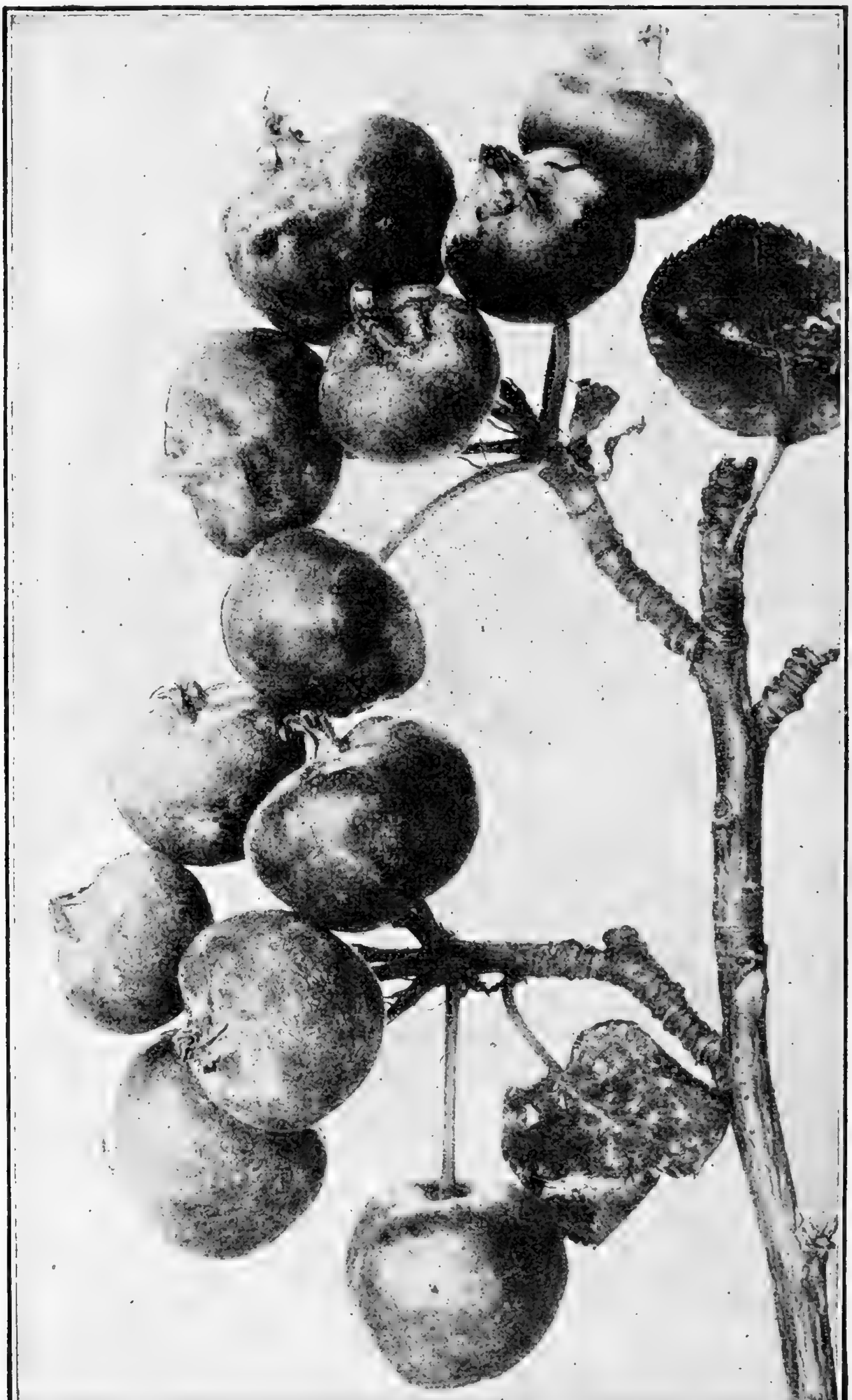


FIG. 1.—The rosy aphis: "Aphis apples." Note that the fruit has failed to thin out in the clusters.

mothers when first hatched from the eggs are dark green, very similar in color to the young stem-mothers of the green apple aphis. The winged forms (Pl. I, I) are dark and often appear almost black, owing to the black head and body and the large black patch upon the abdomen. This is particularly true of the fall migrants, which appear upon the trees in the fall. These produce the orange-yellow, wingless, egg-laying females (Pl. I, K). The males are winged and similar to the fall migrants. (Pl. I, J.) The summer forms occurring upon plantain are yellowish green, with brown patches at the base of the honey tubes.

FIG. 2.—The rosy aphis: Twisted apple twig resulting from injury by this species.

SEASONAL HISTORY.

The eggs of this species are deposited on the apple in the fall. They are light yellow when laid and change from green to polished black. They are placed upon the twigs, in the axils of the buds, or in crevices in the bark, but sometimes they are laid upon the larger branches. (Pl. I, L.) They begin hatching at about the time the buds are breaking in the spring. (Pl. III.)

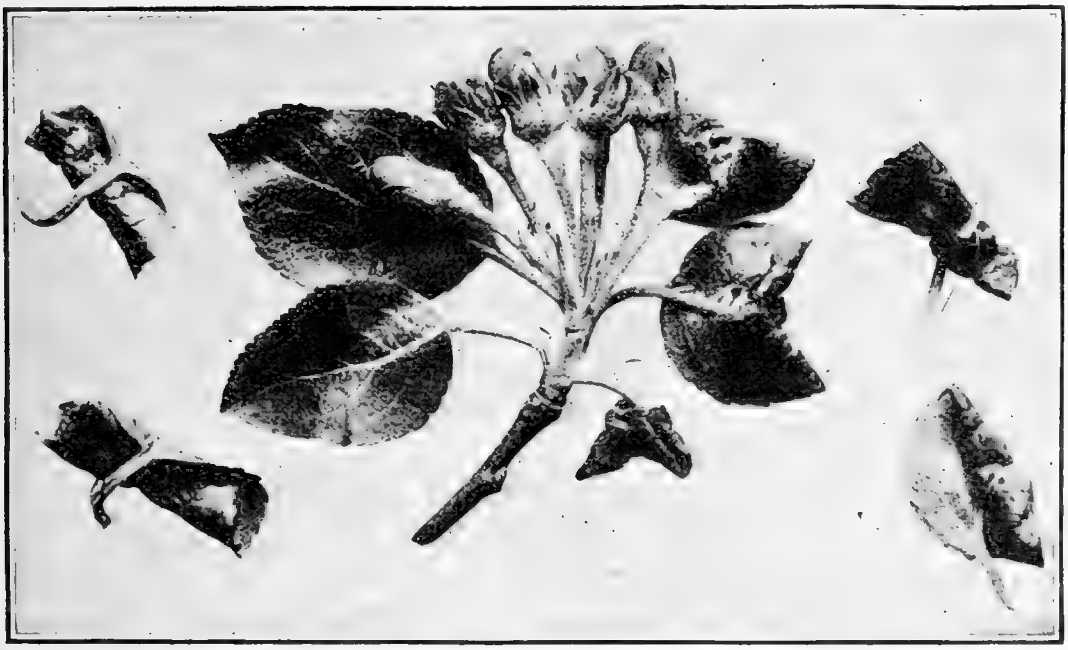


FIG 3.—The rosy aphis: Condition of the foliage in spring when leaves curled by this insect are first in evidence.

The young stem-mother immediately begins feeding upon the bursting buds, and as the young leaves develop they curl about her. (Fig. 3.) Usually in 15 days the stem-mother is mature, whereupon she begins producing young at an average of 6 a day. The stem-mother lives from a month to six weeks.

The offspring of the stem-mother may either become winged or remain wingless, and this condition may continue for at least 7 generations, so that during these generations both winged and wingless forms are to be found upon the apple. Occasional colonies of wingless forms may be found throughout the summer upon the apple. The winged forms, however (Pl. I, D), when mature fly to plantains and settle upon the underside of the leaves, or upon the flower stems, where they produce young (Pl. I, I, E). They live principally upon the species known as rib grass, long-leafed plantain, or buckhorn plantain.[1] This migration to the plantains continues, in the vicinity of Washington, from the middle of May until the first part of July. On the plantains the insects continue to reproduce during the summer months. Most of the forms produced on these plants are wingless, although a few winged ones occur throughout the summer. The color of these forms is yellowish green, in contrast to the pink or rosy color of those upon the apple. From 4 to 14 generations of the summer forms occur upon plantain in the vicinity of Washington.

In the middle of September winged forms, consisting of fall migrants (agamic females) and males, begin to appear upon the plantains. These winged forms are able to live and reproduce only upon apple trees or closely related species. The fall migrants leave the plantains and settle upon the underside of the apple leaves (Pl. I, H), where they produce the young egg-laying females. These egg-laying females are wingless and orange-yellow (Pl. I, K). The males, which are similar in color to the fall migrants, often being nearly black, fly from the plantains and find the egg-laying females upon the trees. Here mating takes place and the females deposit their eggs about the middle of October. As later females are produced by later migrants, egg-laying continues until freezing weather has killed all the females.

THE GREEN APPLE APHIS.[2]

The green apple aphis lives on the apple throughout the year, and infests the tender terminal growth, causing the leaves to curl, as shown in Plate II, J, and figure 4. In young orchards by midsummer the shoots and leaves of the trees may be more or less generally

[1] *Plantago lanceolata.*

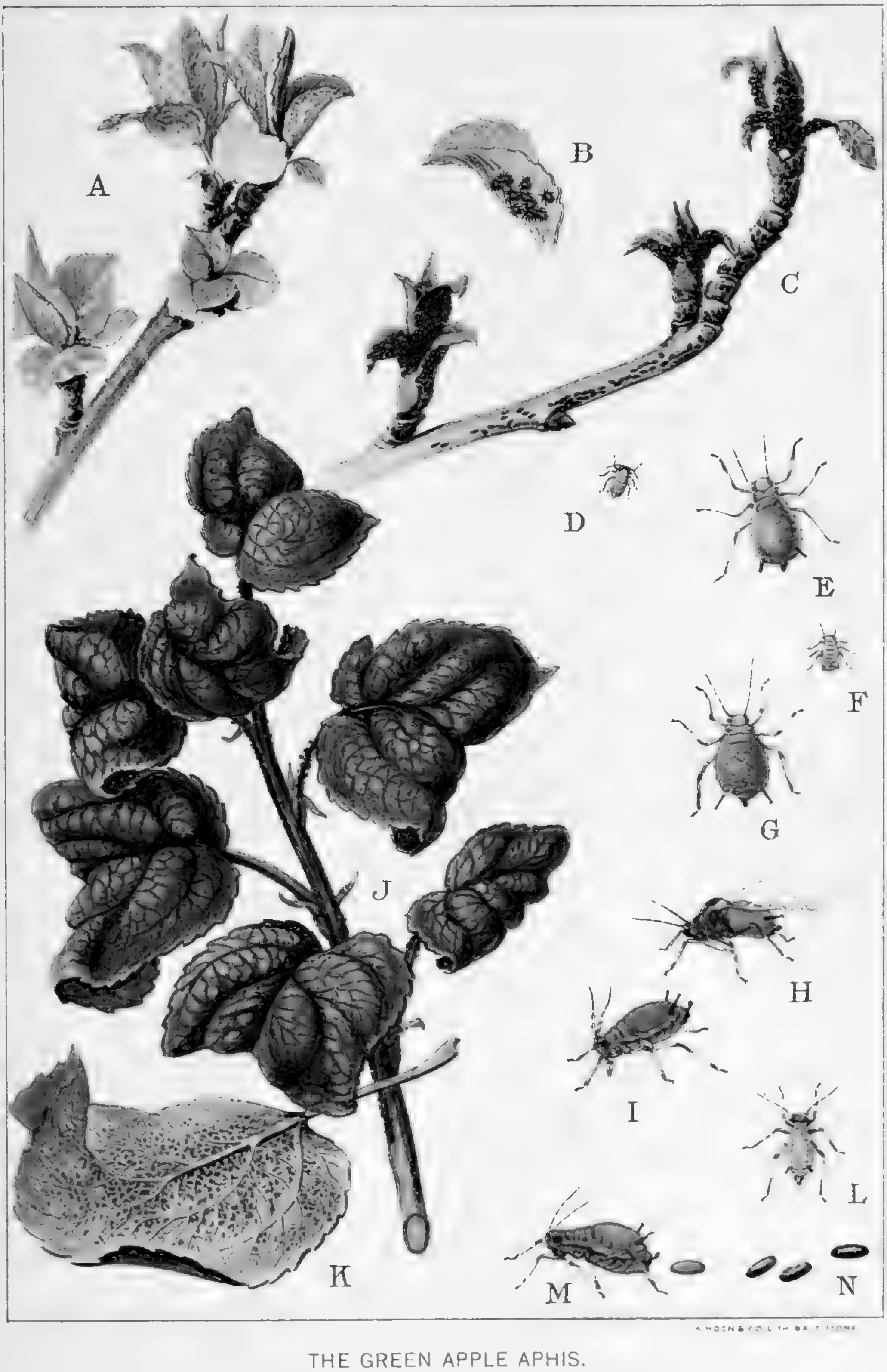
[2] *Aphis pomi* De Geer.

DESCRIPTION OF PLATE II.

THE GREEN APPLE APHIS: *A*, Apple twig in spring with healthy young leaves; *B*, a leaf yellowed by attack of young aphids; *C*, a twig badly infested, showing sickly and stunted opening leaves; *D*, young aphid of first generation; *E*, mature aphid of first generation, a stem-mother; *F*, *G*, young and mature aphids of wingless summer generations; *H*, winged aphid of summer generations; *I*, wingless summer form, side view showing the sucking beak; *J*, terminal shoot of young tree with late summer infestation of aphids; *K*, a leaf from *J* showing aphids and their shed skins on under surface; *L*, a male aphid, produced only in fall; *M*, a sexual female, produced only in fall; *N*, eggs, yellowish when first laid, turning through green to black.

DESCRIPTION OF PLATE III.

GREEN APPLE APHIS ON OPENING APPLE BUDS: Winter eggs and newly hatched aphids on opening apple buds; young aphid much enlarged at right.



THE GREEN APPLE APHIS.

A. HOEN & CO. LITH BALTIMORE

GREEN APPLE APHIS ON OPENING APPLE BUDS

infested, often so much so as decidedly to check the growth. Such trees are likely to be more or less sooty in appearance and overrun with ants. Water sprouts and the shoots of top-worked trees are especially liable to attack. This is the species commonly present on the shoots of apple nursery stock, and much complained of during some years. The work of this aphid is at times confused with that of the apple leafhopper,[1] which distorts the leaves in a manner more or less similar.

The green apple aphis is uniformly green, with black legs, feelers, and honey tubes. (Pl. II, E, G, I.) Occasionally forms are met which are yellowish, instead of a distinct green. The winged forms (Pl. II, H) have a black head and body and a uniformly green abdomen. The males and egg-laying females, which are met during the fall, are somewhat smaller and different in color from the agamic forms (Pl. II, L, M) which occur throughout the summer. The males are orange yellow, sometimes with a brownish tinge, and the females dark green.

FIG. 4.—The green apple aphis: Curled condition of apple foliage due to this insect.

SEASONAL HISTORY.

The eggs when first laid are yellowish green, later turning to polished black. They are laid in the fall upon the smooth twigs and water sprouts of the apple (Pl. II, C; Pl. III; fig. 5), and seem to be laid rarely on the trunks and larger limbs. A very small percentage of the eggs of this species, sometimes as low as 2 per cent, hatches. Hatching occurs at about the same date in the spring as in the case of the rosy aphis.

The young stem-mothers mature in about 10 days, and in about 24 hours after becoming adult begin to produce living young, reproduction continuing for about two weeks. Between 40 and 50 living young are produced by each stem-mother, at the average rate of 4 a day, although many more may be born daily. Of these young

[1] *Empoasca mali* Le Baron.

some develop into winged forms, or migrants (Pl. II, H), and some remain wingless (Pl. II, E, G, I). They mature in a little over a week, and in turn produce either winged or wingless forms. Occasionally another form, intermediate between the winged and the wingless forms, is seen. This reproduction continues throughout the summer, from 9 to 17 summer generations occurring before the sexual forms appear. The true sexes, therefore, appear from the tenth to the nineteenth generation, depending upon the rate of reproduction of their ancestors and upon the time of their birth—that is to say, whether they are early or late young of the parents.

The egg-laying females become adult in from 6 to 16 days, depending upon weather conditions. When adult they mate with the males and begin depositing their eggs upon the apple twigs. Females may be found on the trees until all the leaves have fallen, even when the weather is very cold.

THE APPLE-GRAIN APHIS.[1]

The apple-grain aphis, or the apple-bud aphis, has been confused in this country with the oat aphis [2] or European grain aphis, an insect which is not common here but which occurs in Europe on the bird cherries. Both insects spend the summer on grains and grasses and on these plants look very much alike, but the apple-grain aphis lives during the winter months on apple and not on cherry. It is the earliest apple aphid to hatch in the spring; and as it often occurs in great abundance upon the buds and young foliage, it is frequently the cause of alarm on the part of orchardists. The species probably does not cause important injury, since it migrates from the apple shortly after the blossoms fall. (Pl. IV, A, B, C, D.)

When first hatched the stem-mothers are very dark green, and they remain this color until after the first molt, when they become much paler. The adult wingless forms are pale green (Pl. IV, E), with rusty areas around the base of the honey tubes, although in the summer some individuals become slightly purplish. The winged forms have black head and body with a green abdomen which is marked with black patches along the sides. (Pl. IV, F.) The honey tubes, antennæ, and feet are black. The egg-laying females, which occur in the fall, have an olive cast. (Pl. IV, N.)

SEASONAL HISTORY.

During warm days in winter many of the eggs of this species hatch on the trees, but it is not until about the middle of March, in the vicinity of Washington, that those hatching succeed in escaping destruction and produce stem-mothers. In fact, aphids from eggs hatched before April 1 are sometimes all killed by cold. The important hatching, therefore, commences after April 1.

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[1] *Rhopalosiphum prunifoliae* (Fitch).

[2] *Rhopalosiphum padi* (L.) (*avenae* Fab.).

The young stem-mothers of this species usually are abundant upon the swelling apple buds (Pl. IV, A), and when these begin to open the insects crowd down among the bursting leaves. By the time the stem-mothers are adult—usually in about 13 days—many of the buds have opened and the leaves expanded. Each stem-mother produces about 100 young, and these migrate to the blossoms and to the underside of the leaves, which become coated with them. (Pl. IV, D.) These young may become either winged or wingless adults (Pl. IV, E, F), and at least four generations may be produced upon the apple. The wingless forms upon apple become mature in about seven days, and each individual produces about 75 young. The period of reproduction lasts a little over two weeks and the insects live about a month.

The winged forms produced upon apples become mature in a little over 8 days and then fly to grain and grasses, as wheat, oats, etc. (Pl. IV, G, H, O.)

In the autumn migrants are produced on grains. (Pl. IV, L.) These mature in about 2 weeks and return to the apple, the migration lasting 3 or 4 weeks, since not all the migrants are produced in the same generation. (Pl. IV, J, L.) During their life of some 6 weeks these migrants produce about 5 egg-laying females each.

Fig. 5.—The green apple aphis: Winter eggs on apple twig. Much enlarged.

The winged males are produced upon the summer food plants and migrate to the apple leaves to mate with the sexual females. (Pl. IV, M, N.) After the female has become fertilized she deposits her eggs in crevices of the bark of the larger branches or behind the bud scales of the young twigs of the apple. (Fig. 6.) The length of life of each sex depends upon weather conditions. This is particularly true of the female, which sometimes lives for weeks in a more or less dormant state during cold weather. In warm climates the species may hibernate as wingless females upon the summer hosts.

THE CLOVER APHIS.[1]

The clover aphis, first found injurious to the apple in Colorado, is now known to occur abundantly in some regions in the East. It attacks the apple in a way similar to the green apple aphis, but since there is a considerable migration of individuals to clover, it is less abundant on the apple in summer than the latter species. The stem-mothers of the clover aphis are pink and the individuals of the next generation are yellowish green. The winged forms have a large black patch on the abdomen and in this way resemble the migrants of the rosy aphis. The two species, however, can be distinguished readily by the length of the honey tubes. In the rosy aphis these are very long, while in the clover aphis they are short. The forms of this species which live on clover are pink. (Fig. 7.)

FIG. 6.—The apple-grain aphis: Winter eggs on bark of apple tree. Much enlarged.

SEASONAL HISTORY.

The eggs of the clover aphis are laid upon the apple in much the same manner as those of the species already mentioned. The stem-mothers, which are hatched considerably earlier than those of the rosy aphis and the green apple aphis, give birth to winged and wingless forms, which in turn produce young, some of which become winged, while the others remain wingless. As a rule most of the insects have become winged by early summer, although some wingless colonies occur during the summer on apple. These winged forms fly to clovers, and settling upon the stems produce wingless young. These and succeeding generations, which may contain winged individuals, pass down to the crown of the clover plants, and here the species lives throughout the summer. During October numerous fall migrants are produced upon the clovers and fly to the apple, where they give birth to the young egg-laying females. Winged males produced upon the clovers follow the fall migrants to the apple, and here mate with the females, which later deposit their eggs.

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[1] *Anuraphis bakeri* (Cowan).

DESCRIPTION OF PLATE IV.

THE APPLE-GRAIN APHIS: *A*, Opening apple bud in spring infested with young aphids. The empty egg shells are seen still adhering to the twig; *B*, young aphids, more enlarged; *C*, the leaves unfolding in the bud; *D*, infested blossoms; *E*, a full-grown aphid of the first generation from the blossoms (*D*); *F*, a winged aphid, or spring migrant, from the next generation on the apple leaves; *G*, flight of spring migrants from apple to grain (*H*); *H*, oats infested by summer generations of aphids which are mostly wingless; *I*, wingless summer form; *J*, flight of fall migrants and males from grain back to the apple (*K*); *K*, fall migrants and males alighting on apple leaves, the fall migrants giving birth to the sexual females; *L*, a fall migrant; *M*, a male produced on apple in fall; *N*, sexual females showing extreme color varieties, and eggs which are pale when laid, but later turn black; *O*, wingless aphids that remain about the roots of the grain when the winter is not too severe.

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THE APPLE-GRAIN APHIS.

THE WOOLLY APPLE APHIS.[1]

The woolly apple aphis is often in evidence in summer on the trunk, branches, and twigs of the apple as bluish-white cottony patches (fig. 8) which hide the rusty or purplish brown aphids beneath. While principally injurious to the roots of the apple, its injuries above ground are at times quite important. In orchards grown under arid or semi-arid conditions in the West it is decidedly more troublesome than in the East, attacking the tree wherever the bark is tender and sometimes infesting the stems of the leaves and fruit. Its injuries above ground often result in galls or swellings similar to those on the roots, and when the fruit spurs are invaded the fruiting capacity of the tree may be interfered with seriously.

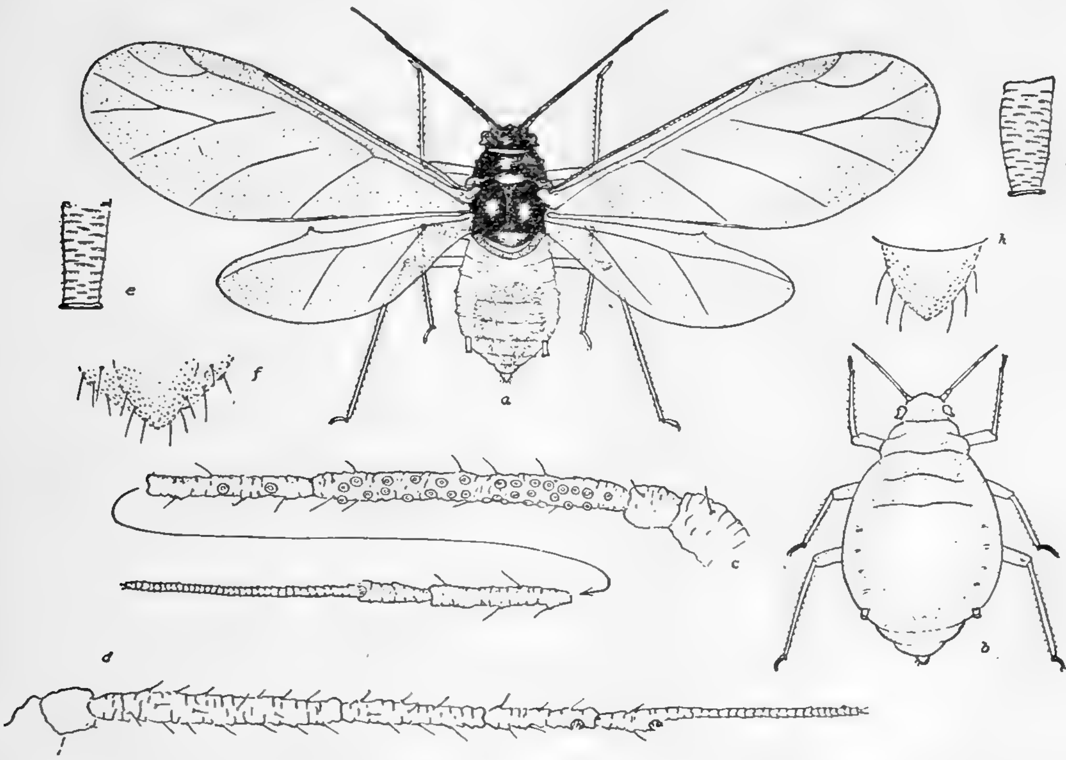

FIG. 7.—The clover aphis: *a*, Spring migrant; *b*, stem mother; *c*, antenna of spring migrant; *d*, antenna of wingless form; *e*, cornicle of spring migrant; *f*, cauda of spring migrant; *g*, cornicle of wingless form; *h*, cauda of wingless form. *a*, *b*, Much enlarged; *c–h*, more enlarged.

The usual contact sprays will be effective in destroying this pest on the limbs and branches. Its treatment on the roots of the apple requires essentially different methods, which are not considered in this bulletin.

APPLE APHIDS OF MINOR IMPORTANCE.

Several additional species of aphids are found upon the apple, but these are at present of minor economic importance.

The potato aphis [2] has been found feeding upon the apple occasionally in the spring. Its normal winter host appears to be the rose. This form is very much larger than the others mentioned, and the winged form, as well as the wingless one, is uniformly light greenish.

[1] *Eriosoma lanigerum* (Hausm.). [2] *Macrosiphum solanifolii* (Ashm.).

Another species, which is slaty blue or black, with white bands upon the legs, and often possesses white waxy tufts, occurs sometimes upon the apple. This is the dock aphis.[1] The apple does not seem to furnish suitable food to these insects, for after a few generations they always leave the trees.

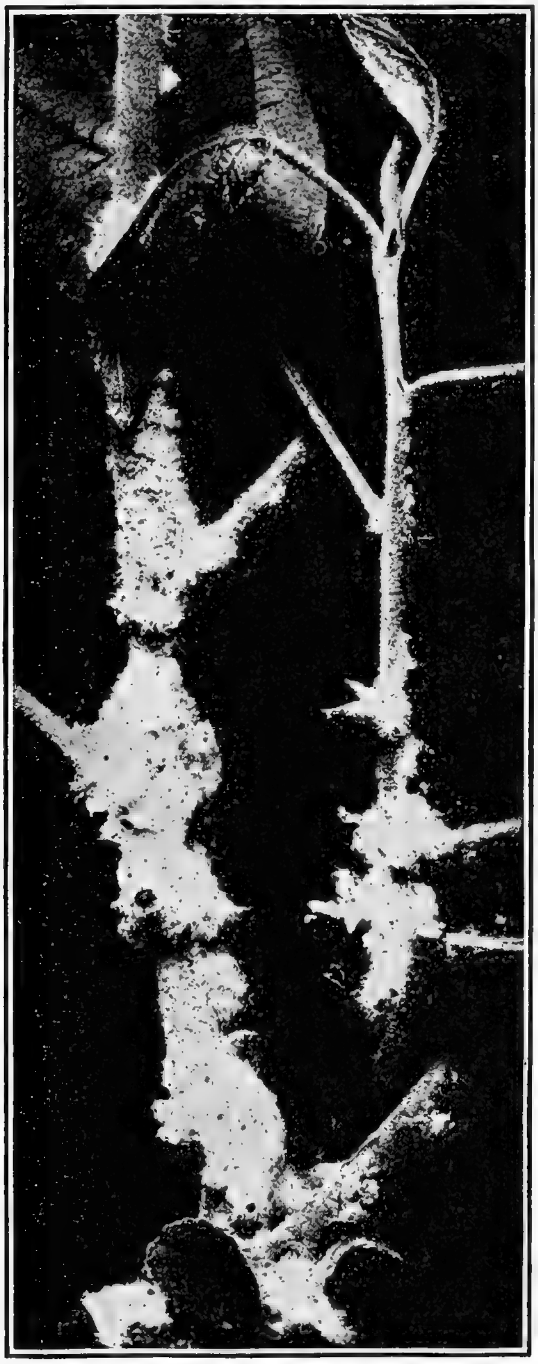

FIG. 8.—The woolly apple aphis: Colonies on apple shoots.

A second dark brown or blackish species which occurs occasionally upon the apple is the bur-clover aphis.[2] It is sometimes encountered during the spring upon apple foliage.

Still another species, the wild-carrot aphis,[3] occurs commonly on the apple in the fall, particularly as the winged form. Its summer hosts are the wild carrot and related plants, and the winged forms fly to honeysuckle vines, but occasionally select apple trees.

The thorn-leaf aphis [4] also is found occasionally upon the apple. Its life history is discussed under aphids attacking the quince.

QUINCE APHIDS.

Two species of aphids which have been discussed under apple occur commonly also upon quince foliage—namely, the green apple aphis and the apple-grain aphis. Their life histories are similar on quince and apple, and the same remedial measures apply.

THE THORN-LEAF APHIS.

The thorn-leaf aphis,[4] called also the long-beaked clover aphis, is most common upon hawthorn trees. Although first found upon thorn, it is not uncommon upon quince leaves. It resembles very closely the clover aphis as found upon apple, but can be distinguished from that insect by its long beak.

On thorn trees the feeding of this species results in a curling of the leaves which is very conspicuous, the twisted leaves taking on a purplish cast. On quinces, however, it does not curl the leaves, or at least not to such an extent.

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[1] *Aphis rumicis* L.
[2] *Aphis medicaginis* Koch.
[3] *Hyadaphis xylostei* (Schrank).
[4] *Anuraphis crataegifoliae* (Fitch).

SEASONAL HISTORY.

The eggs of this insect are laid in the fall upon the twigs of the quince, and the stem-mothers hatch in the early spring. By early summer the insects are abundant and winged forms are being produced. This production of winged forms, or migrants, continues until late summer. The migrants fly from their winter hosts to clovers and peas and produce numerous generations on these plants in a manner very similar to that of the clover aphis. In the fall, migrants are produced which return to the quinces and produce the egg-laying females, which after mating with the males deposit the winter eggs. The flight of the insects from clover begins in September and extends throughout October.

PEAR APHIDS ATTACKING THE FOLIAGE.

Several species of aphids are found upon pear foliage. Most of these, however, occur also upon other trees and are treated elsewhere in this bulletin. The more common forms upon pear are the green apple aphis, the apple-grain aphis, and the clover aphis.

Another species, the woolly thorn aphis,[1] is common in some localities. Both winged and wingless forms are covered with a white, waxy substance. The wingless forms are pale green and the winged forms have a black head and body. The insects hatch in the early spring and soon attack the leaves, curling and twisting them. During early summer the winged forms leave the pear tree. In the fall migrants may be found again, and these produce the sexual forms, the females of which lay their eggs upon the bark. Besides attacking pear, this species occurs upon thorn, quince, and Juneberry.

Two other forms are found commonly upon pear, but these occur upon the roots, and since they are seldom found upon the branches and foliage and require different remedial measures, they are not treated in this bulletin. The first of these is the woolly pear aphis,[2] which is common in the western part of the country, and the second is Fitch's pear root-aphis,[3] which is very similar to the woolly thorn aphis and occurs in the eastern United States.

PLUM APHIDS.

Three or four species of aphids are common on the plum, two of which are, during some seasons, very injurious. Many complaints of injury to Japanese and native plums by the rusty plum aphis have come from the more southern States, while the mealy plum aphis is more often prevalent in the North and West, on Domestica, or the European type of plums. The hop aphis, according to records of the Bureau of Entomology, has not occasioned much injury to plums in recent years, although in the Pacific Northwest it continues to be a pest of importance to hops.

[1] *Prociphilus corrugatans* (Sirrine). [2] *Eriosoma pyricola* B. & D. [3] *Prociphilus fitchi* B. & D.

THE RUSTY PLUM APHIS.[1]

The rusty plum aphis was discovered and named from individuals feeding on grass, but is better known by its injuries to plums. It is rusty brown or deep purplish, with white bands upon the legs.

This species feeds upon the tender twigs and foliage of the plum and also upon the peach. The first stem-mothers attack the buds just as they are expanding in the spring and later crawl down among the opening leaves. As the season advances whole twigs or small branches may be literally crowded with the aphids (fig. 9), and such twigs usually die. Another species, not yet named, also has this habit, and this form may be very injurious to the twigs, as it remains on the plum throughout the summer.

FIG. 9.—The rusty plum aphis: Colony on shoot and foliage of plum.

SEASONAL HISTORY.

The eggs of the rusty plum aphis hatch early in the spring and the normal life period of the stem-mother is about a month. During this time she produces young at the rate of four to six a day. In a little over a week these young are mature and reproducing, so that large colonies soon result. A few winged forms occur in the early generations, but it is not until late spring that a large percentage of spring migrants is found. These winged forms fly from the plum and settle upon various grasses, where they produce colonies throughout the summer around the crowns of the plants. In October the fall migrants are produced upon the grasses, return to the plum, and there give birth to the egg-laying wingless females. The males also produced upon the grasses, migrate to the plum in order to locate and fertilize the egg-laying females. In some regions the species seemingly lives on the plum throughout the year.

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[1] *Hesteroneura setariae* (Thos.).

THE LONG-BEAKED THISTLE APHIS.[1]

In some localities the long-beaked thistle aphis is abundant on plum trees. In structure this species most closely resembles the rusty plum aphis. The insects are shiny green and black, some of the wingless ones and all of the winged ones having a large black patch on the abdomen. (Fig. 10.)

Although this species becomes very abundant on the trees, it does not curl the leaves to any extent. Trees have been observed in the vicinity of Washington with the underside of nearly every leaf thickly covered with the insects, and yet these leaves were rolled only slightly from the edges. The insects always feed on the underside of the leaves or on the very tender twigs. Practically all the injury done to the trees is by the spring forms, the fall migrants being scattered.

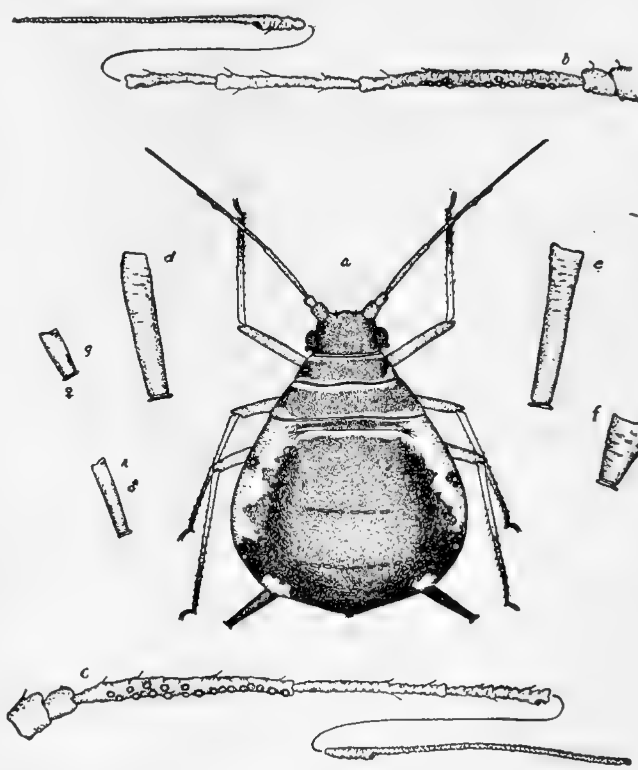

FIG. 10.—The long-beaked thistle aphis: *a*, Wingless female; *b*, antenna of spring migrant; *c*, antenna of fall migrant; *d*, cornicle of fall migrant; *e*, cornicle of spring migrant; *f*, cornicle of stem mother; *g*, cornicle of egg-laying female; *h*, cornicle of male. *a*, Much enlarged; *b–h*, more enlarged.

SEASONAL HISTORY.

The eggs of this species are laid upon the plum, as are those of the rusty plum aphis. In the early spring the stem-mother hatches and gives birth to living young. Winged forms begin to appear as early as the second generation and continue to be produced until midsummer. These migrate to thistles, where they produce the first of the summer forms. After having produced numerous generations on the thistle during the summer, fall migrants are produced which return to the plum trees to deposit the young egg-laying females. These, after being fertilized by the males, lay the winter eggs.

THE WATER-LILY APHIS.[2]

Plum trees are sometimes thickly infested by an aphid with swollen honey tubes, the water-lily aphis. The insects are brownish, the winged forms having a black head and body.

[1] *Anuraphis cardui* (L.).

[2] *Rhopalosiphum nymphaeae* (L.).

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The spring forms feed upon the underside of the leaves or on the tender twigs of the plums, but they do not curl the leaves to any extent. The summer feeding habits of the species on water plants are very interesting, as colonies often are partially submerged for some time without apparent injury.

SEASONAL HISTORY.

The stem-mothers of this species hatch early in the spring upon the plum, and soon the young produced cover the lower side of the leaves and the twigs. Winged forms are found during June and these fly to various water plants, on which they reproduce and live during the summer months. In the fall the migrants return to the plum and produce the egg-laying females, which, when adult, are fertilized by the winged males. The flight of the fall migrants and males extends over a long period, the males having been found on the plum trees from early until late fall.

THE HOP APHIS.[1]

A large green aphid, the hop aphis, is in some regions very common upon plums in the spring. The wingless forms are light green and the winged forms are light green with black head and body and a patch of the same color on the abdomen.

The stem-mothers of this species feed upon both the flower buds and the leaf buds of the plum. After the leaves have expanded, the insects attack the underside of the leaves and often may be found thickly crowded thereon.

SEASONAL HISTORY.

The eggs hatch on the plum twigs considerably later as a rule than those of the thistle aphis. The young stem-mothers soon develop and begin the production of young. Winged forms soon appear, the greater number of these occurring in the third generation. These winged forms fly to hop vines, where they produce young that feed upon the hop plant. Eight or more generations of these summer forms are produced upon the hop, and winged fall migrants are then produced, which return to the plum trees to produce the sexual females. Males appear during the fall for a period of several weeks, the last ones usually occuring late in October or in November. These fertilize the egg-laying females, which then lay their eggs upon the twigs.

In some cases the species is able to complete its life cycle on the hop and does not necessarily alternate with the plum, whereas in other cases it remains all summer upon the plums.

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[1] *Phorodon humuli* (Schrank).

THE MEALY PLUM APHIS.[1]

The mealy plum aphis is a common form on plum trees and it can be distinguished from the other species attacking plum foliage by its uniform green color and the fine, white, powdery covering of the body. The honey tubes also differ in that they are very short.

FIG. 11.—The mealy plum aphis: Infested plum foliage.

SEASONAL HISTORY.

These insects feed upon the underside of the leaves, often being very closely packed together. (Fig. 11.) As a rule they do not curl the leaves, even when present in great numbers.

The stem-mothers of this species hatch from the winter eggs on the plum early in the spring and in about 10 days they are mature.

[1] *Hyalopterus arundinis* (Fab.).

They then give birth to young, and these when grown produce others until the leaves are often thickly covered with the insects. Winged forms develop toward late spring and continue to appear until late midsummer or later. These winged forms migrate to certain grasses and produce numerous generations during the summer. In the fall return migrants are produced, which give birth to the egg-laying forms on the plums. These migrants first appear in early September, but continue to arrive until late October or early November.

THE HAWKWEED APHIS.[1]

The hawkweed aphis is a native of Europe, where it lives on plums. In India it is very injurious to peaches and is there known as the peach-curl aphis. It has recently been found in numbers in our western region on plums. The winged forms have a black head and thorax and a green abdomen with a large black patch on it. The honey tubes are short. The wingless forms are green. (Fig. 12.)

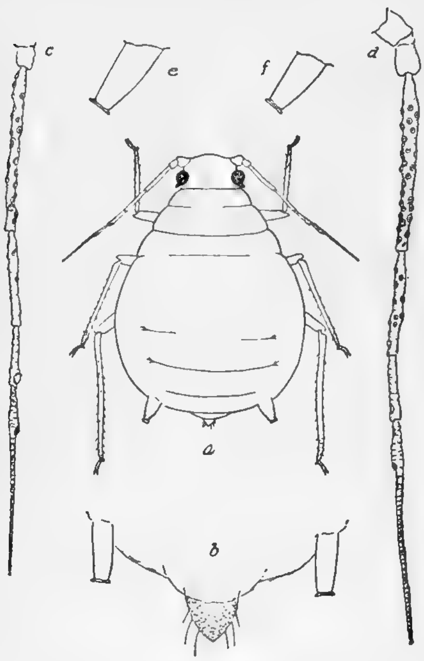

FIG. 12.—The hawkweed aphis: *a*, Wingless form from plums; *b*, cornicles of the spring migrant; *c*, antenna of summer winged form; *d*, antenna of spring migrant; *e*, cornicle of summer wingless form; *f*, cornicle of spring wingless form. *a*, Much enlarged; *b-f*, more enlarged.

SEASONAL HISTORY.

The eggs are laid upon plum trees and in the spring hatch to the greenish stem-mothers. These produce wingless forms and in late spring the winged ones may be found. These winged ones migrate to hawkweed, scorpion-grass, groundsel, etc., and produce summer colonies on these plants. In the fall winged migrants return to the plums and deposit the wingless egg-laying females. The winged males follow and mating takes place on the plums, peaches, etc. In this country the insect has not been found to be injurious to peaches, but it may become so in time.

CHERRY APHIDS.

THE BLACK CHERRY APHIS.[2]

The black cherry aphis is an abundant species almost everywhere upon cherry trees. The wingless insects have a rounded abdomen, which gives them a more or less globular appearance. Both wingless and winged forms are shining deep brown to black, while the

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[1] *Anuraphis helichrysi* (Kalt.). [2] *Myzus cerasi* (Fab.).

color of the young ranges from amber through various shades of brown. The young stem-mothers are deep greenish.

On account of their early hatching in spring the young stem-mothers do not find leaf food available. They therefore attack the buds even before these show any signs of bursting. Sometimes

Fig. 13.—The black cherry aphis: Curled terminal cherry leaves following attack by this species.

the stem-mothers will feed in this manner for nearly a week before the buds begin to open. As soon as the leaves are formed the young insects attack them and cause them to curl. As they spread from leaf to leaf a large and conspicuous cluster of curled-up leaves (fig. 13) is formed, within which the insects feed.

SEASONAL HISTORY.

The eggs are laid upon the cherry twigs in the fall and hatch early in the spring. The insects are able to withstand freezing weather, and after the return of warmer weather continue their activities. Within two or three weeks after hatching the stem-mothers are mature and produce young. These later generations become adult usually in less than a week. Some of the insects so produced become winged while others remain wingless.

The winged forms migrate to pepper-grass and other related plants and here they form colonies throughout the summer. The number which migrate varies in different parts of the country. In some regions there is a very distinct and complete migration, while in other places the wingless forms remain.

The wingless ones continue reproduction, and sometimes give rise to as many as 11 generations before the end of July. The numbers on cherry, however, gradually diminish, and during midsummer very

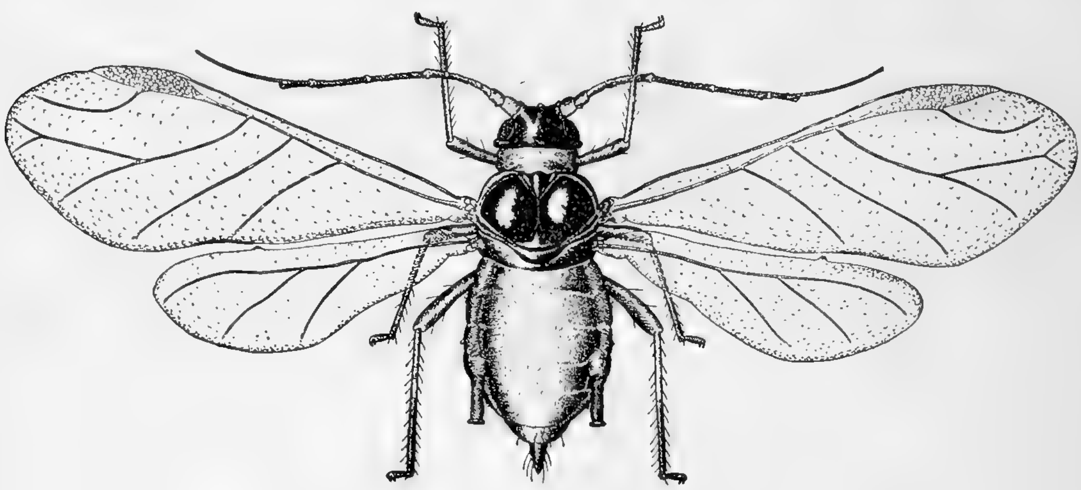

Fig. 14.—The chokecherry aphis: Spring migrant. Much enlarged.

few are seen upon the trees, and in some cases no insects can be found upon trees which earlier in the season were badly infested. During October fall migrants and winged males may be found returning to cherry trees and are often encountered during the migration period in larger numbers than might be expected. The fall migrants produce the egg-laying females which, when mature, are fertilized by the males.

THE CHOKECHERRY APHIS.[1]

The chokecherry aphis is found abundantly upon chokecherries and related trees. It is a pale green insect and is conspicuously mealy. The winged forms have a black head and body.

The feeding habits of this species are very similar to those of the black cherry aphis. The leaves of the terminal twigs are attacked and twisted by the feeding of the insects, entire twigs sometimes being destroyed.

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[1] *Aphis cerasifoliae* Fitch.

SEASONAL HISTORY.

As in the case of the black cherry aphis, the eggs of this insect are laid on the cherry twigs. After the stem-mothers have become mature and produced young, these latter crowd the terminal leaves. Winged forms (fig. 14) are produced during early summer, and by midsummer the insects usually have disappeared from the trees. The winged forms migrate to grains and grasses and here produce colonies which are very similar to those of the apple-grain aphis. Here they live throughout the summer, and in the fall winged forms return to the cherry trees to deposit the egg-laying females.

THE CHOKECHERRY-GRAIN APHIS.[1]

The chokecherry-grain aphis is very similar indeed to the oat aphis of Europe and it is not improbable that it is the same species. The wingless forms (fig. 15) are a dark olive green, irregularly mottled with a darker color and dusted with a whitish powder, especially along the sides of the abdomen and in the abdominal wrinkles. The winged forms have the head and thorax shiny black, and the general body color dark olive with black markings on the abdomen and black honey tubes. The pupa, which later becomes the winged form, has powdery tufts along the sides and across the hind part of the abdomen. The insect attacks the terminal twigs of the chokecherry and causes a twisting and curling of the leaves. (Fig. 16.)

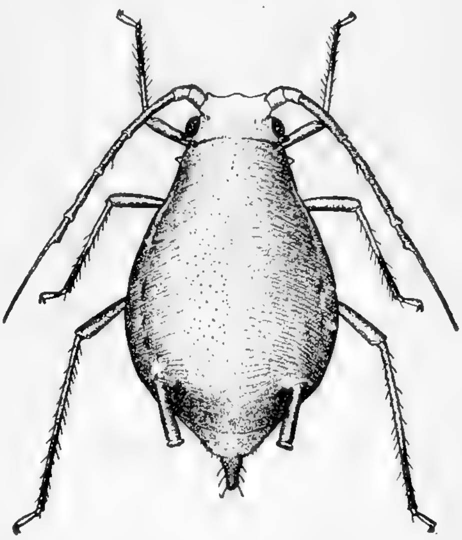

FIG. 15.—The chokecherry-grain aphis: Summer wingless form. Much enlarged.

SEASONAL HISTORY.

The complete life history has not been worked out. Undoubtedly the eggs are laid upon the cherry and hatch to stem-mothers, which with their young cause the curling of the leaves. Winged forms appear in June and continue to be produced for some weeks. These migrate to grains and produce colonies there somewhat similar to those of the apple-grain aphis. On the grains, however, the insects do not possess the mealy covering seen on the cherry forms. In the fall migrants return from the grains and grasses to the cherry and here produce the oviparous females which lay the overwintering eggs.

THE RED AND BLACK CHERRY APHIS.[2]

The red and black cherry aphis lives in dense red masses on the young shoots of the black cherry. It does not attack the leaves, but

[1] *Rhopalosiphum pseudoavenae* (Patch). [2] *Aphis tuberculata* Patch.

confines itself to the shoots. The species has been recorded only from Maine. In colonies found on wild cherry in the District of Columbia a few insects have been seen along the midrib of the leaf. The wingless forms have a light red body dusted with a whitish powder. The legs, honey tubes, and some spots along the sides of the abdomen are black. The winged forms have the head and thorax black and the abdomen red. The life history is unknown.

Fig. 16.—The chokecherry-grain aphis: Work on chokecherry leaves. (Maine Agricultural Experiment Station.)

THE SMALL CHOKECHERRY APHIS.[1]

A very small species lives on the chokecherry in Maine. It resembles the apple-grain aphis in appearance, except for the fact that the honey tubes have no swelling. Its life history is unknown.

[1] *Aphis furcata* Patch.

PEACH APHIDS.

THE GREEN PEACH APHIS.[1]

The green peach aphis is a common form upon peach trees. The stem-mothers in spring, as well as the fall egg-laying females, are often pinkish, and at other times light green. The wingless agamic form also is light green, while the winged individuals have a black head and body and a large dark-brown patch on the abdomen. This marking occurs upon both the spring migrant and the fall migrant. They are similar in other respects, excepting that the fall form has the honey tubes somewhat swollen.

On the peach this species feeds entirely upon the leaves, on which the insects may be found in large numbers crowded on the underside. (Fig. 17.) It has a large number of other food plants, including numerous garden vegetables.

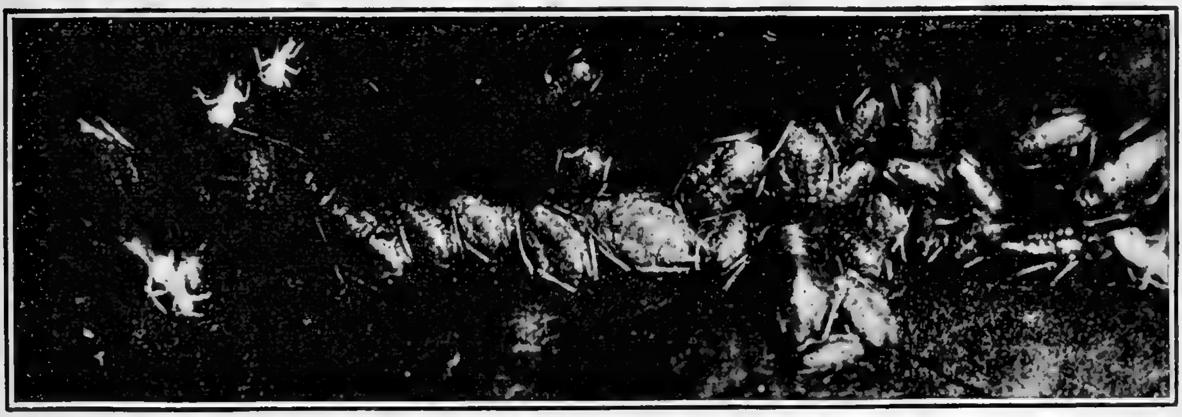

FIG. 17.—The green peach aphis: Colony on underside of peach leaves. Much enlarged.

SEASONAL HISTORY.

The eggs of this aphid are laid upon the peach twigs, and early in the spring before the buds are opened the green stem-mothers are hatched. From this form during the spring may be produced one or more generations of wingless individuals upon the leaves. Spring migrants, however, begin to occur very early and continue to appear until the middle of June. These fly to a large number of different plants, where numerous generations occur throughout the summer. During September and October fall migrants are developed which return to the peach, where they deposit the young egg-laying females. These are fertilized by the winged males, which also have returned to the peach, and the females then lay their eggs upon the twigs. Occasionally, however, migrants are found which do not return to the peach, and these deposit egg-laying females upon the summer host plants.

[1] *Myzus persicae* (Sulz.).

THE BLACK PEACH APHIS.[1]

The well-known black peach aphis is injurious to the twigs, shoots, and roots. It is shiny dark brown to black, with the young an amber color.

The insect lives throughout the year on the roots of the peach and is most injurious to peach growing on sandy soils. It is prevalent in portions of Maryland and in Delaware, New Jersey, and Michigan. Individuals migrate from the roots during the warm periods in winter or in early spring and start colonies on the twigs and young shoots. (Fig. 18.) Often these become so numerous as to cause the death of dormant-budded nursery trees (fig. 19) and do serious or fatal injury to young orchard trees. In mild climates the insects may exist all winter on the twigs, reproducing during periods of warmth, though the twigs are for the most part reinfested each year from the insects below the soil.

Fig. 18.—The black peach aphis: Colonies on peach shoot in early spring.

The complaints of serious injury by this species on the roots of orchard peach trees, in the experience of the writers, have not been justified, the unthrifty condition of the trees being in most cases due to other causes.

SEASONAL HISTORY.

The complete seasonal history of this species is not known. The number of young produced by a given parent varies greatly, depending upon weather conditions. Sometimes only one young aphis a day will be produced, with a total of 25 or 30 young to a mother, while under favorable conditions as many as 12 young

[1] *Anuraphis persicae-niger* (Smith).

may be produced in a day and considerably over 100 as the total for a given parent. In spring large numbers of winged forms (fig. 20) appear and the percentage of these gradually increases until all

Fig. 19.—The black peach aphis: Injury to dormant-budded peach nursery stock in the spring.

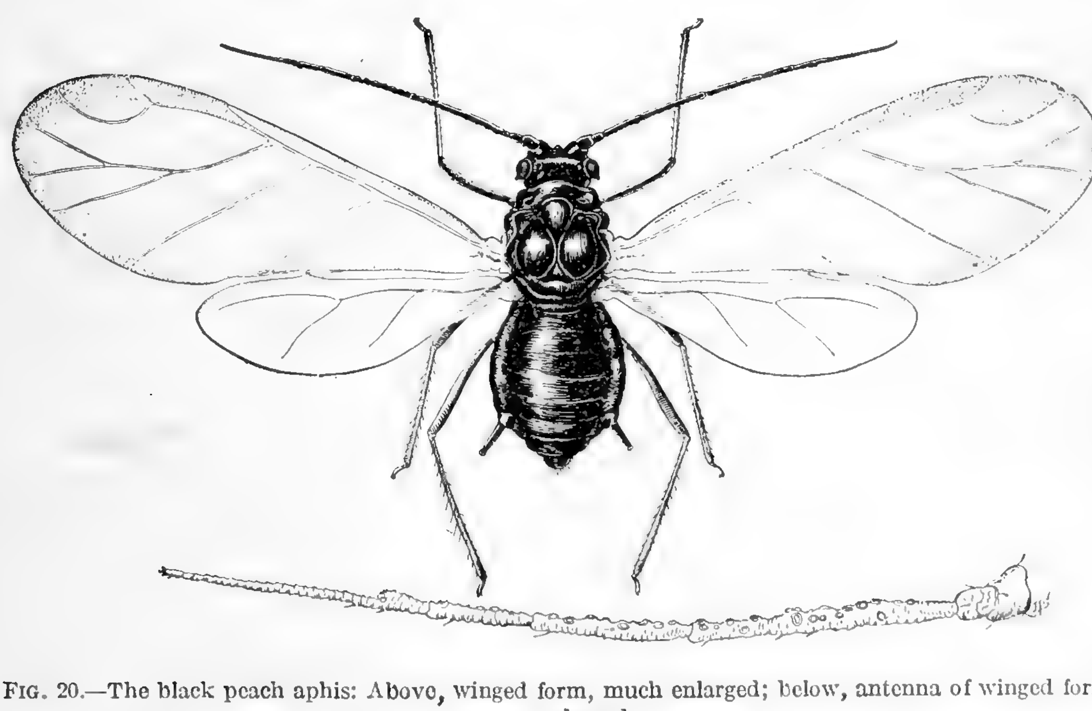

Fig. 20.—The black peach aphis: Above, winged form, much enlarged; below, antenna of winged form, more enlarged.

of the forms above ground have become winged. These fly to some plant or plants not known and are not met on peach foliage until the next year.

THE EUROPEAN PEACH APHIS.[1]

The European peach aphis (fig. 21) is one of the chief insect pests of the peach in certain parts of Europe. In this country it has been found so far only in New England. It resembles our black peach aphis in many details, but the honey tubes are much shorter and the coloring is quite different. The general color is a rusty yellow or even a pinkish and the wingless form has a row of dark brown dots along each side and a large black patch on the abdomen. This patch is, however, very often broken up into distinct transverse bands. The young are yellow.

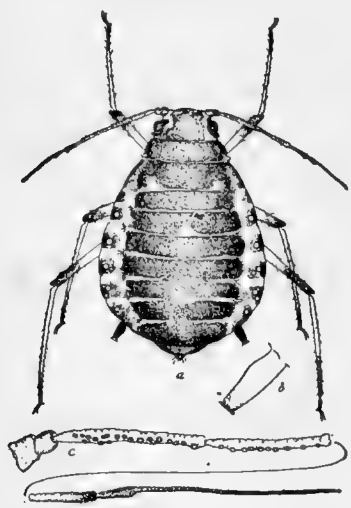

FIG. 21.—The European peach aphis: *a*, Wingless form; *b*, cornicle of winged form; *c*, antenna of winged form. *a*, Much enlarged; *b*, *c*, more enlarged.

SEASONAL HISTORY.

The eggs are laid upon the peach twigs and the young stemmothers attack the foliage. Wingless and winged forms are produced and these reach their maximum number during late spring. During late summer their numbers diminish and in the fall wingless egg-laying forms and winged males are produced.

THE VARIABLE PEACH APHIS.[2]

The variable peach aphis is a pale yellow or green and black form which looks somewhat like the green peach aphis. It occurs in California and sometimes severely injures peach trees. Colonies are formed on the tender terminal twigs and the leaves are rolled up tightly by the attacks of the insects. (Fig. 22.) Such leaves take on a reddish tinge and suggest leaf-curl. Inside of the curled leaves, however, can be found large numbers of the aphids.

The life history has not been fully worked out, but the insect is found throughout the spring and summer on clematis, which may be its normal food plant.

CURRANT AND GOOSEBERRY APHIDS.

THE CURRANT APHIS.[3]

The currant aphis is distributed over the entire country and its injury, on account of its conspicuousness, is the occasion of much complaint. The insect causes the terminal leaves to become much distorted, and little pits or pockets are formed on the underside. (See fig. 23, *b;* fig. 24.) The upper surface of the leaves assumes a

[1] *Anuraphis prunicola* (Kalt.). [2] *Myzus varians* Davidson. [3] *Myzus ribis* (L.).

more or less reddish color, evident some distance away. When the plants are badly infested these leaves fall and the fruit becomes poor and ripens prematurely. Red currants are most subject to attack, but black currants and gooseberries also are injured.

FIG. 22.—The variable peach aphis: Work on peach. (Essig.)

The stem-mothers of the species are green, the other wingless forms (fig. 23, *a*) a yellowish green, while the winged ones have a black head and body and a large black patch on the abdomen. The eggs are polished black.

SEASONAL HISTORY.

The stem-mothers hatch from the eggs in the early spring soon after the leaves open. After completing their growth they produce young aphids which infest the lower surface of the leaves. Some of the offspring of the stem-mother are winged and these fly to motherworts, hedge-nettles, and related plants. Here colonies develop during the summer, augmented by winged forms produced in other generations on the currants. The wingless ones remain upon the currants and continue reproduction. In each generation some winged forms occur, but wingless individuals are present until late in July upon the bushes. In fact, occasional colonies remain throughout the summer. In the fall, during early October, migrants return to the currant bushes and deposit the sexual females. These when mature are fertilized by the winged males and the eggs are laid upon the twigs.

THE SOW-THISTLE APHIS.[1]

The sow-thistle aphis is at times quite as abundant on currants as is the currant aphis. It is somewhat similar in color but can be distinguished at once from the currant aphis by the swollen honey tubes. (Fig. 23, *c*.) In the currant aphis these are long and very slender. (Fig. 23, *a*.) The eggs are polished black. The sow-thistle aphis injures the currant in about the same way as does the currant aphis, though the infested leaves (fig. 23, *d*) do not take on a reddish coloration.

SEASONAL HISTORY.

The seasonal history of this species upon currants is very similar to that of the currant aphis. The winged forms, however, migrate to the sow thistle and upon this they reproduce. After the production of numerous generations here during the summer, fall migrants are developed which return to the currants. Egg-laying females are then produced and these are fertilized by the winged males. The eggs are laid upon the twigs at about the same time as those of the currant aphis.

THE GREEN CURRANT APHIS.[2]

A species which may be called the green currant aphis has for years occurred with the currant aphis, which it resembles closely. The wingless forms of the present species are green, whereas those of the currant aphis are yellowish. The life history, so far as is known, is very like that of the currant aphis and the two forms often may be found on the same leaf. In fact, it is not improbable that the green currant aphis is merely a dimorphic form of the currant aphis.

THE VARIABLE CURRANT APHIS.[3]

The variable currant aphis is one of the most injurious species. The stem-mother is purplish green with white honey tubes. The wingless form is dark green, tan, or dark brown, whereas the winged

[1] *Amphorophora lactucae* (Kalt.). [2] *Myzus dispar* Patch. [3] *Aphis varians* Patch.

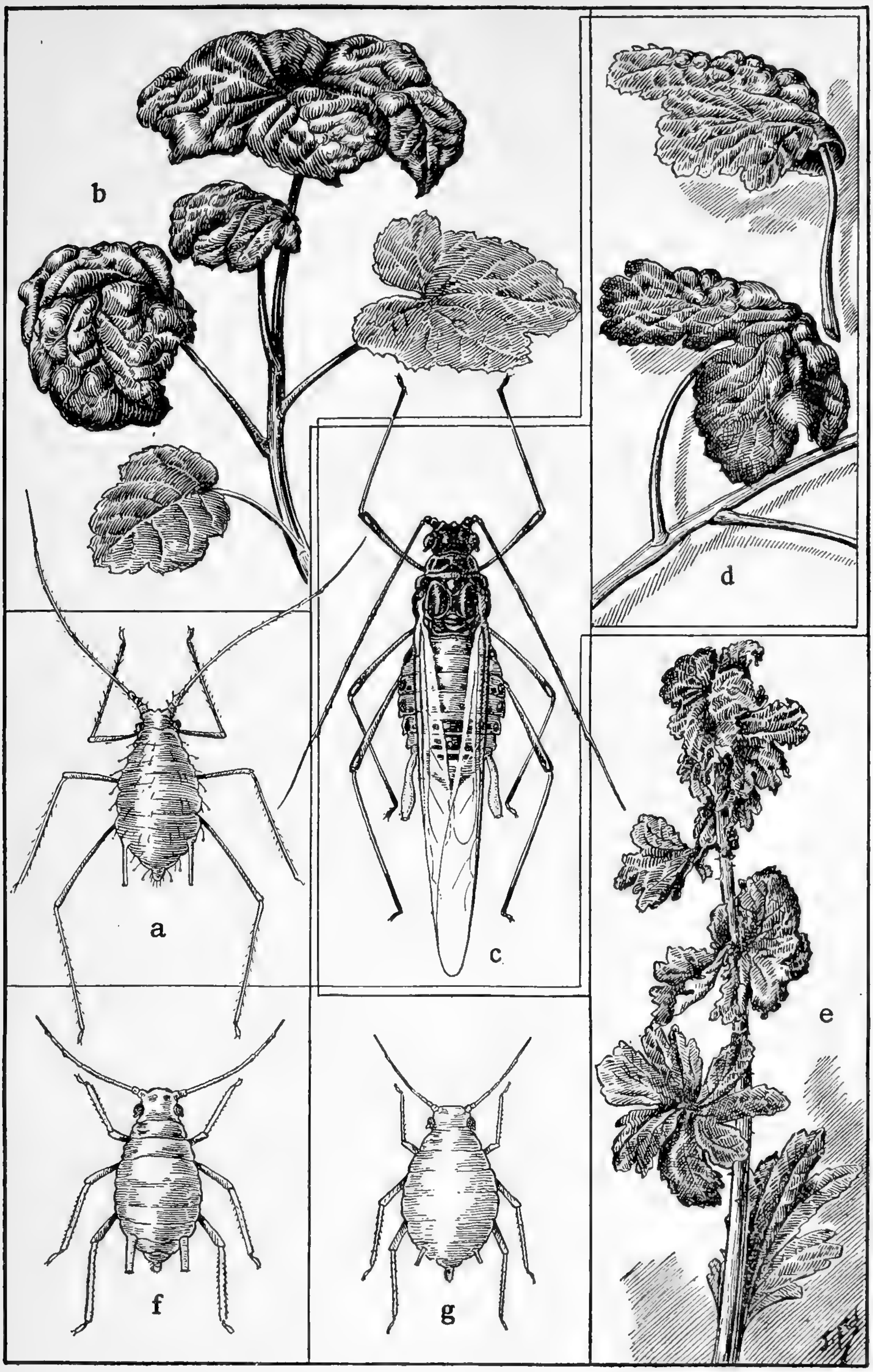

FIG. 23.—Currant aphids: *a*, Wingless viviparous female of the currant aphis; *b*, distorted currant foliage due to attack of this species; *c*, spring migrant of the sow-thistle aphis; *d*, injury to currant by this species; *e*, work of the green gooseberry aphis on gooseberry; *f*, wingless viviparous female of the New Mexico gooseberry aphis; *g*, wingless viviparous female of Sanborn's currant aphis. *a*, *c*, *f*, *g*, greatly enlarged.

form has a black head and body, with a dark green abdomen marked near the tip and on the sides with black.

As soon as the stem-mother begins to feed, the young leaf begins curling about her. As young are produced other leaves are attacked until large irregular bunches of twisted leaves occur. Later the insects attack the shoots, sometimes thickly covering them. The species infests currants, gooseberries, and flowering currants.

FIG. 24.—The currant aphis: Injury to currant foliage.

SEASONAL HISTORY.

The stem-mother hatches from the eggs early in the spring and becomes mature early in May. She produces young which are all wingless. These in turn produce young which may or may not be winged. The winged ones take flight to some unknown summer host, while the wingless ones continue the infestation upon the currants until nearly midsummer. In the fall migrants return to the currants and produce young which develop into males and egg-laying females, the latter depositing eggs upon the twigs.

THE GREEN GOOSEBERRY APHIS.[1]

The green gooseberry aphis is a green species with white honey tubes. It lives upon the underside of gooseberry leaves, which it deforms badly (fig. 23, *e*), and also upon the twigs.

The seasonal history of this species has not been determined. The winter eggs are laid upon the host plant upon which the stem-mother develops. Wingless forms occur later than the stem-mother, and winged ones also are produced upon the gooseberry.

THE NEW MEXICO GOOSEBERRY APHIS.[2]

Another species is found on gooseberries in New Mexico. The wingless forms (fig. 23, *f*) are green, while the winged forms have black head and body, with green abdomen marked with some dark bands or spots. Its life history is unknown. A variety of this species is found in California, feeding upon the red currant.

SANBORN'S CURRANT APHIS.[3]

A small species of aphid occurs in the Middle West and Southwest on Missouri gooseberries and cultivated currants. This is Sanborn's currant aphis. The wingless forms (fig. 23, *g*) are green, and the winged forms have black head, body, legs, honey tubes, and an-

Fig. 25.—The Houghton gooseberry aphis: Work on Houghton bushes.

[1] *Aphis sanborni* Patch. [2] *Aphis neomexicanus* (Ckll.). [3] *Aphis ribis* Sanborn.

tennæ. The species is found in the spring in rather large colonies on the underside of the leaves, which it causes to curl and twist.

THE HOUGHTON GOOSEBERRY APHIS.[1]

A pale green species has become prominent in recent years by reason of its attacks on gooseberries. The wingless ones are green and covered with knobbed hairs. The winged ones are dark green with a brown head and thorax. The insects attack the growing

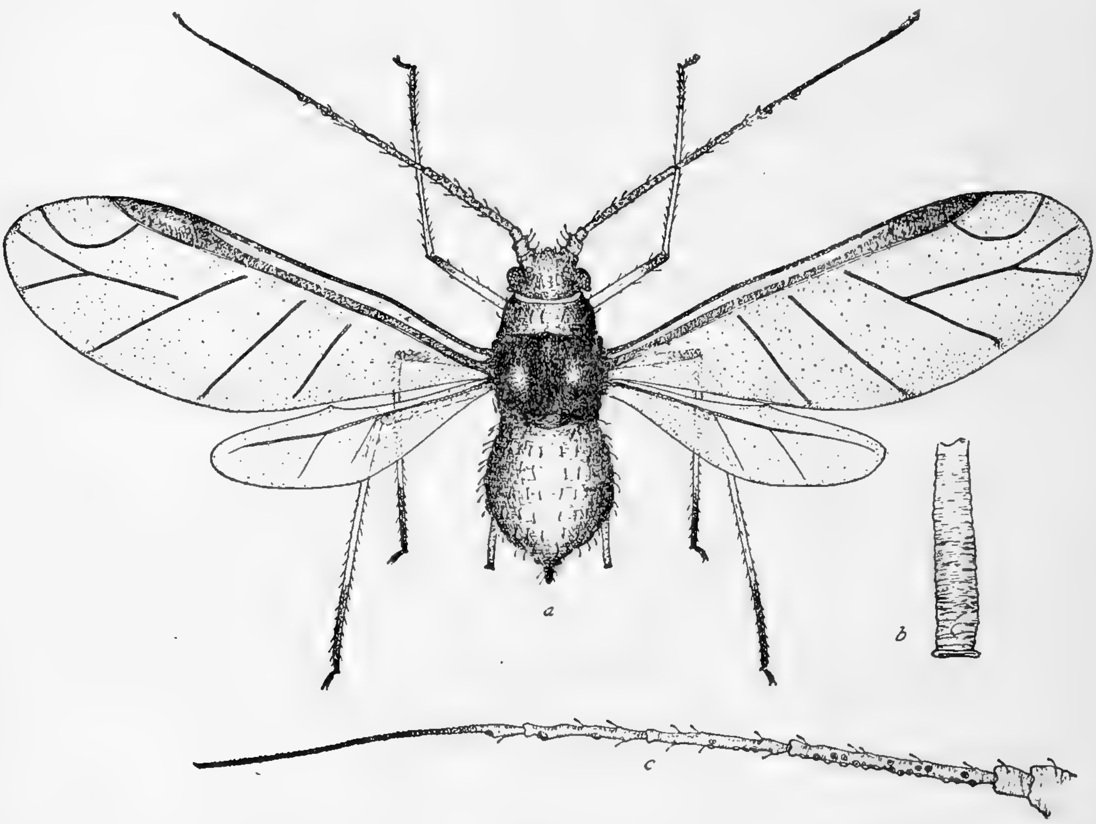

FIG. 26.—The Houghton gooseberry aphis: *a*, Winged form; *b*, cornicle of winged form; *c*, antenna of winged form. *a*, Much enlarged; *b*, *c*, more enlarged.

tips and ultimately produce a "witches broom" like that seen in the illustration (fig. 25).

SEASONAL HISTORY.

The eggs are laid on the bark under the loose folds which extend down the twigs. Occasionally also they occur on the bases of the buds or even on the thorns.

The eggs hatch with the expanding buds and the young stem-mothers place themselves on the underside of the leaves, the petioles, or tender twigs. The leaves soon curl and twist, forming a protection for the stem-mother and her young. The stem-mother and succeeding wingless forms therefore cause the twisting of the leaves.

The winged forms (fig. 26) occur in all generations from the second onward, even the stem-mother producing some winged forms.

[1] *Myzus houghtonensis* (Troop).

These winged ones leave the plants, and we have not been able to trace them farther. They begin to appear early in May.

The wingless forms carry on the infestation and in September and October the sexed forms appear. The male is very small and wingless and is slightly darker than the ordinary wingless form. The egg-laying female is somewhat larger than the male and also wingless. These mate and the female lays her eggs on the twigs a short time later.

THE ORNAMENTAL CURRANT APHIS.[1]

The wingless forms of the ornamental currant aphis are pale greenish with the honey tubes dusky at the tips. The winged forms are similar in color with pale brownish lobes on the thorax. The egg-laying female is orange in color with pale yellowish spots, while the abdomen of the male is dark.

SEASONAL HISTORY.

This species usually occurs on the ornamental currants. The eggs hatch in the spring and numerous generations of wingless forms are produced. By August these are present in large numbers on the tender terminal twigs and to a less extent on the undersides of the leaves. Winged forms appear in September or earlier and ants are found attending the insects. Early in October the orange, wingless, egg-laying females may be found mating with the winged males and the eggs are laid shortly afterward.

THE WESTERN CURRANT APHIS.[2]

This species lives on the flowering currant in California, on which it makes curls or blisters similar to those produced by the currant aphis. The wingless form is green or yellowish green. The winged form is green with black head and thorax. The egg-laying female is whitish-yellow and the male red.

SEASONAL HISTORY.

The eggs are supposedly laid on the twigs and the stem-mother appears very early in the season. The winged forms begin to appear in March and the male and egg-laying female may be found as early as the month of May.

THE DOGBERRY APHIS.[3]

The dogberry aphis is very like the Houghton gooseberry aphis. It was found on the prickly gooseberry or dogberry and occurs also on the Buffalo currant (*Ribes aureum*). It differs from the Houghton gooseberry aphis in having fewer pores or sensoria upon the antennæ, and less distinctly knobbed hairs. Its life history is not fully known.

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[1] *Macrosiphum ribiellum* Davis. [2] *Myzus ribifolii* Davidson. [3] *Myzus cynosbati* (Oest.).

GRAPE APHIDS ATTACKING THE FOLIAGE.

The well-known grape phylloxera [1] occurs in some localities upon grape foliage (fig. 27), but this species is not treated in this bulletin, since it is injurious principally to the roots and requires control

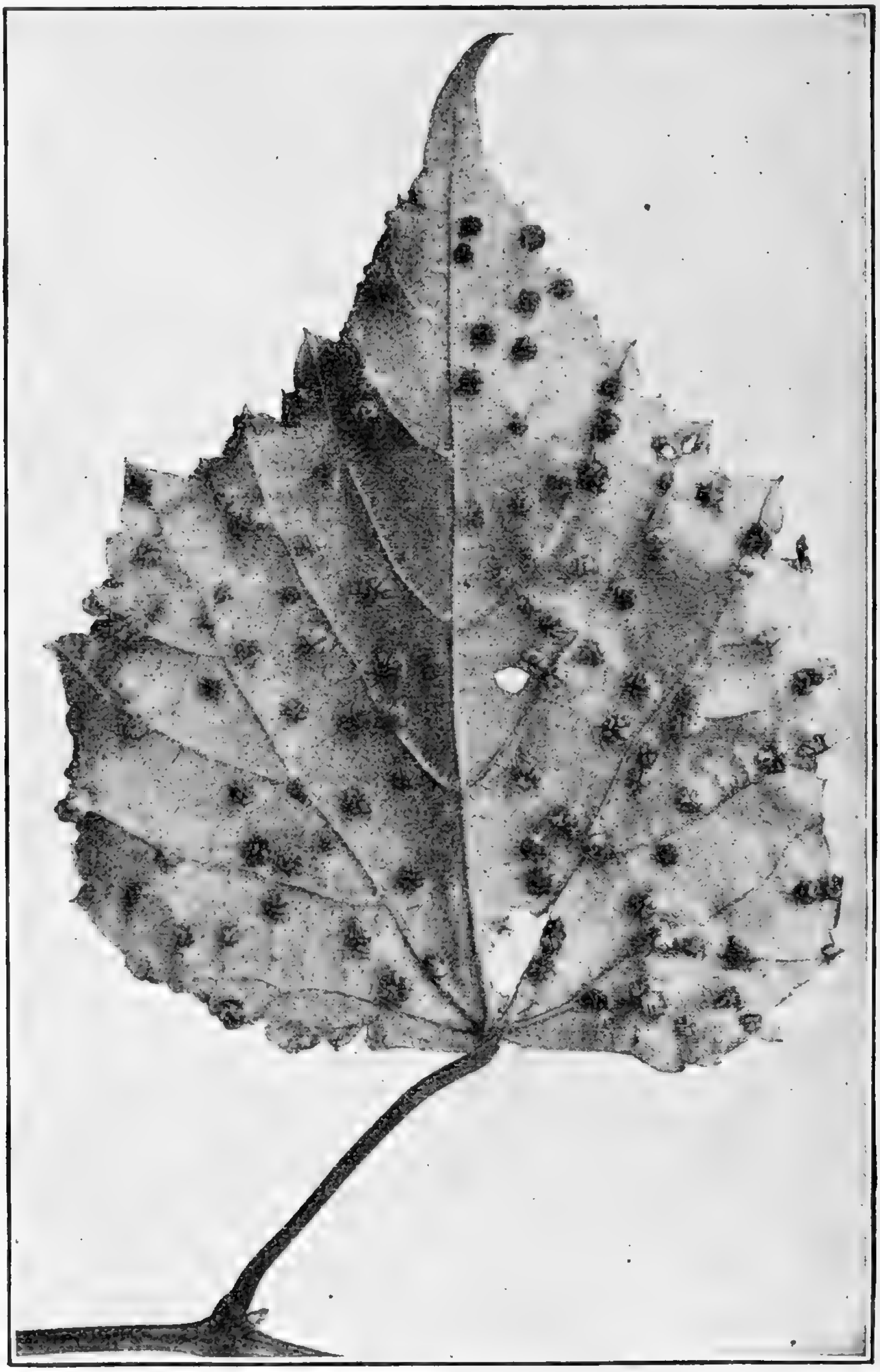

FIG. 27.—Galls of grape phylloxera on grape leaf.

measures radically different from those employed against foliage-inhabiting species.

THE GRAPEVINE APHIS.[2]

The grapevine aphis is very numerous in some localities, infesting the tender shoots and leaves (fig. 28) and sometimes the fruit clusters,

---

[1] *Phylloxera vitifoliae* (Fitch).

[2] *Aphis illinoisensis* Shimer.

causing the berries to drop. It can be distinguished easily from any other forms occurring on the grape by its large size and its dark-brown color.

SEASONAL HISTORY.

The eggs of this species are laid upon the twigs of the black haw.[1] Very early in the spring they begin hatching, but these first stem-mothers may be killed by frost. Six or eight weeks later the aphids of the second generation mature, and these nearly all become winged. These migrants fly to the grape and produce young upon the tender growing shoots, where in less than 10 days they are mature and producing young. Reproduction on the grape continues throughout the summer, and often more than a dozen generations may occur. In each generation winged forms are found and these carry the infestation to new vines. During October fall migrants are produced, which return to the haw trees and deposit the egg-laying females. When mature these are fertilized by the winged males which follow the fall migrants, and egg laying results.

FIG. 28.—The grapevine aphis: Colony on grape shoot.

NATURAL ENEMIES OF APHIDS.

Aphids are attacked by various species of parasitic and predacious insects and by fungous diseases, and these agencies exert a very important influence in their control. The combined effect of these several factors normally keeps the aphids pretty well reduced, but when for any reason their activities are lessened the aphids may increase enormously and do widespread injury. Heavy driving rains are believed to be inimical to aphids,

[1] *Viburnum prunifolium.*

whereas cool, cloudy weather seems to reduce the activities of the parasitic and predacious enemies, permitting the aphids to become correspondingly abundant.

Ladybird beetles (fig. 29) may be found in almost any colony of aphids, both the beetles and larvæ feeding freely on the insects. Numerous species of these beetles attack the aphids, and they should be protected and encouraged when possible.

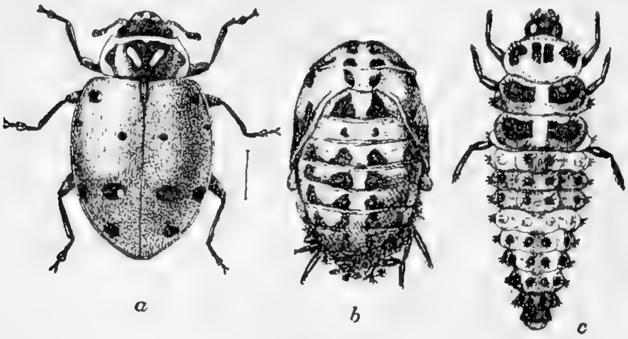

FIG. 29.—The convergent ladybird (*Hippodamia convergens*), an enemy of orchard aphids: *a*, Adult; *b*, pupa; *c*, larva. Enlarged. (Chittenden.)

Larvæ, or maggots, of syrphus flies, also called sweat flies (figs. 30 and 31), are very generally present in aphid colonies and are most important checks to their increase. The larvæ of two or three species of lacewing flies feed freely on aphids, although they are not so important as the insects mentioned above.

Probably the most important check to aphid increase, however, is the work of certain minute, four-winged flies which live parasitically on the aphids. These multiply very rapidly and under normal conditions are very effective. The bodies of parasitized aphids usually become enlarged, assume a more or less globular shape, and finally show the exit hole of the adult parasite. (Fig. 32.)

CONTROL MEASURES.

As previously stated, aphids feed upon plant juices which they obtain by means of a beak inserted into the plant tissues. Paris green, arsenate of lead, and other arsenicals, or stomach poisons, are therefore ineffective against these insects, and the so-called contact sprays, such as kerosene emulsion, soap washes, nicotine sprays, etc., must be employed. These sprays, to be effective, must come in contact with the bodies of the insects, and great thoroughness in spraying is necessary.

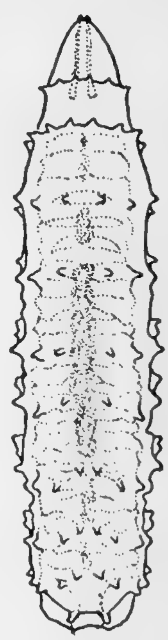

FIG. 30.—Larva of the syrphid fly *Allograpta obliqua*, an important enemy of aphids. Much enlarged. (Metcalf.)

Two principal plans of attack may be followed in the control of orchard aphids. Those species which winter in the egg stage on the plants to be protected may be treated with sprays early in the spring as the buds are expanding, to destroy the young stem-mothers. Treatment at this time assumes that without it the aphids would become injurious later in the season and is in the nature of insurance.

Following the other plan, spraying is not done until the insects actually have become troublesome, which does not occur as a rule until after the foliage is well out. With species that cause the leaves to curl this is too late to obtain much benefit from spraying. In view of the more or less irregular occurrence of aphids many growers will prefer to delay treatment until the insects actually are present on

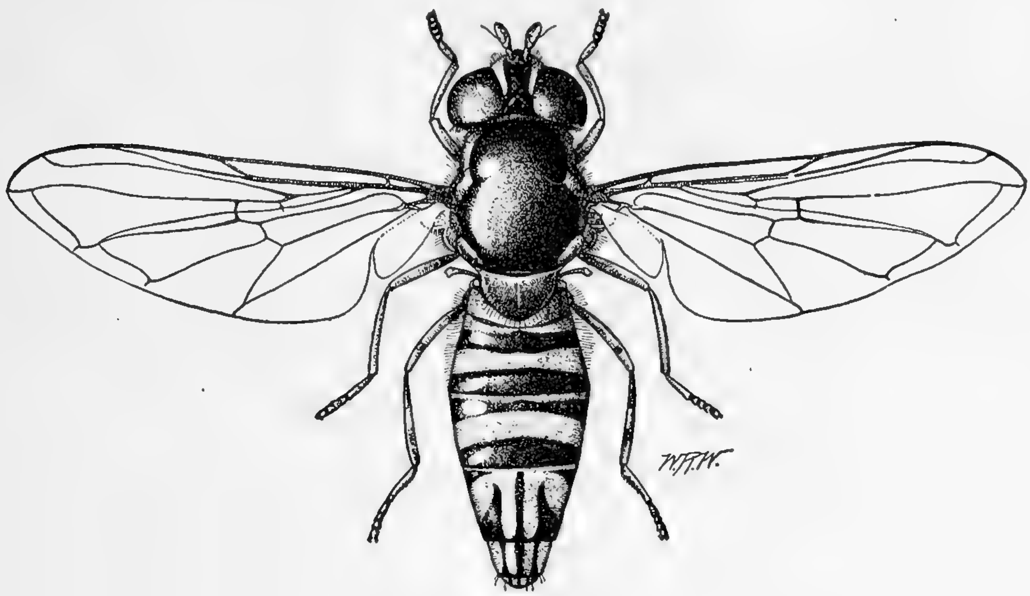

FIG. 31.—The adult syrphid fly *Allograpta obliqua.* Much enlarged. (Davis.)

the plants in destructive numbers, and in the case of those species which do not curl the leaves to any extent this plan will be satisfactory. Care should be taken, however, to treat the aphids promptly when they are found to be becoming abundant. It is a question for the grower to decide whether under his conditions danger of aphid injury, especially by the leaf-curling species, makes the bud application desirable or whether this danger is so small that he is warranted in taking chances on the insects becoming troublesome. Examination of the plants to determine the abundance of winter eggs and young stem-mothers on the opening buds should be of assistance in this connection, though abundant winter eggs are not always followed by aphid abundance, since many may succumb to unfavorable weather conditions.

INSECTICIDES.

INSECTICIDES MADE FROM TOBACCO.

Commercial Nicotine Solutions.

Aphids are killed by surprisingly small quantities of nicotine in water, and because of the entire safety with which it may be applied to plants nicotine is better suited than other sprays to control these insects. While the cost of the concentrated article is high, the extent to which it may be diluted makes the spray compare favorably in cost with other contact sprays. Nicotine is extracted from refuse tobacco, principally stems, by different commercial concerns, and is put on the market in several grades and strengths. The 40 per cent nicotine sulphate, containing 40 per cent of nicotine, is the solution principally used, although weaker grades of nicotine may be employed, provided care is taken that the spray be made so as to contain not less than 0.05 or 0.06 per cent of actual nicotine.

FIG. 32.—A colony of the black peach aphis on peach twig heavily infested by a species of parasitic four-winged fly. Enlarged.

Nicotine may be added either to the winter-strength lime-sulphur solution for the San Jose scale or to the dilute lime-sulphur solution and arsenate of lead spray employed in the control of insects and diseases of fruit and foliage. It may also be used in Bordeaux mixture and arsenate of lead spray without interfering with its effectiveness or in an arsenate of lead, milk of lime, and water spray. In orchard spraying the 40 per cent nicotine sulphate is used at the rate of about three-fourths of a pint to 100 gallons of water, lime-sulphur solution, or Bordeaux mixture. When used in water the addition of soap at the rate of 4 or 5 pounds to 100 gallons adds much to its spreading power and efficiency. *Soap should not be used with lime-sulphur solution, but may be used in Bordeaux mixture.* Where only a small quantity of spray is required the nicotine sulphate may be used at the rate of 1 teaspoonful to a gallon, or 1 ounce to 8 gallons of soapy water.

Homemade Nicotine Sprays.

Tobacco decoctions may be prepared readily at home, and, although varying somewhat in strength, will give as satisfactory results as the commercial products unless used too weak. The practicability of making the nicotine sprays will depend chiefly upon the availability and cost of the refuse tobacco. Tobacco stems, sweepings, and damaged tobacco are the most economical for this purpose and the dark types of tobacco, owing to their relatively high nicotine content, are preferable to light-colored tobacco. If a desirable type of refuse tobacco can be purchased at a reasonable price, the fruit grower can often make nicotine sprays profitably at home. The first cost of the tobacco waste is reduced, since, after the nicotine has been extracted, the tobacco still has a fertilizer value of about one-half its first cost.

The amount of refuse tobacco necessary to give a spray containing 0.05 or 9.06 per cent of nicotine will vary considerably, as will be noted in the following table adapted from a publication of the Virginia Agricultural Experiment Station,[1] which is given as a guide:

Formula for making nicotine extracts.

Kind of tobacco.	From—	Nicotine.	Number of pounds per 100 gallons necessary to make solutions containing different percentages of nicotine.	
		Per cent.	*0.06 per cent.*	*0.05 per cent.*
Light stems	Richmond, Va	0.481	145	121
Do	Danville, Va	.609	110	91
Sweepings	do	.884	74	62
N. L. Orinoco	Appomattox, Va	5.535	12¼	10⅓
Olive	Powhatan, Va	3.367	19½	16¼
Light	Danville, Va	2.984	22	18
Sweepings	Louisville, Ky	.753	91	85
Smoker	Chatham, Va	2.306	28¼	23½
Wrapper	do	3.05	21½	18
Cutter	do	3.466	19	15
Dark	Appomattox, Va	2.835	23¼	19¼
N. L. Orinoco	Bowling Green, Va	5.629	11¾	10
Medium smoker	Chatham, Va	3.766	17½	14½
Common smoker	do	2.47	26	21½

Since it is impracticable for the fruit grower to have the refuse tobacco chemically analyzed, he should approximate the class to which it belongs and use according to the foregoing table. The chief danger lies in making the solution too weak. If made stronger than necessary, no damage to the plant will result.

Methods of Making.

One of the most convenient as well as satisfactory methods of making nicotine sprays on the farm is by simply soaking the tobacco

[1] Ellett, W. B., and Grissom, J. Thomas. Preparation of nicotine extracts on the farm. Va. Agr. Exp. Sta. Bul. 208. 1914.

in the full quantity of water, with occasional stirrings, for a period of 24 hours. About 70 to 80 per cent of the nicotine will be extracted. After straining the tobacco solution to remove the particles of leaves and stems, it is ready for use.

The tobacco spray may also be made in a lime-sulphur plant equipped with steam. Place the proper amount of tobacco and water in the cooker and release the steam, and, as soon as the water reaches the boiling point, shut off the steam. As soon as the solution has cooled it is ready to use. By this method about the same percentage of nicotine is extracted as by the soaking process. The solution should never be boiled, as the nicotine is volatile.

Nicotine sprays should not be made up until they are to be used, since fermentation begins within two or three days, perhaps spoiling them for spraying purposes.

The homemade nicotine solutions, when prepared as above at the strengths indicated, will give control of most aphids. But as a matter of precaution it will be advisable to observe the effect of the spray upon the insects, and, if not effective, to strengthen it.

Tobacco Dust.

Tobacco dust has long been recommended for the control of the woolly apple aphis on the roots of the apple, and for other root-inhabiting insects, and to a less extent for dusting low-growing plants, as currants and gooseberries for the destruction of aphids.

Tobacco dust has some value as a treatment for the woolly aphis on the roots of the apple, its effectiveness varying much with the amount of nicotine in the dust and its fineness and the character of the weather. Abundant moisture in the soil, as from irrigation or rains, leaches out the nicotine, thus destroying the insects to a greater or less extent. Where tobacco dust may be obtained cheaply its use is warranted for the woolly aphis, but the purchaser should insure himself that the dust is not the grade sold for fertilizer purposes from which the nicotine has been extracted. In addition to its insecticidal value, tobacco dust has a distinct fertilizer value.

SOAP SPRAYS.

Sprays made from several kinds of soap are much used for the destruction of various soft-bodied sucking insects, particularly aphids, the pear psylla, certain plant-bugs, etc.

Commercial Fish-Oil Soaps.

The commercial fish-oil soap, formerly known under the trade name of "whale-oil soap," is usually made from fish oils combined with either caustic soda or potash and should contain not over 30 per cent of water. An average grade of a soda fish-oil soap should contain, in addition to the water, about 10 per cent of caustic soda, 58 per cent of fatty matter as anhydrides, and about 2 per cent of other matter. Soda fish-oil soap is generally of medium to hard consistency, whereas the potash soaps are much softer. They are brownish in color, with a distinct fishy odor.

For foliage sprays the fish-oil soap is dissolved at the rate of 1 pound in 3 to 4 gallons of water or at greater dilutions, depending upon the insects to be treated and the hardiness of the foliage. Soda soaps are fairly hard and usually require slicing and dissolving in hot water.

Fish-oil soaps may be used with the following spray materials to increase their spreading and adhesive qualities: Arsenate of lead, nicotine solutions, Bordeaux mixture, and sulphur. *Do not use soap in lime-sulphur solutions, or in waters containing compounds of lime and magnesium (hard waters).*

Homemade Fish-oil Soap.

A good fish-oil soap[1] may be made at ordinary summer temperatures without the aid of external heat according to the formula given below:

Caustic soda	pounds..	6
Water	gallon..	$\frac{1}{2}$
Fish oil	gallons..	$3\frac{1}{4}$

Thoroughly dissolve the caustic soda in the required amount of water. Then, while stirring constantly, add the fish oil very slowly and continue active stirring for about 20 minutes or until the soap is complete. The homemade fish-oil soaps may be used in about the same proportions as the commercial products.

Liquid Fish-oil Soap.

Commercial liquid fish-oil soap may be substituted for the harder fish-oil soaps. Apply according to the directions given for fish-oil soap, using 1 pint of the liquid soap in place of 1 pound of the hard soap. Liquid soaps are especially convenient in making oil emulsions.

Tobacco Fish-oil Soap.

Commercial fish-oil soaps containing a small percentage of nicotine are sold for insecticidal purposes. Soaps of this kind are somewhat expensive and their use is scarcely justified unless the nicotine is present in sufficient quantity to have distinct insecticidal value, namely, 0.05 to 0.06 per cent in the completed spray.

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[1] Van Slyke, L. L., and Urner, F. A. N. Y. Agr. Exp. Sta. (Geneva) Bul. 257. 1904.

QUASSIA AND FISH-OIL SOAP.

Quassia extracts are used for destroying certain sucking insects, especially the plum or hop aphis. Solutions containing quassiin are more effective when combined with soap, which serves as a spreader and "sticker." Various formulas with different amounts of quassia chips and soap have been used, depending upon the insects to be destroyed. The following formula gives a fairly strong spray solution:

Quassia chips	pounds..	$2\frac{1}{2}$, or	pound..	$\frac{1}{4}$
Fish-oil soap	do....	5, or	do....	$\frac{1}{2}$
Water	gallons..	50, or	gallons..	5

First dissolve the soap in a little hot water and pour into the container and then add sufficient water to make the total product equal to that given in the formula. Place the quassia chips (small chips are best) in cloth sacks and submerge in the soapy liquid for 24 hours. The soap aids in extracting the quassiin. Instead of soaking the chips as above, they may be boiled in the same amount of soapy water for 4 to 5 hours. In order to extract a large percentage of the quassiin the full amount of the water indicated in the formulas should be used. Fruit growers will find no particular advantage in using quassia chips over nicotine solutions or kerosene emulsion. Quassia chips are not readily obtainable and the homemade extract, owing to its somewhat variable strength, is not always dependable.

KEROSENE EMULSION.

Kerosene emulsion has long served as a standard spray for control of soft-bodied sucking insects. If well made and properly diluted kerosene emulsion will give satisfactory results. *It should never be combined with lime-sulphur.*

A good stock solution of kerosene emulsion containing 66 per cent of oil (by volume) may be made according to the following formula:

Kerosene (coal oil, lamp oil)	gallons..	2
Fish-oil or laundry soap (or 1 quart soft soap)	pound..	$\frac{1}{2}$
Water	gallon..	1

First dissolve the soap in boiling water; then remove the vessel from the fire. Immediately add the kerosene, and thoroughly agitate the mixture until a creamy solution results. The stock solution may be more conveniently made by pouring the mixture into the tank of a spray pump and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if properly made, should last for some time, but it is better to make it up as needed. Do not dilute until ready to use. To make a 10 per cent spray (the strength for trees in foliage) add, for each gallon of the stock solution, about $5\frac{2}{3}$ gallons of water. Agitate the mixture in all cases after adding the water.

The preparation of the emulsion may be simplified by the use of a naphtha soap. No heat will be required, as the kerosene will combine readily with the naphtha soap in water, when thoroughly agitated. If naphtha soap is used, twice as much will be required as is given for the other kinds of soap in the foregoing formula, and soft or rain water should be used in making the emulsion. In regions where the water is "hard" this should first be "broken" with a little carbonate of soda, or common lye, before use for dilution, to prevent the soap from combining with the lime or magnesia present, thus liberating some of the kerosene; or rain water may be employed.

SPRAYING FOR APPLE APHIDS.

Experiments made by the Bureau of Entomology and several of the agricultural experiment stations, notably those of Colorado and Oregon and the Geneva, N. Y., station, show that the aphids attacking the fruit and foliage of the apple are best controlled by spraying in the early spring just as the buds are breaking to destroy the stem-mothers. At this time the insects are hatching from the winter eggs, and are so exposed that one thorough treatment should destroy from 95 to 98 per cent of them and prevent their increase to such an extent that they will not cause serious injury later in the season. This applies especially to the oat aphis, the rosy aphis, and the clover aphis.

THE DELAYED DORMANT TREATMENT.

The plan is to delay the application of the winter-strength lime-sulphur solution until the buds begin to show green, and, by the addition to the spray of tobacco extract or nicotine, effect a combination treatment for the San Jose scale[1] and the aphids. Principally nicotine sulphate, containing 40 per cent nicotine, is used at the rate of ¾ pint to 100 gallons of lime-sulphur spray. The nicotine destroys the hatched aphids that are hit with the spray, while the lime-sulphur, in addition to controlling the scale, is thought to destroy a large proportion of the eggs of the aphids on the trees, should any be still unhatched.

In orchards badly infested with the scale it is doubtful whether the grower should take chances with the delayed dormant treatment, especially in large orchards where the spraying takes considerable time. Unfavorable weather or other conditions may so delay spraying operations that the foliage will develop to such an extent that the use of dormant-strength lime-sulphur would endanger the leaves. Such late spraying, furthermore, would not be as effective as desirable in destroying the aphids, since most of these would be more or less protected by the foliage or would have penetrated the expanding shoots.

[1] *Aspidiotus perniciosus* (Comst.)

Figure 33 illustrates an apple bud with aphids clustered on it in about the right condition for the delayed dormant treatment. Figure 34 shows an apple bud with leaves so far out that the aphids are pretty well protected between the leaves, and the delayed dormant application would not be very effective in killing the aphids, and might cause some foliage injury.

In the case of the green apple aphis, which lives on the apple throughout the year, the suppression of stem-mothers in the spring

FIG. 33.—Young stem-mothers of an apple aphid and condition of buds when the bud spraying should be given. Enlarged.

does not always guarantee freedom from this insect during midsummer, and supplementary treatments sometimes are desirable. In the case of young orchards, where the green apple aphis is principally to be considered, the bud spray should be given, but additional applications should be made in summer if found necessary.

Spraying in the fall for the destruction of the fall migrants and the egg-laying females has been tried to a limited extent, but the adequacy of the treatment has not yet been proven.

Annual bud spraying of apple orchards would appear to be good practice, and over a series of years would no doubt prove profitable.

This is especially true of varieties subject to "fruit spots" or "stigmonose," since these troubles have been shown by the Bureaus of Plant Industry and Entomology to be due, in part at least, to the activities of aphids.

CONTROL OF APHIDS ON PLUM, PEACH, CHERRY, ETC.

The several aphids which occur on plum, as well as the green peach aphis, pass the winter on the trees in the egg stage, hatching in the spring about the time when foliage appears. None of these species curls the foliage to the same extent as do some of the apple aphids, and thorough spraying of the trees when the insects are in evidence usually will be satisfactory. Nevertheless spring spraying against the stem-mothers is desirable in orchards where the insects have been troublesome regularly or where winter eggs are seen to be present in numbers.

FIG. 34.—Young apple shoot too far expanded for successful aphid spraying. Enlarged.

The black peach aphis, which winters on the roots of the peach, should be treated as soon as the insects are observed to be present on the foliage and twigs, and in regions where they are likely to be troublesome, as on nursery stock in sandy situations, careful watch should be made for their first appearance.

The black cherry aphis is likely to be in evidence each year on cherries. The insect winters on the trees in the egg stage and the eggs hatch somewhat in advance of the opening of the buds. Since this species causes a decided curling of foliage so that later treatments are not satisfactory, the effort should be made to destroy the stem-mothers as the buds are breaking.

CONTROL OF APHIDS ON CURRANT, GOOSEBERRY, AND GRAPE.

All of the important aphids attacking the currant and gooseberry pass the winter on these plants in the egg stage, the stem-mothers hatching as the leaf buds are opening and soon causing the leaves to become more or less pitted or curled. It is especially important, therefore, to spray as the shoots are pushing out, to destroy the stem-mothers before they are protected by the distorted foliage. In spraying for these insects later in the season the liquid should be directed upward to wet the insects on the underside of the leaves.

The grapevine aphis, while often abundant on the terminal growth, is rarely very injurious. It is much subject to parasitic and predatory enemies, and migrates from the grape to Viburnum in early fall. When so abundant as to require treatment, any of the contact insecticides may be used.

CLEAN CULTURE.

As the reader will have learned, most aphids have a winter and early spring host plant, and from this they migrate to other plants, on which they subsist for several weeks or months during the summer.

In most instances this alternation of food plants is essential to the life of the species, and in general the aphids are most troublesome in regions where alternate hosts are present in abundance. Often one or more of the host plants are of little or no economic importance in the locality, and in some cases are troublesome weeds. The destruction of worthless plants is desirable and should serve materially to reduce the aphids in question. Thus, in the case of the rosy aphis, the alternate food plants of which are species of plantain, the destruction of these in and about orchards is especially desirable, and should be a part of the remedial work against this pest in localities where it is more or less chronically injurious.

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GRASSHOPPER CONTROL IN THE PACIFIC STATES

T. D. URBAHNS

Entomological Assistant, Cereal and Forage Insect Investigations

FARMERS' BULLETIN 1140

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

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THE SEVERE grasshopper infestations of recent years have made it urgently necessary to put before the farming population in many communities the most practical and efficient methods of destroying these pests. In the Pacific Coast States conditions are such that the grasshoppers are able to develop in the immense uncultivated areas and migrate to the irrigated districts, attacking the cultivated crops and doing extensive damage.

The use of the hopperdozer, the use of fire, the destruction of the eggs in the soil, driving the wingless species and nymphs into pits, and the use of poisoned bran mixture are some of the control measures that have proved efficient under western conditions. The most successful of these has been the poisoned bran mixture, which is discussed in detail on pages 8 to 11.

The following pages also outline a program for organized community action; describe the common species of grasshoppers; and discuss control on the ranges, in alfalfa fields, in orchards, vineyards, and mountain meadows, and in corn, grain, and bean fields.

GRASSHOPPER CONTROL IN THE PACIFIC STATES [1]

CONTENTS.

GRASSHOPPER OUTBREAKS.

The natural conditions over the Western States are such that grasshopper outbreaks may be expected for many years to come, as the immense uncultivated areas of mountains, foothills, grass lands, and alfalfa fields offer many varying conditions favorable to the abundant development of one or more of the destructive species involved. The earliest outbreaks occur on the warm, sunny, dry lands and foothills. These are followed by later outbreaks appearing on the cool, damp valley soils. The nymphs appear in greatest abundance wherever the adults have massed and deposited eggs in large numbers the preceding year. This massing of grasshoppers is normal for some species, but may be influenced by the abundance of food plants or by the presence of conditions favorable to egg laying, such as dense crowns of bunch grasses, large alfalfa crowns, uncultivated gravel soils, and dry sunny hillsides.

The destructiveness of these outbreaks depends upon many factors. The early drying of range grasses in June of 1919 was in part responsible for the abundant migration in that year of destructive species to cultivated crops. Grasshopper migration from the foothills and range lands is not so marked when there is an abundance of spring rain and grasses continue green until weeds begin to grow.

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[1] The studies in regard to poisoning grasshoppers were extended to deciduous fruit orchards at the request of Dr. A. L. Quaintance, in charge of Deciduous Fruit Insect Investigations, Bureau of Entomology.

Immense swarms of grasshoppers are sometimes held on the uncultivated lands because of the presence of certain weeds which are natural food plants. Cutting meadow grasses or alfalfa on severely infested fields may cause the grasshoppers to migrate to other fields or orchards. A hot wind may cause sudden migration, while cool, dark weather frequently results in considerable inactivity on the part of these pests.

FAVORABLE AND UNFAVORABLE CONDITIONS.

Dry weather favors the development of young grasshoppers, provided they have the necessary green food, and the most severe outbreaks follow a succession of comparatively dry years. Grasshoppers usually deposit their eggs on knolls, ridges, or well-drained hillsides. In the Sacramento Valley of California grasshoppers also hatch in large numbers on grass lands which sometimes are flooded by a foot or more of water in early spring. A similar condition obtains in some of the valleys of the Sierra Nevada Mountains, where the meadows are flooded after the snows melt. Alternate freezing and thawing, or even severe drying after an early fall rain, appears to disturb many of the egg pods sufficiently to admit moisture and destroy the eggs. A heavy frost is fatal to many nymphs. Cloudy weather and cool rains are conditions unfavorable to their development.

FIG. 1.—The California devastating grasshopper.

SOME OF THE COMMON DESTRUCTIVE GRASSHOPPERS.

The California devastating grasshopper[1] (fig. 1) is yellowish brown in color, and has small dark spots on the wings. It measures about 1 inch in length. It breeds mostly on dry lands and dry alfalfa fields. The adults of this species are active in flight, and are very destructive to orchards, vineyards, alfalfa, gardens, and bean fields.

The differential grasshopper[2] (fig. 2) is a large species, measuring about $1\frac{1}{2}$ inches in length. In color it varies from yellow to rich

[1] *Melanoplus devastator* Scudder.

[2] *Melanoplus differentialis* Thomas.

brown, with dark markings on the legs. The wings are without distinctive markings. Some of the nymphs are almost green. It is very destructive in alfalfa fields, where it breeds in abundance, and also attacks adjoining orchards, gardens, or cornfields. This species is clumsy in flight and never migrates far.

The lesser migratory grasshopper[1] (fig. 3) is a yellowish or light brown species averaging about 1 inch in length. It breeds on waste areas and alfalfa fields, and is especially destructive to alfalfa, melons, beans, and corn.

Fig. 2.—The differential grasshopper.

The pellucid grasshopper[2] (fig. 4) is ashy brown with dark spots on the wings. A light yellowish form is sometimes present. This species breeds abundantly on grass lands, and is destructive to mountain meadows, corn, oats, beans, orchards, and gardens. It is active in flight and frequently appears in swarms.

The margined grasshopper[3] (fig. 5) is a small, dark-brown species, measuring slightly less than an inch in length, and normally is almost wingless. It breeds in alfalfa fields and foothills and attacks orchards, bean fields, and gardens.

The enigma grasshopper[4] (fig. 6) is a yellowish species about 1 inch in length. It has short wings and is awkward in flight. It breeds mostly on grass lands, and has proved very destructive to almond orchards, alfalfa, and bean fields.

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[1] *Melanoplus atlanis* Riley.
[2] *Camnula pellucida* Scudder.
[3] *Melanoplus marginatus* Scudder.
[4] *Oedaleus enigma* Scudder.

The foul grasshopper[1] is large and grayish, measuring about $1\frac{1}{2}$ inches in length, with dark wing markings. It breeds abundantly on dry hillsides and attacks almond orchards along the foothills.

The red-legged grasshopper[2] is a brownish species, measuring about three-fourths of an inch in length. It breeds on waste areas and attacks alfalfa, beans, and corn. It is most abundant in the higher mountain valleys.

FIG. 3.—The lesser migratory grasshopper.

COMMUNITY ACTION.

Grasshoppers frequently develop in great abundance on the uncultivated lands, where they can do comparatively little harm, and migrate into irrigated districts, where they feed upon valuable crops on intensively cultivated areas. The ranges, foothills, grassy meadows, and uncultivated alfalfa fields are favorite breeding places from which grasshoppers frequently migrate. Such migrations are

[1] *Dissosteira spurcata* Sauss.

[2] *Melanoplus femur-rubrum* DeGeer.

often so severe and sudden that communities must be organized and prepared to meet the attack in order to prevent destruction of their fields and orchards. Such work can best be accomplished by the farmers' organizations in the different localities.

The following outline is given as a helpful suggestion in organizing a community against the invasion by this pest: (1) A farmers' organization with energetic leaders; (2) the cooperation of county horticultural inspectors and farm advisers; (3) representation of the range and foothill landowners as well as those practicing intensive agriculture; (4) means of securing necessary funds for quick action; (5) a business man to locate and purchase supplies in large quantities; (6) the necessary legal advice for burning over waste areas and spreading poison on properties of nonresident and uninterested landowners; (7) reliable persons to supervise the preparation and spreading of the poison mixture; (8) definite days designated for the "grasshopper campaign," in order to cover the largest possible area at one time and thus prevent reinfestation of fields once cleaned up.

Fig. 4.—The pellucid grasshopper.

CONTROL METHODS.

The following control methods are based mostly upon the agricultural and climatic conditions prevailing over the area extending from southern Oregon through California, Nevada, and western Arizona. The methods advocated have been thoroughly tested over a period of five years and practised with excellent results on diversified farms, orchards, vineyards, and large ranches. The recurrence of serious losses to farm crops by grasshopper outbreaks can in most instances be prevented by diligent application, in due time, of the methods herein described.

There are many different methods by which grasshoppers may be fought. Some of these are: The use of the hopperdozer, destroying the eggs in the soil, the use of fire, driving the wingless species and nymphs into pits, and the use of poison in one of several attractive baits. These and other methods all have their use under certain particular conditions, and two or more of them can frequently be combined in a fight against this pest.

For general use the poisoned-bran mixture has given the most satisfactory results in grasshopper control, and this method is especially emphasized in the present discussion of the subject.

FIG. 5.—The margined grasshopper.

THE POISONED-BRAN MIXTURE.

PREPARATION OF THE MIXTURE.

The poisoned-bran mixture has given most satisfactory results in grasshopper control. When prepared it consists of a wet bran mash with sufficient poison to kill this pest, and flavored with molasses and lemon to render it most attractive. A slight variation with regard to the proportion of water required in the mixture may be necessary under varying climatic conditions. It should never be so wet that the liquid drains out. The poisoned-bran mixture apparently is most attractive while moist and fragrant with the odor of lemon and molasses, at least under California conditions, although it is taken freely by grasshoppers after drying for a day or more in the hot fields.

The following formula has proved most effective, and is recommended:

Paris green, or white arsenic	1 lb.
Molasses, cheap blackstrap	2 qts.
Lemons	½ doz.
Water ... about	4 gals.
Wheat bran, or alfalfa meal	25 lbs.

This amount should be sufficient to cover about 5 acres. The cost of these materials averages from 30 cents to 50 cents per acre.

The following articles (fig. 7) are necessary, or at least convenient, for mixing the poison:

Bucket for measuring water.
Shovel, or hoe, to stir the bran.
Tub in which to mix the liquids.
Small platform or mixing box.
Meat grinder to grind lemons.
Small scales for weighing poison.

Fig. 6.—The enigma grasshopper.

The molasses, Paris green, ground lemons, and water should be mixed in the tub and stirred thoroughly. Then slowly pour this solution over the bran in the mixing box and stir with a shovel until an even mixture is secured. It is sometimes preferable to mix the bran and Paris green dry, adding the water containing the molasses and lemon.

White arsenic may be used with good results as a substitute for Paris green, but does not mix so readily, and therefore requires much more prolonged and careful stirring to insure the best results. Alfalfa meal is a good substitute for bran, but does not spread as uniformly from a grain seeder as the coarse-flaked bran. Sour oranges and grapefruit may be used in place of the lemons.

WHEN TO POISON.

The spreading of poisoned bran should begin with the abundant appearance of small grasshoppers and before actual loss to the crops has occurred. Warm sunny days should be selected if possible, since the small nymphs feed very little when it is cool and cloudy. Hot and dry weather proves most satisfactory. The grasshopper eggs usually hatch later on cool, damp soils than on dry gravel ridges, and for this reason it is sometimes necessary to repeat the spreading of poison for the complete control of this pest. If the grasshoppers are found to spend the night under sod or clods and come out to feed in the morning, the best results are secured by spreading the poison early in the day before the grasshoppers begin moving about on the ground. On alfalfa fields, meadows, and dry-grass lands it usually is best to spread the poison in the afternoon of a hot day. Whenever the infestation is general the largest possible area should be covered in the shortest possible time to prevent reinfestation. Poisoning the grasshoppers late in the summer is of value in preventing eggs from being deposited in the soil.

SPREADING THE POISONED BRAN.

The poisoned bran mixture should be spread while it is wet, and within one day after it is prepared. It ferments rapidly in hot

FIG. 7.—Preparing the poisoned bran mixture.

weather if allowed to stand, and there is an increased danger of poisoning live stock if sacks of the prepared poison are kept around the yard. Along fence lines, narrow ditch banks, and rocky hillsides the mixture is most conveniently spread by hand from a bucket. It should be spread as finely as possible, lumps being avoided. Over orchards, alfalfa fields, and ranges it can best be spread with an end gate grain seeder (fig. 8).[1] The poisoned bran mixture is thrown into the hopper in small quantities with a paddle or small shovel, using slightly less than a sackful of the mixture over an area of 5 or 6 acres. When properly spread it is so thin that the bran can hardly be seen on the ground.

[1] The type of seeder useful for this purpose has a horizontal spreading wheel which throws the bran mixture out with considerable force.

RESULTS TO BE EXPECTED.

Under the most favorable conditions large numbers of grasshoppers have been killed as early as eight hours after the poison was spread in the fields, but usually the maximum number of dead hoppers will be noticed two or three days later. These may be found under clods or weeds and in the crowns of alfalfa plants. The poisoned grasshoppers are eaten by other grasshoppers, beetles, and ants, in which the poison is again effective.

DANGER OF POISONING LIVE STOCK.

After the poison has been finely and properly spread over the fields at the rate of 25 pounds of dry wheat bran to 5 acres, there

FIG. 8.—The end-gate grain seeder in use for spreading grasshopper poison.

is no danger of poisoning live stock. The danger lies in preparing and keeping this attractive mixture around the farmyard where poultry and live stock are present and might eat quantities of it; also in spreading it by handfuls or lumps over the field. It is advisable to keep poultry penned up for a few days after spreading the poison; or to feed them well in the morning if they are to run at large where the poison is being spread, so that they will not pick up too many of the poisoned grasshoppers.

DESTROYING EGGS BY CULTIVATION.

Grasshoppers deposit their eggs in the soil, frequently at the bases of plants with bushy crowns. The abdomen is worked into the soil to a depth of 1 or 2 inches (fig. 9). The eggs are deposited with a secretion which later dries and forms a waterproof protection for each egg mass. From 20 to 100 eggs may be deposited at one time. The egg pod or mass is completely sealed up before the abdomen is withdrawn from the ground.

Thoroughly cultivating and pulverizing the soil to a depth of 3 inches late in the fall will break many of these pods and expose the eggs to the action of the weather. Eggs thus exposed will mold with an abundance of moisture and will dry up if there is a lack of moisture. Alternate freezing and thawing of the exposed eggs aids greatly toward their destruction.

Spring cultivation, however, is of less value in destroying grasshopper eggs. Soil kept loose and pulverized throughout the summer is not selected by the grasshoppers as a place to deposit their eggs.

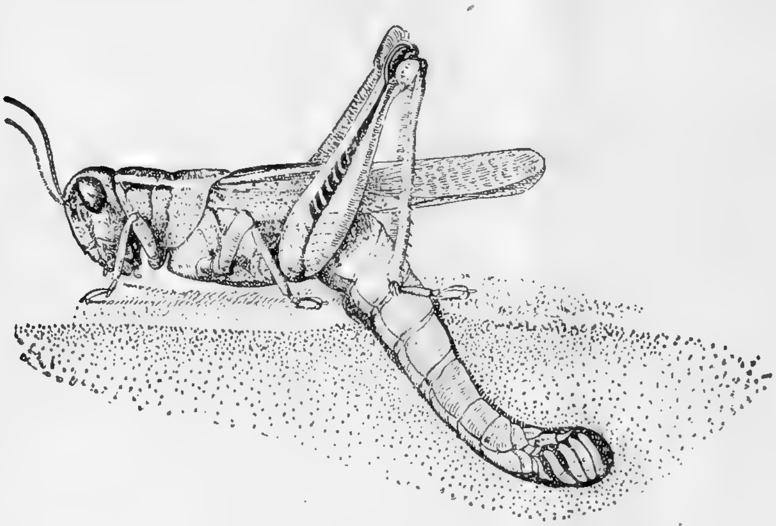

Fig. 9.—Grasshopper laying her eggs. (Webster.)

BURNING OVER DRY AREAS.

Fire has frequently been used with splendid success in connection with grasshopper control, and is practicable where the vegetation is dry and dense enough to produce a hot flame. These conditions frequently obtain in the regions to which this discussion particularly applies. The danger of fire can not be too highly emphasized, and every possible precaution should be taken to safeguard buildings, ranches, forests, and orchard trees. Burning over waste areas and fence lines during daylight frequently proves unsatisfactory because the flames drive the grasshoppers from the dry grasses into adjoining fields and orchards. Very few grasshoppers will escape the flames if the burning is done at night. Their migration from the ranges into farming communities frequently can be checked by burning over an area from 20 to 40 rods wide between the cultivated fields and the open range country.

USE OF TURKEYS.

Large flocks of turkeys are sometimes secured to feed upon and reduce the numbers of grasshoppers. Turkeys are of value in utilizing grasshoppers in such a way as to turn them into human food, and on outlying waste areas, where no expensive crops are in danger, this is a good practice. But grasshoppers abundantly infesting alfalfa fields, orchards, vineyards, or bean fields can seldom be satisfactorily controlled by this method. The turkeys feed for a short time and then rest. Their presence also interferes with other and more effective control measures.

CONTROL ON THE RANGES.

The earliest appearance of grasshoppers is usually on the gravel soils of the rolling range lands which are warmed by the first sunny spring days. Four or five species frequently appear as very small, wingless nymphs, hopping among the grasses. One species may be especially abundant in a certain locality and a different species most abundant just a few miles away. The nymphs feed upon the grasses and develop rapidly. Winged forms usually become abundant in May and June. By this time the grasses on the unirrigated areas and foothills of California usually mature and dry. It is at this time that the grasshoppers migrate to green fields and orchards in the irrigated districts. The most pronounced migrations from the ranges follow hot winds and rapid drying of range grasses. Every effort should then be made to control these pests. The poisoned bran mixture has been most effective, and may be used with good results at reasonable cost. Migration sometimes can be checked by burning over an area from 20 to 40 rods wide between the infested grass lands and the farming community. Sometimes the grasshoppers are especially abundant on certain sunny slopes, where they can be effectively poisoned. If the area of uncultivated country is too large to cover with poisoned bran, much can be accomplished by spreading the poison in strips with grain seeders, driving about 200 feet apart, and not attempting to cover the area completely.

It is sometimes possible to drive grasshoppers back from cultivated fields, and concentrate them for more effective poisoning, by herding sheep slowly back and forth, thus keeping the grasshoppers moving in the desired direction.

CONTROL IN ALFALFA FIELDS.

Alfalfa fields become infested from two principal sources. The early infestations usually come from waste areas and range lands when the migratory grasshoppers become active. This may be followed by the abundant hatching of one or two additional species on the cool soils of irrigated fields. *Melanoplus differentialis* Thomas, a large and most destructive grasshopper, greatly favors alfalfa as food, and deposits its eggs on the ridges, ditch banks, and fence lines. *M. marginatus* Scudder, a small, short-winged form, is also a destructive grasshopper, especially in California, seldom migrating far from alfalfa fields, where it breeds in abundance.

The poisoned bran mixture applied early in the season along edges of the field, and later over the entire field, has given excellent results. Lightly infested fields may be cut so as to leave strips, or lands, of standing alfalfa to attract and concentrate the grasshoppers. They can then be poisoned at a comparatively small cost. The grasshoppers usually roost on the alfalfa stems during warm nights, feed early, and descend to the ground as the heat of the sun becomes intense. They feed ravenously in the late afternoon following a hot day. The best results therefore are secured by spreading the poisoned bran mixture on fields with standing alfalfa in the afternoon of hot, dry days.

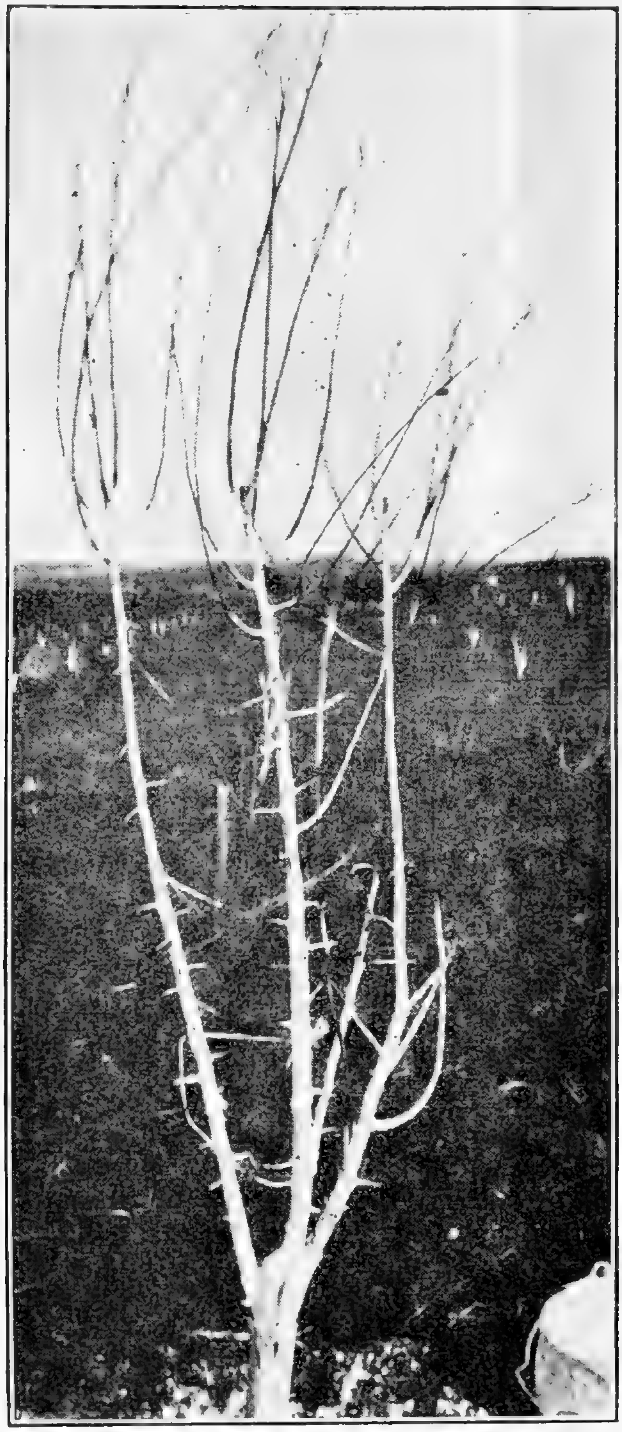

FIG. 10.—Grasshopper injury to fruit tree.

CONTROL IN ORCHARDS AND VINEYARDS.

Orchards (fig. 10) and vineyards suffering most severely from grasshopper attacks are those bordering on or within the radius of grasshopper migration from infested alfalfa fields, foothills, or waste areas. Grasshoppers do not deposit their eggs in the loose soil of carefully cultivated orchards. Uncultivated fence lines or roadsides may, however, be a source of infestation. Every effort should be made to poison the grasshoppers before they enter the trees or vines. If they are already present in the orchard, the poison should be spread over the ground and the grasshoppers shaken from the branches and kept moving so that they will find the poison. On the cultivated soils the grasshoppers frequently descend in the evening and spend the night under the warm clods. Best results are then secured by spreading the poison in the morning, since the grasshoppers again make their appearance with the first rays of the morning sun and will take the poison bran before entering the trees. The poison mixture never should be placed in small piles against the trees, since burning of the bark may result. Covering small trees with cheesecloth or burlap frequently is practised, but is useful only for temporary protection (fig. 11). Grasshoppers eat through the lighter material and girdle the tree where the cloth is tied, unless it is extended to the ground.

FIG. 11.—Part of an almond orchard. Small trees covered with cloth. The grasshoppers soon ate through the cloth and girdled many trees where the cloth was tied.

CONTROL IN MOUNTAIN MEADOWS.

Mountain meadows frequently become infested from the grassy slopes of surrounding hills and from low ridges, where the grasshoppers collect in the fall to deposit their eggs. The small grasshoppers appear in early summer and destroy the valuable meadow grasses. The poisoned bran mixture has given splendid results in destroying grasshoppers under these conditions, and in some sections has saved stockmen thousands of dollars' worth of fodder. The poisoning should begin when the nymphs appear in considerable numbers, and should be continued until late in the fall, even after the crops have been removed from the fields, if necessary. This later poisoning is to prevent the laying of eggs in the soil.

CONTROL IN CULTIVATED FIELDS.

Corn, grain, and bean fields frequently suffer severe injuries from grasshopper attacks. Such infestations usually come from uncultivated, waste areas and alfalfa fields, to which the grasshoppers frequently return for the night. The poisoned bran mixture should be spread over such adjoining waste areas, as well as on the fields where the crops are injured. On the cultivated fields it is well to spread the poison during the morning hours, when the grasshoppers are coming in.

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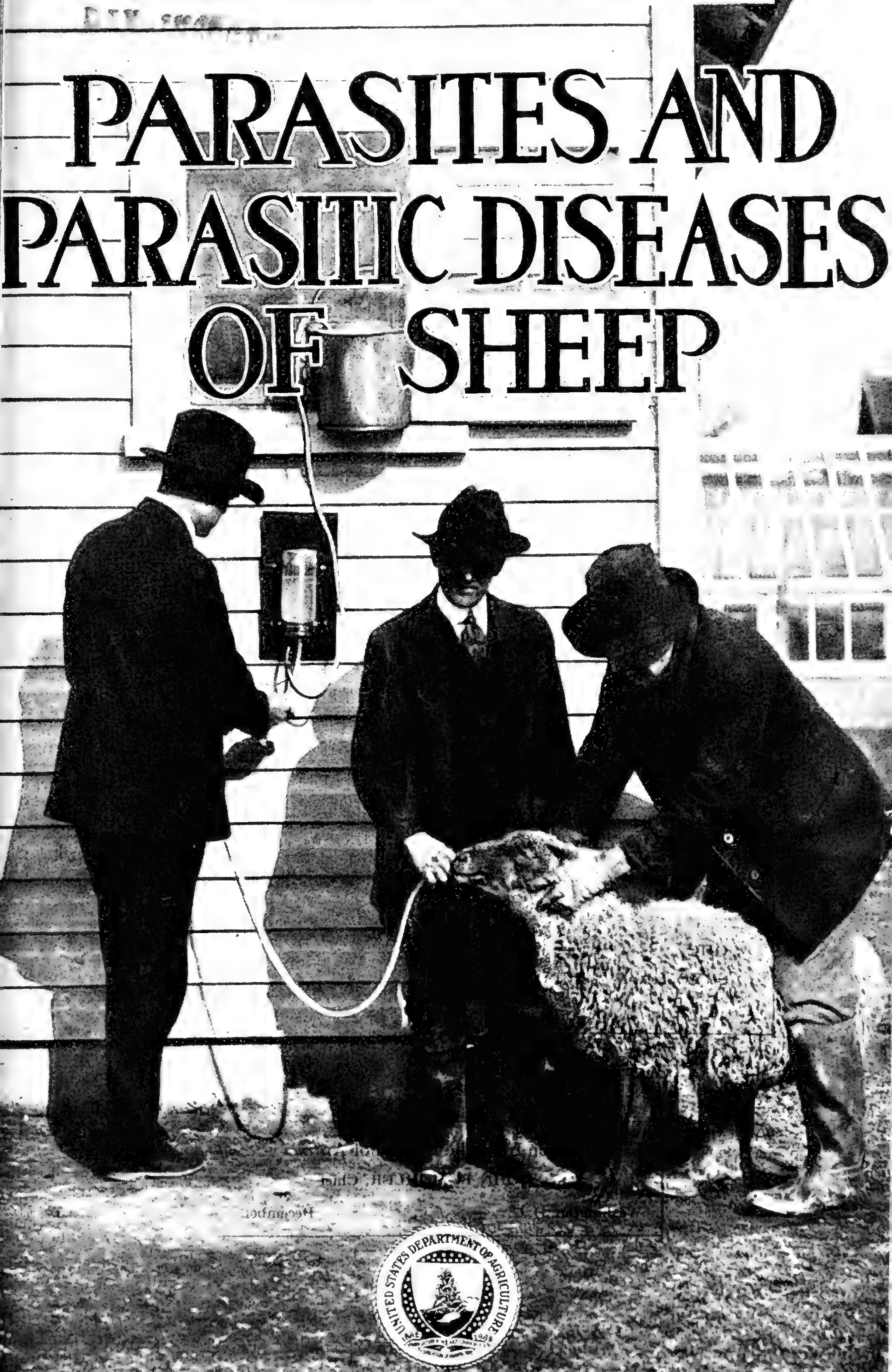
FARMERS' BULLETIN 1150
UNITED STATES DEPARTMENT OF AGRICULTURE

PARASITES AND PARASITIC DISEASES OF SHEEP



SHEEP PROBABLY SUFFER more from parasites than do any other kind of livestock.

Most of our loss in sheep, mutton, and wool is from animal parasites, as sheep suffer comparatively little from bacterial diseases.

Lambs and young animals are most susceptible to parasites and suffer most from them.

It is the sheepman's business to *prevent* disease. When disease is present it is advisable to call in a competent veterinarian.

Pasture rotation, use of forage crops, feeding from racks or bare floors, draining or filling swamps, and restraint of wandering dogs are measures of value in parasite control. *Permanent pastures perpetuate parasites!*

Parasite eggs pass in the manure, usually. The disposal of the manure determines the fate of these eggs.

Parasitized animals usually do not have fever; they are unthrifty. This unthriftiness may have a fatal termination.

Act promptly to ascertain the trouble when sheep become unthrifty. A post-mortem examination of one of the sick animals may disclose the trouble and save the others.

Contribution from the Bureau of Animal Industry
JOHN R. MOHLER, Chief

Washington, D. C. December, 1920

PARASITES AND PARASITIC DISEASES OF SHEEP.

Maurice C. Hall, *Zoological Division.*

CONTENTS.

LIABILITY OF SHEEP TO PARASITIC DISEASES.

SHEEP are very liable to attack by parasites, probably suffering more severely from this cause than any other kind of livestock. The importance of parasites and parasitic diseases of sheep is the more evident because of the fact that sheep are but little subject to serious bacterial plagues or virus diseases. They are practically immune from tuberculosis, which is one of the serious conditions in cattle and swine, and among sheep there is nothing comparable to the devastating outbreaks of hog cholera among swine. Occasionally a virulent strain of the bacillus producing lip-and-leg ulcer will spread under favorable conditions and necessitate the treatment of entire flocks, or individual sheep will die of pneumonia or other bacterial diseases, but the steady loss of sheep, mutton, and wool from disease in this country is due mostly to parasites.

The damage from parasites is greatest as a rule among lambs and young animals. The young tissues seem less resistant and more intolerant of injury and the more sensitive nervous system breaks down more quickly under the influence of parasitic injury and poisoning from the excretions and secretions of parasites. It also seems to be fairly well established that in general young animals are more easily infected by parasites than older ones, although very old sheep sometimes appear to acquire an increased susceptibility to infection. Hence it is important in undertaking to prevent infestation with parasites to pay especial attention to the care and handling of lambs and yearlings.

IMPORTANT PREVENTIVE MEASURES.

The use of measures intended to prevent sheep from becoming infested with parasites is especially the function of the sheepman. When sheep become diseased, the niceties of diagnosis and the administration of drugs are well within the province of the veterinarian. Errors in diagnosis by unskilled persons waste valuable time and lead to useless or injurious measures. Drugs intended to kill parasites are from the nature of things usually very potent, and are commonly poisonous substances capable of doing much damage in the hands of unskilled or careless persons; therefore, it is usually advisable to secure the services of a competent veterinarian whenever there is an outbreak of disease and a good veterinarian is available. In places where there are no qualified veterinarians available, the farmer or stockman must use his own judgment in determining whether he can recognize the trouble and administer the remedy.

One of the most important preventive measures in keeping flocks free from parasites is based on the fact that many of the sheep parasites live in the digestive tract of the sheep or in organs in communication with the digestive tract, so that the eggs or young worms pass out in the manure and thus infect the pastures. The fact that sheep manure carries worm infestation is the basis of such preventive measures as pasture rotation, rotation of different kinds of stock on the same pasture, feeding from racks or board floors, use of bare lots for nursing lambs, etc.

Another important preventive measure is based on the fact that many parasites which do not get back to the sheep from a pasture infected with sheep manure are carried back to the sheep by dogs. The fact that the dog which feeds on uncooked sheep meat or viscera may become infested with worms that produce eggs which pass out on to the pastures and may then infect the sheep, is the reason for keeping sheep dogs and other dogs on the farm free from worms and related parasites and for insisting that stray dogs must not wander over pastures and fields under penalty of being shot. Another preventive measure is based on the fact that diseases like scab are transmitted by contact with infected animals and places, and clean flocks must be protected from unsafe contacts.

In a general way, the presence of parasites may be suspected as the cause of disease where there is little or no fever, the animals losing condition and becoming thin and commonly having a diarrhea or being constipated. Other features may be associated with certain parasites. Bloodsucking parasites produce anemia, the blood becoming thin and pale as a result of having too few red blood corpuscles for the amount of serum present. Often there is associated with this an edema, in which fluid accumulates in the pendant or lower portions of the body; this is especially prominent in stomach-worm infestation in sheep, the fluid accumulating under the lower jaw and giving rise to the so-called "bottle jaw."

In this connection, the advisability of finding out promptly the cause of the trouble when sheep become diseased should be emphasized. Curtice has stated the case as follows:

> The sheep owner who discovers weakness among his lambs should not wait until one of them dies before he endeavors to make a diagnosis, but should undertake to diagnose the disease in the earlier stages by sacrificing one or more of the worst affected, and thus gain time in treating and preventing the extension of the disease. By waiting for the disease to develop he allows the lambs to grow poorer and weaker, and when action is finally undertaken it is upon patients which are, in many cases, already too weak to stand vigorous treatment and which in no way profit by preventive measures as they should.

EXTERNAL PARASITES.

External parasites are those which live on the exterior of another animal called the host animal, that is, on the skin or in the layers of the skin or in the hair follicles. Internal parasites are those which live in the body tissues or cavities of the animal that serves as a host.

The external parasites of sheep are all arthropods, or animals having 6 or more legs, some of them being insects, which have 6 legs in the adult stage, others, such as mites and ticks, being more closely related to the spiders and possessing 8 legs in the adult stage. Some of these parasites spend their lives on the sheep; this is true of the scab mites and the lice. These are the important forms. Others, such as various kinds of biting flies, attack sheep occasionally but spend much of their lives off the sheep.

LICE.[1]

Location.—Lice live on the skin of sheep, crawling about on the wool or hair from place to place and clinging to the wool fibers or hairs in feeding. The sucking body louse (*Hæmatopinus ovillus*) is commonly found in colonies on various parts of the body, including the face. The foot louse (*Linognathus pedalis*) is usually found on the lower portions of the legs, below the true wool and in the short, coarse hair. The biting louse (*Trichodectes ovis*) occurs on various parts of the body.

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[1] *Hæmatopinus ovillus, Linognathus pedalis, Trichodectes ovis* (=*Tr. sphærocephalus*).

Appearance.—The sucking body louse has a head somewhat longer than the thorax (fig. 1). The abdominal segments bear two rows of long hairs. The male is 2.1 millimeters (about one-twelfth of an inch) long and the female is 2.8 mm. (about one-tenth of an inch) long. There is an inconspicuous eye on each side of the head. The wool in the region attacked by this louse is usually discolored and contains numerous brown particles, the fecal deposits of the lice.

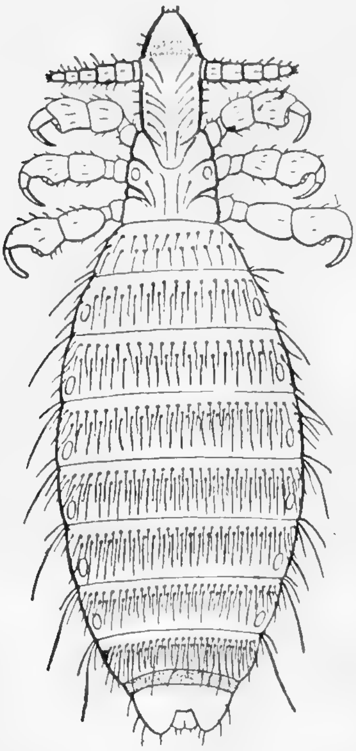

FIG. 1.—Sucking body louse (*Hæmatopinus ovillus*). Female, back view: Highly magnified. (From Neumann, 1907.)

The foot louse has a short head, as wide as it is long, which merges into the thorax, with reddish oblique bands on each side (fig. 2). No eyes are present. The abdominal segments bear two rows of hairs, of which those at the lateral margin are longer than the others. The female is 2.2 mm. (about one-twelfth of an inch) long and 1 mm. (one-twenty-fifth of an inch) wide; the male is broader and flatter. This is a sucking louse like the preceding species.

The biting louse has a head that is wider than long, with a broad, round anterior end (fig. 3). The abdominal segments show a median dark line and have only a single row of hairs. The male is 1.4 mm. (about one-twentieth of an inch) long and the female is 1.6 mm. long.

Life history.—The eggs of the various species of sheep lice are attached to the hair or wool in the sites customarily infested by the adult lice. The eggs of the sucking lice are said to hatch in 10 to 18 days; those of the biting lice in 5 to 8 days ordinarily, or 10 days in cold weather. Available evidence indicates that the young lice become mature and begin laying eggs in the course of about two weeks after hatching. The sucking lice, as the name implies, are bloodsuckers. The biting lice feed on the epithelial scales and other material on the surface of the skin. Lice usually cause little trouble in summer, but become more numerous and annoying in winter.

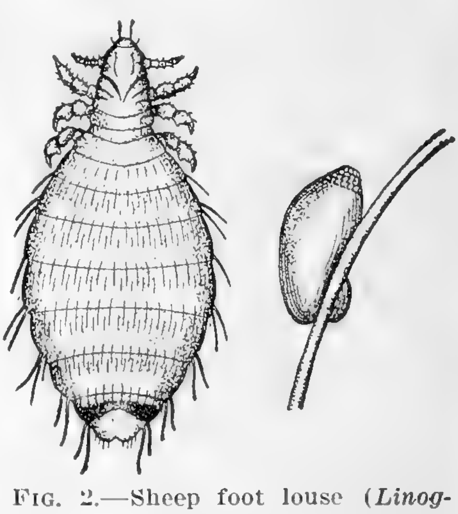

FIG. 2.—Sheep foot louse (*Linognathus pedalis*). Adult female and egg, enlarged. (From Osborn, 1896.)

Distribution.—Biting lice are rather common in the United States. The sucking body louse is fairly common on sheep in the Southwest. The foot louse has been found on sheep in various parts of the country.

Symptoms and lesions.—Lice, whether biting lice or sucking lice, cause itching and irritation. This of itself interferes with nutrition, and affected animals fail to fatten or keep in condition as they should. Moreover, the itching leads to scratching, with a resultant loss of wool, and this scratching adds more time lost from feeding to that lost from discomfort. Scratching may also cause cuts and bruises. The loss of nervous energy and the interference with feeding and nutrition tend to stunt the growth of young animals, interfere with the fattening of the entire flock, and predispose to other diseases by lowering the vitality. Actual lesions in the form of sores are caused where numerous biting lice cluster. The sucking lice abstract blood and lymph in considerable quantities where the lice are numerous. Finally, the excreta of the lice soil the wool, sometimes to a considerable extent; this is particularly true of the sucking body louse.

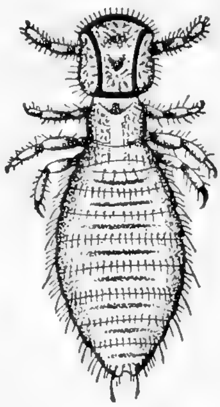

FIG. 3.—Sheep louse (*Trichodectes ovis*). Adult female, enlarged. (After Neumann, 1892.)

Lice are readily found on infested animals by examining them carefully, preferably in direct sunlight.

Treatment.—Where sheep are infested with biting lice only, sodium fluorid may be applied in the form of a powder to get rid of them, a single application sufficing for this purpose. The powder is rubbed into the skin at a number of places so as to insure a good distribution. It is of no value against sucking lice.

For sucking lice it is necessary to use a contact poison, and these poisons are also satisfactory for biting lice. In cold weather, where dipping is inadvisable, insect powders, composed largely of pyrethrum and naphthalene, may be used as a control measure and will serve to control the lice, but are not satisfactory in eradicating them.

For dipping, the substances which have been found effective in field tests are coal-tar creosote, cresol, arsenical dip, and 0.07 per cent nicotin solution with 2 per cent flowers of sulphur. To eradicate lice it is usually necessary to dip at least twice, with an interval of 14 to 16 days between dippings, in order to kill the lice that hatch out after dipping, since these dips can not be depended upon to kill all the eggs or "nits." Spraying is generally unsatisfactory as a method of applying dips to sheep, as it is too difficult to wet the wool.

Sheep should be handled carefully, not roughly. Dip the bucks, ewes, and lambs separately. The sheep should be fed and watered from 3 to 6 hours before dipping, in order that they may not be hungry or thirsty and yet not gorged with food. In hot weather they should be cooled off before dipping, and when the nights are cold they should be dipped in time to dry off before night. Ten days should elapse after shearing before dipping, in order that cuts may heal, especially when arsenical dips are used. Because of their extremely poisonous nature it is usually inadvisable to use arsenical dips in treating sheep.

Prevention.—To prevent infestation with lice it is essential that contact with lousy animals be prevented and that animals free from lice be kept out of sheds, pens, inclosures, or pastures where lousy stock has been present within three weeks. After the first dipping, sheep should be put on clean pastures or held in clean inclosures to allow time for any eggs to hatch and the lice to die, or else the sheds and lots should be thoroughly cleaned out and disinfected before using them. For this sort of disinfection the coal-tar dips in double the strength used for dipping are satisfactory.

THE SHEEP TICK.[2]

Location.—The sheep tick occurs in the wool and on the skin.

Appearance.—The sheep tick is not really a tick, but is a kind of wingless fly (fig. 4). It has 6 legs, whereas the full-grown true ticks have 8 legs. The mouth parts are very similar to those of other flies. These insects are reddish or gray-brown in color, and are about a quarter of an inch long on an average, and may therefore be easily distinguished from the lice. They are distinctly divided into head, thorax, and abdomen, which distinguishes them from the true ticks, which are occasionally found on sheep, as these true ticks have the thorax and abdomen fused. with the head not conspicuously distinct.

Life history.—The egg of the sheep tick is not laid as such, but is retained in the body of the female until it develops into a larva or pupa, which occurs in about seven days. The pupa is then deposited by the tick and is attached to the wool of the sheep by a gluelike substance. When deposited it is covered with a soft, white membrane, which becomes brown and hard in about 12 hours. The pupæ of the sheep tick are commonly called eggs. The young ticks emerge from the pupal stage in 19 to 24 days, the shorter time being in warm weather and the longer in cold weather. The tick is almost full-grown when it leaves the pupal case and it becomes mature in 3 to 4 days. After copulation the female may deposit its first pupa in 8 to 10 days.

[2] *Melophagus ovinus.* For additional information see Farmers' Bulletin 798 on "The Sheep Tick."

Distribution.—Sheep ticks are widely distributed over the world and are common in the United States on both farms and ranges. Where dipping of range sheep for scab has been practiced it has kept down the sheep tick, but where it has ceased sheep ticks have become very prevalent. They are most common on coarse-wool and medium-wool sheep, and prefer the neck, breast, shoulders, belly, and thighs.

Symptoms and lesions.—The damage done by the sheep tick is of two kinds. It is a bloodsucker, thus causing great irritation, loss of blood, interference with feeding, and consequently poor nutrition and reduced vitality. It lives in the wool and lowers the value of the wool by soiling it with the excreta and with the pupal cases. The loss caused is in addition to the wool deterioration which results from the injury to the sheep itself. The ticks may be easily found on parting the wool. Their presence may be suspected when sheep bite, scratch, or rub, and show a ragged fleece as a result.

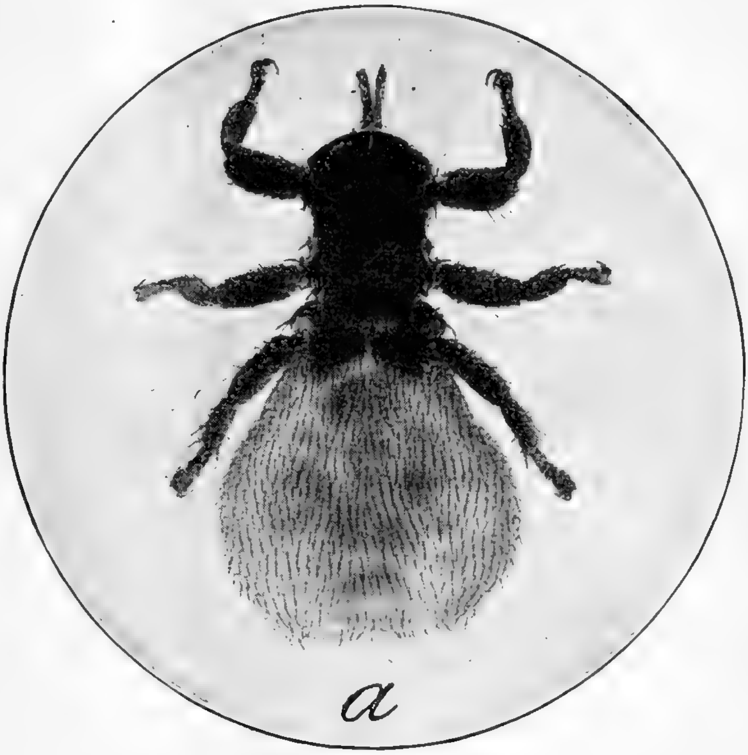

FIG. 4.—Sheep tick (*Melophagus ovinus*). Engorged female, enlarged. (From Imes, 1917.)

Treatment.—The treatment for ticks is dipping. The coal-tar creosote, cresol, nicotin, and the lime-sulphur-arsenic dips are all satisfactory, but dips containing arsenic are not desirable for sheep. Dip twice at a 24- to 28-day interval.

Prevention.—All places which have been occupied by ticky sheep should be regarded as dangerous from this standpoint for a period of two months, as the pupæ may retain their vitality under certain conditions for almost this length of time. Usually pupæ remain in the wool, but wool containing pupæ may be rubbed off or pulled off and young ticks hatching from such pupæ may afterwards get on sheep. If inclosures are to be used for clean sheep within this period they should be thoroughly cleaned and the litter and manure disposed of in such a way that sheep can not come into contact with them until after the lapse of the 60-day period. A strong solution of coal-tar dip should also be used, but this can not be depended on to kill the pupæ, though it is useful in killing the ticks that might escape a cleaning process. To disinfect stone or wire-fence corrals, brush or straw may be scattered over the surface of the ground and burned. Clean sheep must be kept away from contact with ticky sheep and care must be taken to see that goats or other animals do not convey ticks to the sheep. Even persons may occasionally carry ticks for a short time in their clothing, and this must be kept in mind at shearing time and whenever there is danger of infection from persons who travel from one flock of sheep to another.

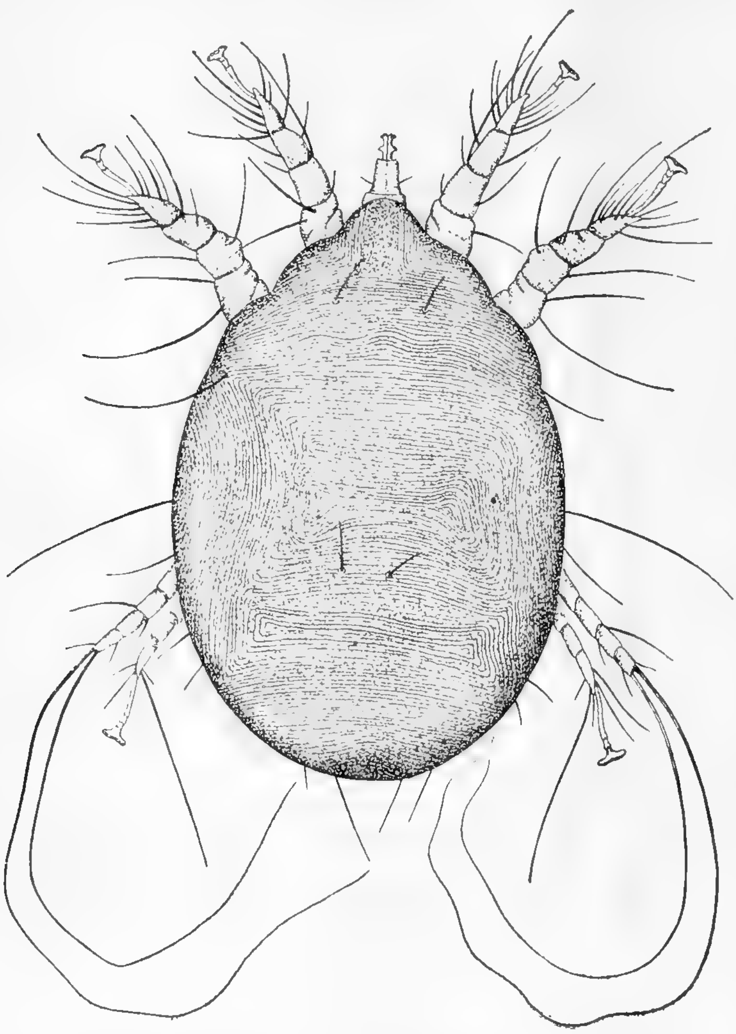

Fig. 5.—Sheep-scab mite (*Psoroptes communis ovis*). Female. Back view, greatly enlarged. (After Salmon and Stiles, 1898.)

SHEEP-SCAB MITE.[3]

Location.—On the skin.

Appearance.—These parasites are very small animals, commonly called scab mites (fig. 5). The male is only 0.5 mm. (one-fiftieth of an inch) long and the female 0.625 mm. (one-fortieth of an inch), but they may be seen with the naked eye as small white objects, especially when placed on a dark background. It is easier to see them when they are warmed, by sunlight or otherwise, on such a background, as they may then be seen in motion. The full-grown mites have 4 pairs of legs and these legs have long hairs. In the female there is a so-called sucker on a jointed stalk on the tip of the first, second, and fourth pairs of legs, and in the male on the first, second, and third, the fourth pair in the male having a sucker which is not on a jointed stalk.

[3] *Psoroptes communis ovis.* For additional information see Farmers' Bulletin 713 on "Sheep Scab."

Life history.—The female mite usually deposits at least 15 eggs during her life, and may deposit 24. In 3 or 4 days these hatch, the young mites beginning life with only 6 legs. In 7 or 8 days these have become 8-legged mites, which mate and begin depositing eggs in the course of the next 3 or 4 days. One investigator (Gerlach) has estimated that in 90 days this rate of reproduction under favorable circumstances, beginning with a single impregnated female, would produce one and one-half million mites.

Distribution.—Scab was formerly widely distributed over the United States, being the greatest pest that sheepmen had to contend with. Quarantine and eradicative dippings have nearly cleaned it out of the greater part of this country, so that at present

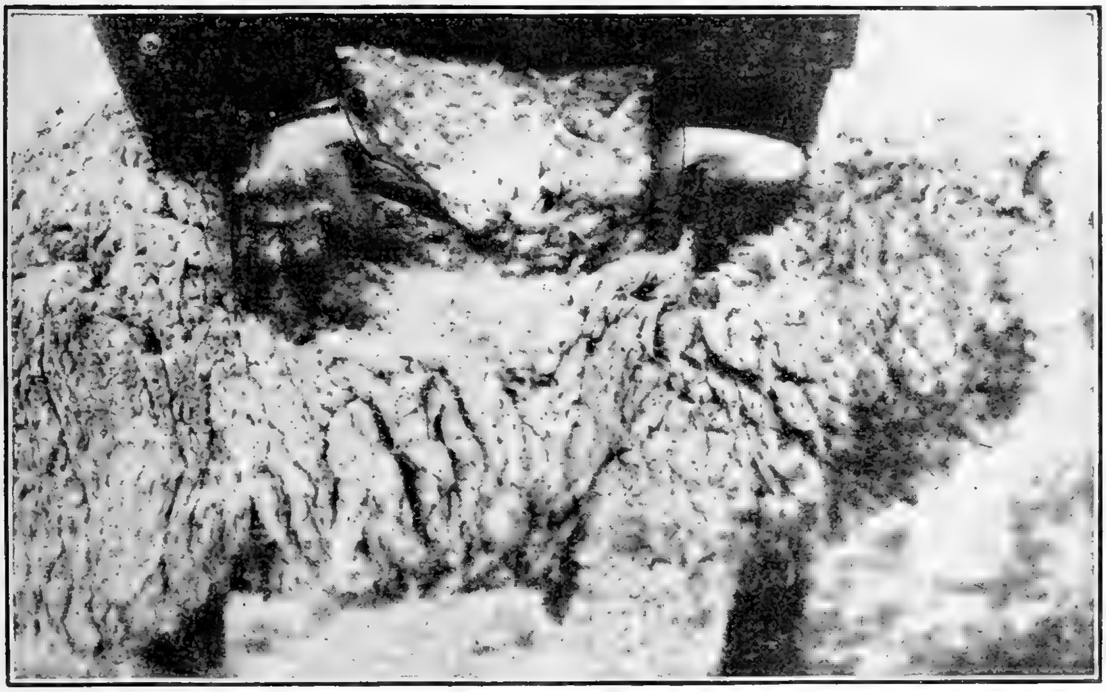

Fig. 6.—Characteristic scab lesion in early stages of the disease. (From Imes, 1916.)

it is largely a matter of cleaning up the relatively small amount that is scattered about, an exceedingly difficult task, however, because of the scattered condition of the infection. The cooperation of individual owners in promptly reporting to local livestock sanitary authorities cases of scab or cases suggestive of scab is highly important in scab eradication.

Symptoms and lesions.—The scab mite pricks the skin and sucks the blood serum. The puncture becomes inflamed, forming a small red spot with a slight exudation of serum. This serum forms the scab, from which the disease takes its name (fig. 6). The watery part of the serum dries out, leaving a small crust for each bite, the total aggregate of these bites leading to the formation of considerable crusts or scabs. At the same time the bite of the mite causes itching, and this in turn leads to scratching, rubbing, and biting, thereby adding to the initial inflammation and producing a certain amount of hemorrhage as the scabs are rubbed off and sores form. The serum and sores afford lodging and favorable conditions for bacteria and become infected. The skin reacts to the continued inflammation and becomes thickened.

The first symptom noticed as a rule is the itching, manifested by a disposition to rub and scratch. The wool is roughened and broken by the scratching, and this condition suggests the possibility of scab. The sheep become restless and spend considerable time biting and rubbing the affected spots, finally losing the wool off large

FIG. 7.—Scabby buck with entire hind quarters and flank affected. (From Imes, 1916.) (The discolored area is due to dip stain from hand dressing.)

areas and leaving scabby sores (fig. 7). The time and energy spent in trying to alleviate itching is time and energy lost from feeding and growing, and this fact shows itself in the poor condition of scabby sheep. Ultimately many of these sheep will die unless treated and they are always so weakened as readily to fall victims to other diseases.

The diagnosis of this disease is best made by a capable veterinarian, as the disease is too serious to warrant taking any chance on its spread. Itching, loss of wool, and other conditions present in scab may also be shown in the presence of lice, sheep ticks, true ticks, bearded seeds, cactus spines, eczema, wildfire, summer sores, rain rot, shear cuts, sunburn, and inflammation of the sebaceous glands; the effects of alkali dust may at times be mistaken for scab.

Treatment.—The only satisfactory treatment for scab is dipping. Hand dressing will not suffice and permits the spread of the disease while seeming to cure obviously affected areas. Animals must be dipped twice at intervals of 10 to 14 days, preferably 10, in warm dip. Ewes, bucks, and lambs should be dipped separately. Sheep must be held in the dip not less than two minutes; in the case of animals with advanced cases, especially in the fine-wool sheep, they should be held three to five minutes the first time, unless the crusts and scabs are first broken up and soaked with dip. The lime-sulphur dip and the nicotin-and-sulphur dip are the two dips recognized in official dipping for scabies.

Prevention.—Open pasture that has been used by scabby sheep should be regarded as dangerous for a month or two, and buildings are regarded as suspicious for a year or more. Keep sheep away from old bedding grounds and other infected areas. As regards buildings, pens, etc., it is advisable to abandon them, burn them, or else clean and disinfect thoroughly if they are to be used after having had scabby sheep in them. Stray sheep should be looked on with suspicion and goats may carry scab mites for long periods. Care must be used in purchasing sheep from areas where there has been any scab.

OTHER VARIETIES OF SCAB.

Head scab and foot scab in sheep are relatively rare diseases caused by species of mites different from those causing common scab. The same methods of treatment may be used, but head scab may prove more difficult to cure and four or five or more dippings, supplemented by local applications of remedies, may be necessary. In cases of head scab the interval between dippings should be shortened to a week or even to five days.

OTHER EXTERNAL PARASITES.

True ticks occasionally infest sheep, but in this country it is rare to find ticks present on sheep and we are fortunately free from ticks that habitually infest sheep. Among those that do occur on our sheep is the spinose ear tick.[4] This is particularly prevalent in the Southwest. It enters the external canal of the ear and attaches there well below the hair line, sucking blood from the tender skin. The ticks enter the ear as 6-legged seed ticks, become engorged, grub-like larvæ, molt to form the 8-legged nymph, which is covered with numerous small spines, and after months spent in the ear the nymphs

[4] *Otobius mégnini* (*Ornithodoros mégnini*). For additional information see Farmers' Bulletin 980 on "The Spinose Ear Tick and Methods of Treating Infested Animals."

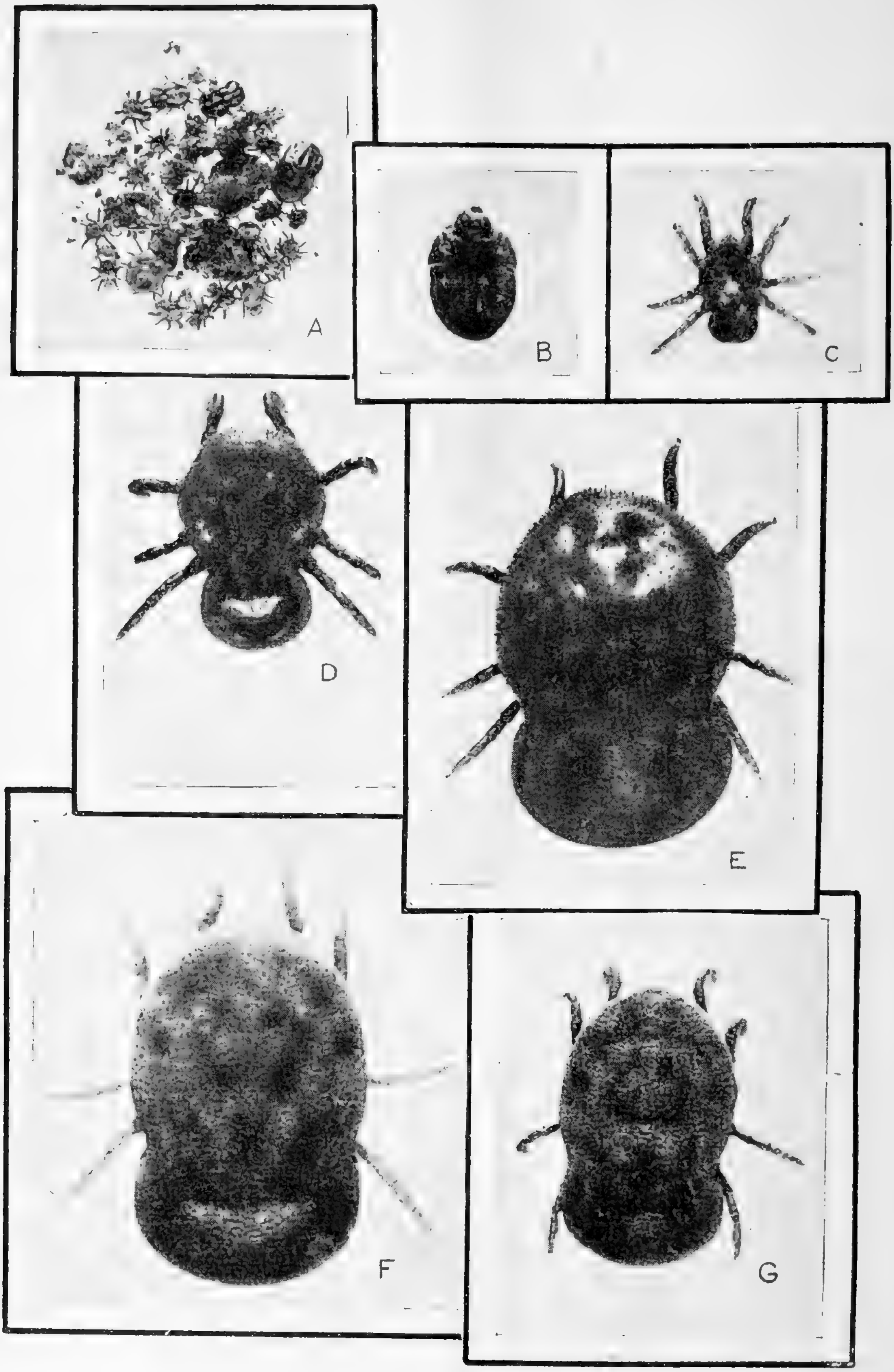

FIG. 8.—The spinose ear tick (*Otobius mégnini*). *A*, ear ticks and débris from ear of cow (about natural size). *B*, engorged larva (magnified five times). *C*, young tick (magnified five times). *D*, partially engorged young tick (magnified five times). *E*, fully engorged young tick (magnified five times). *F*, adult female (magnified five times). *G*, adult male (magnified five times). (From Imes, 1918.)

crawl out, conceal themselves in dry protected places, transform into adult ticks, and mate (fig. 8). The female lays eggs which give rise to the 6-legged seed ticks and these in turn infest new hosts. Infested animals often have the ear canal plugged with wax and the excretions of the ticks. Such animals shake their heads or turn them from side to side. The ticks cause serious injury and occasionally death, especially among horses and cattle. The best treatment is to clean the ear canal with a wire loop, using care not to injure the animal, and inject into the canal a mixture of 2 parts commercial pine tar and 1 part cottonseed oil.

The screw worm[5] is the name commonly given to the maggot of a sort of blowfly especially prevalent in the Southwest. It is especially apt to infest sheep recently sheared, getting into the fresh cuts, and in the same way attacks sheep and other animals that have been recently castrated, dehorned, or otherwise injured by having the skin broken. The fly is larger than the housefly (fig. 9), dark bluish-green in color, with three black stripes on the back between the wings, and with a red or reddish-yellow coloring in the face. It deposits its eggs in carcasses or in wounds, in masses of from 40 to 250 eggs. In wounds these eggs hatch in three hours or less, giving rise to young maggots which burrow into the wound and grow rapidly during a period of 4 or 5 days (fig. 10). They then leave the wound, burrow into the ground and form pupæ. The adult fly emerges from the pupal case in 3 to 14 days, the entire life cycle being 1 to 4 weeks.

FIG. 9.—Screw-worm fly, as seen from above. Much enlarged. (From Bishopp, Mitchell, and Parman, 1917.)

The best treatment for an infested wound is to pour in chloroform, later remove the maggots, wash with a suitable disinfectant, and apply pine tar to prevent fresh attacks. Probing and opening the burrows is regarded as inadvisable. When the wound is severe it is advisable to call in a veterinarian, as there is sometimes serious

[5] *Cochliomyia macellaria* (*Chrysomyia macellaria*). For additional information see Farmers' Bulletin 857 on "Screw-Worms and Other Maggots Affecting Animals."

danger from hemorrhage and infection. Every year numerous animals die from screw-worm infestation.

By way of prevention it is essential that carcasses of animals dying from any cause should be promptly burned or otherwise disposed of so that flies can not breed in them. If they are buried they should be buried in quicklime and the entire carcass should be at least two feet under ground and the soil tightly packed. Shearing cuts and other injuries from accident or operations should be coated with pine tar to prevent flyblow. Flytraps are valuable as control measures.

Sheep-wool maggots belonging to a number of species[6] are somewhat similar in habits to the screw-worm fly. Related flies have become a very serious pest to sheep in Australia. The flies deposit their eggs or young in the wool. Infested sheep are sometimes treated by clipping the wool about infested parts and applying concentrated dip, chloroform, or mixtures of turpentine and tar. It is also advised that lambing should occur as early as possible and shearing be carried on before the warm weather sets in, to reduce the chance of infestation. The wool of sheep, especially those affected with diarrhea, should be kept trimmed about the tail region to prevent flyblow at this place. A practice which has been found of considerable value in Australia consists in spraying the tail region of the sheep with 0.2 per cent solution of arsenious oxid just before lambing time. This can be done quickly and easily, is cheap, and affords considerable protection. The prompt destruction of carcasses is as important in the control of these maggots as it is in the control of the screw worm.

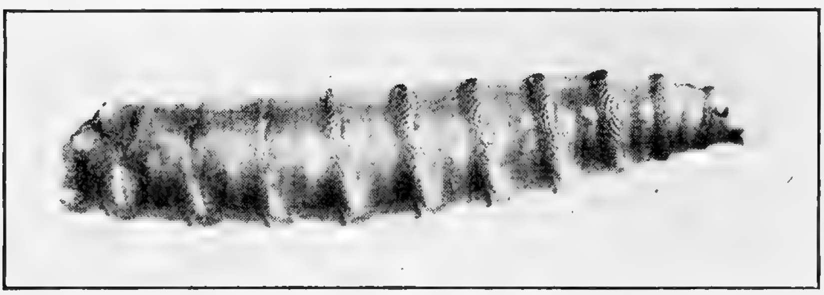

FIG. 10.—Screw-worm maggot, side view. Enlarged. (From Bishopp, Mitchell, and Parman, 1917.)

INTERNAL PARASITES.

The internal parasites include tapeworms, flukes, roundworms, and a few other forms, such as the maggots causing grub in the head, the tongue worm, and the one-celled forms, or Protozoa, these last being microscopic in size and of comparatively little known importance in the United States so far as sheep are concerned.

The following discussion includes the more important of the numerous kinds of internal parasites that infest sheep.

[6] *Phormia regina, Lucilia sericata,* and others.

ARTHROPODS.

The arthropods include certain forms that live during a portion of their life as internal parasites of sheep, though most of the arthropod parasites of sheep are external parasites.

The arthropods are forms which possess 6 or more leglike appendages, such as the insects, which, in a limited sense of the word, include those forms with 6 legs, the spiders and spiderlike forms, which as adults have 8 legs, and other forms having more than 8 legs, some of them having a considerable number.

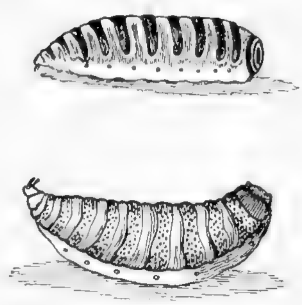

FIG. 11.—Grub in the head (*Œstrus ovis*). Above, normal position; below, grub turned on its back. (From Osborn, 1896, after Riley.)

The life history of the arthropods varies so greatly in the case of different forms that it is hardly possible to give a general statement covering it.

GRUB IN THE HEAD.[7]

Location.—The grubs occur in the nostrils and in such communicating cavities as the frontal sinus and the maxillary sinuses, cavities in the upper jawbone.

Appearance.—The parasites appear as maggots which at first are less than 2 mm. (one-twelfth of an inch) long. When fully developed in the sheep, they are usually over 2 cm. (four-fifths of an inch) long and 7 mm. (almost one-third of an inch) wide, though the grub may contract or expand to a smaller or greater dimension. There are 11 segments, rather flattened on the ventral (lower) surface and arched on the dorsal (upper) surface. The ventral surface is spiny, the dorsal smooth. At first the grubs are white, later they become yellowish and darker, a band appearing on the dorsal side of the segments, and finally becoming black (fig. 11). At the head end are two large hooks and at the tail end are two rounded breathing pores.

FIG. 12.—Adult fly which causes grub in the head (*Œstrus ovis*). (From Curtice, 1890.)

Life history.—The adult fly (fig. 12), which looks something like an overgrown housefly, is active during the summer, usually in June and July. The female fly deposits a tiny grub on the edge of the sheep's nostril. Sheep usually run when the fly attacks them

[7] *Œstrus ovis*.

or is seen by them, often becoming frantic and holding the nose in the dust or against other sheep. The attack occurs usually during the heat of the day, the fly being quiet in the early morning and late afternoon. The grub migrates up the nostrils by means of its hooks and spines, and may make its way to the communicating cavities. Occasional grubs fail to leave the sinuses in time and become too large to get through the apertures they entered; these die and usually become calcified. The grub in the sinuses feeds and grows until it is ready to leave the sheep. Sometime during the spring or summer, in temperate climates, the grubs leave the sheep and fall to the ground, into which they burrow a short distance. Their skin becomes hard and leathery and they lie quiescent for three weeks to two months, according to conditions of temperature and moisture. Finally the adult flies break out from the leathery envelopes within which they have undergone their transformation from the preceding stage, like a butterfly in a chrysalis, crawl to the surface, and are ready to mate and then to deposit their young.

Distribution.—This parasite appears to be prevalent throughout the United States wherever sheep are kept. It is a common and troublesome pest, especially in the South.

Symptoms and lesions.—As the grub crawls about in the nostrils the hooks and spines set up an irritation which is at first acute with a resultant flow of serum from the nose, resembling a "cold in the head." Presently the nostrils show evidence of bacterial infection, the flow thickens and becomes discolored, presenting the picture called by the sheepmen "snotty nose," a pronounced catarrhal condition. The hooks and spines set up minute hemorrhages, which are visible on post-mortem examination as rows of blackened dots on the mucous lining of the nostrils and sinuses. One result of this irritation and inflammation is a thickening of the mucous membrane, a condition which interferes with its normal function of smell and helps to close the breathing passages, which are already functioning improperly as a result of the thick, catarrhal secretions. As a consequence the sheep experiences difficulty in breathing, which tends to impair its general physical condition. Add to this the fact that the sinuses may become filled with purulent matter and that the toxins from the purulent matter here and elsewhere are constantly absorbed and there is evidently present a condition which must weaken an animal. Furthermore, the irritation due to the wandering of these spiny grubs over the sensitive mucous membrane of the nostrils prevents the sheep from resting or devoting its full time and energy to feeding and growing.

Though the characteristic symptom of grub in the head is the profuse discharge from the nose, the sheep show other evidences of the infection. They sneeze frequently and often show symptoms of difficult breathing. The eyes become inflamed, as would be expected in connection with an inflammation of the nostrils, the head is often carried low or may be moved about in a peculiar manner as though the sheep were trying to rid themselves of an obstruction in the head, the appetite is diminished, or at least the sheep eat less owing to distraction from pain and difficult breathing, and in severe cases the animals may have convulsions and ultimately die.

Treatment.—The treatment for this condition is not very satisfactory and dependence should be placed on preventive measures, which are, fortunately, of a comparatively simple sort and easily applied. One of the measures which has been advocated in the way of treatment is to put the sheep in an inclosure on hard ground or on a floor of some sort which has been sprinkled with lime, and to mill them around so as to stir up the lime and cause violent sneezing, in the hope of expelling the grubs in this manner. This may remove some grubs from their position in the nostrils, but it can have no effect on those in the sinuses and will by no means remove all those in the nostrils. Attempts have been made to kill or remove grubs by putting the sheep in a room with burning sulphur, some person remaining there as long as possible to test the strength of the fumes. This is dangerous to the sheep and the operator and can not be recommended, especially since it is not very successful. In the case of particularly valuable animals which are seriously affected, the sinuses may be opened with a trephine and the grubs extracted with forceps. Sheep tolerate the operation well enough, but the operation is one that is suitable only for trained and skilled operators and should be done by a competent veterinarian. If the sheep is not worth the cost of such an operation, it should be sent to the butcher before the progress of the disease has rendered the animal unfit for food.

Prevention.—Smearing the nose of the sheep with a preparation that will prevent the fly from depositing its larvæ successfully on the nostril has been found to be a very satisfactory preventive measure and is one that is extensively practiced. Various preparations have been used, such as equal parts of tar and grease, of tar and fish oil, or of tar and whale oil; but the use of pine tar alone seems to be quite satisfactory. It is advisable to apply the tar by hand, at least the first time, and to make sure that it is applied liberally to the entire margins of the nostrils. The application may be renewed by hand later, as often as necessary, or may be automatically renewed by using a salt lick consisting of a thick plank or split log in which holes, 2 inches in diameter, are bored, with salt placed in the holes and the edges of the holes heavily tarred, so that the sheep get the tar on their nostrils as they lick the salt.

TAPEWORMS.

Adult tapeworms are usually composed of a head, armed with hooks and suckers as a rule (though those in the sheep's intestines have no hooks), and a body consisting of a number of flat segments arranged in a chain. Adult tapeworms are usually found in the small intestines, but in some cases they may occur in the stomach, large intestines, or the ducts of the liver and pancreas. Tapeworms produce eggs of microscopic size which pass out in the feces and which on being swallowed by a suitable host, usually of a sort different from the host of the adult tapeworm, give rise to an intermediate stage, or larva, which is usually more or less spherical or elliptical and composed of a tapeworm head and neck attached to a membrane, the membrane usually inclosing a clear fluid. In the case of many of the common tapeworms this form is called a bladderworm. It usually occurs in the body tissues, and when these are eaten by the host of the adult tapeworm the head of the tapeworm passes to the intestine and forms the adult worm by the addition of segments back of the head. This tapeworm in turn produces eggs and the cycle is repeated. Thus, certain tapeworms in the dog give rise to certain bladderworms in sheep, the tapeworm eggs in the feces of the dog being deposited on the pasture and picked up by sheep with the herbage that they eat. The dog in turn becomes infested with tapeworms when it eats the bladderworms in the meat, brain, liver, entrails, or other parts of the sheep.

Sheep may harbor adult tapeworms in the intestine and bladderworms in the body tissues.

THE MONIEZIAS.[8]

Location.—These tapeworms are found in the small intestines.

Appearance.—They are whitish to yellowish in color and may attain a length, in some specimens, of several yards (see fig. 13). The individual segments of a worm are broader than long, and each segment contains at some period of its development a complete set of reproductive organs. The end segments are full of eggs, and these segments break off from the rest of the worm and pass out in the manure, where they are often found by the farmer and regarded as complete worms. The presence of these segments in the feces serves to diagnose cases of infestation with the tapeworm.

Life history.—The life history of these tapeworms is not known. Sheep are herbivorous animals and would only by accident eat animals, such as insects, that might serve as intermediate hosts. It is probable that the intermediate hosts are small animals, such as insects, that are taken in by the sheep on grass, but we have no evidence on this subject.

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[8] *Moniezia expansa, M. trigonophora,* and *M. planissima.*

Distribution.—These tapeworms are more or less common throughout the United States. Two of the forms (*M. expansa* and *M. planissima*) are also widely distributed outside the United States.

Symptoms and lesions.—When these worms are present in sheep in large numbers they cause obstruction of the intestine and intestinal irritation, with the result that they interfere with digestion and the sheep become unthrifty, weak, and emaciated; such sheep are unable to stand adverse conditions, such as bad weather or poor food, and die where sheep not so infested may survive. The digestive derangement is manifested by diarrhea as a rule. It is known that tapeworms often cause very marked and even severe nervous symptoms in man, and while such symptoms are more difficult to detect in sheep, there is every reason to suppose that they may occur.

On post-mortem examination of affected sheep the tapeworms are found in the small intestine, often in large numbers. The sheep show no special indications of their presence other than poor condition, evidences of diarrhea, and inflammation or catarrh of the intestines.

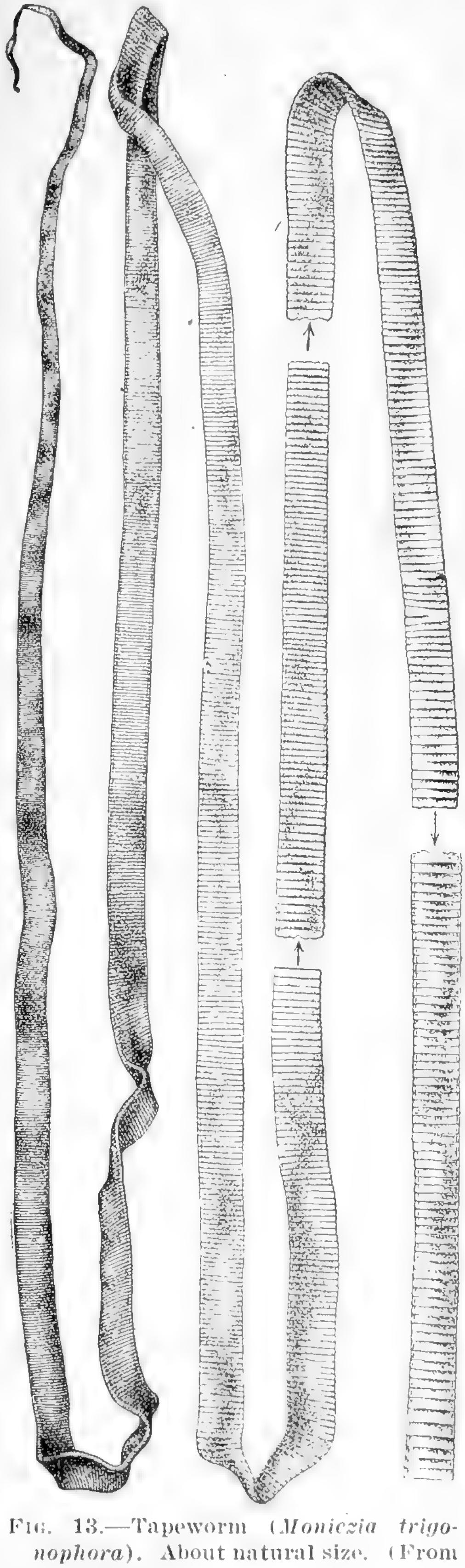

FIG. 13.—Tapeworm (*Moniezia trigonophora*). About natural size. (From Stiles, 1898.)

Treatment.—There are no well-established treatments for tapeworms in sheep. Among the remedies which have been used are the following:

Kamala.—This drug has been given in doses of 1 dram to lambs. It causes diarrhea and lambs so treated may remain poor for some time in spite of abundant food and good conditions otherwise.

Kousso.—This is said to have given good results in doses of 2 drams to lambs.

Koussin.—This is reported as giving good results in 2-grain doses. It expelled the tapeworms, and the animals remained in good spirits and improved in condition.

Oleoresin of male fern.—This is given in doses of 1 dram and may be given with 2 to 4 ounces of castor oil.

Areca nut.—This may be given to lambs in doses of 1 to 3 drams. It must be freshly ground shortly before being used, preferably the day it is used.

The copper-sulphate treatment for stomach worms, given on pages 39 to 41, will also remove tapeworms.

In South Africa good results have been reported from the use of a mixture containing 1 part of sodium arsenite (testing 80 per cent arsenious oxid) and 4 parts of copper sulphate. The total dose of the mixture is as follows: For animals 2 to 4 months old, 180 milligrams; 4 to 6 months old, 250 mg.; 6 to 10 months old, 375 mg.; 1 year old, 500 mg.; 2 years old or older, 625 mg. This may be given as a powder. Remove food and water the afternoon before dosing: dose the following morning; allow food that afternoon and food and water the next morning. The dose may be repeated the day after the first dose, in which case food is allowed the afternoon after the first dose, the animal is dosed the following morning and fed that afternoon, but no water is allowed from the afternoon preceding the first treatment until the morning following the second treatment. Owing to the poisonous nature of arsenic, it is best to test the treatment on a few sheep to be sure the dose is safe before dosing a flock, and the drugs should be kept out of reach of children and animals. If the treatment is repeated at intervals of a month or more through warm weather, the single treatment should be used.

The Oklahoma experiment station claims very good results from a solution containing 1 per cent copper sulphate and 1 per cent by weight of snuff or powdered tobacco. The tobacco is steeped overnight and the copper sulphate then added. The dose is 50 mils (about 1½ ounces) for lambs and twice this amount for full-grown sheep.

Prevention.—No dependable preventive measures against these tapeworms can be recommended, owing to the fact that the life history is unknown.

THE FRINGED TAPEWORM.[9]

Location.—This tapeworm is found in the small intestine, the gall ducts, gall bladder, and biliary canals of the liver, and in the duct of the pancreas.

Appearance.—These are whitish or yellowish tapeworms and may be a foot long (fig. 14), but are commonly shorter. They may be readily distinguished from other tapeworms by the fact that each

[9] *Thysanosoma actinioides*

of the segments has a fringe on its posterior border. This fringe may be most easily seen when the segment is put in water, where the fringes can float out from the segment. Tapeworms found in the liver or pancreas will be this worm and not the Moniezias already described.

Life history.—As in the case of the Moniezias (and this is true of all the adult tapeworms of cattle, sheep, and horses), the life history is unknown. Presumably it has an intermediate stage, probably in an insect or other small animal.

Distribution.—The fringed tapeworm is a parasite of western sheep and is found in the East probably only when the sheep have been shipped from the West. The infected range is probably confined to North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, and the States west of these. The parasite apparently has found conditions most favorable among range sheep, and it seems to be losing ground with the breaking up of the big western sheep ranges and the substitution of small holdings of sheep.

Symptoms and lesions.—The obstruction of the bile ducts and pancreatic ducts causes inflammation of these ducts and derangement of the liver. As a result there is an alteration in the secretions as regards amount and character, which impairs digestion and causes a lack of thriftiness. This shows in lost flesh and poor quality of flesh and wool. Sheep weakened by fringed tapeworms may die from the parasitic infestation or from inability to withstand other adverse conditions. Infested sheep are commonly hidebound and suffer from diarrhea.

On post-mortem examination the tapeworms may be found in the intestine and in the liver and pancreas, and the ducts of these glands are usually found thickened when infested. In the spring of the year fringed tapeworms seem more likely to be found in the small intestine than at other seasons.

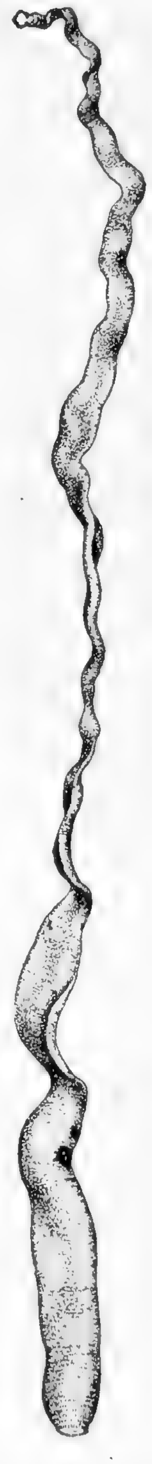

Fig. 14.—Fringed tapeworm (*Thysanosoma actinioides*.) About natural size. (From Stiles, 1898.)

Treatment.—No successful treatment is known for this parasite. Such treatments as have been attempted have failed, and all that can be recommended at this time is careful nursing and good feeding.

Prevention.—As in the case of the Moniezias, the fact that we do not know the life history of this worm makes it impossible to give specific directions for preventing infestation.

BLADDERWORMS.

THE THIN-NECKED BLADDERWORM.[10]

Location.—The thin-necked bladderworm is found in the abdominal cavity attached to the mesenteries or omenta or in the liver.

Appearance.—The bladderworm looks like a sac full of a clear fluid, with a white object, which is the head and neck, projecting into it from one end. It is usually about 1 inch in diameter, but may attain a long diameter of several inches. The bladderworm proper is surrounded by a cyst, which is developed by the host animal as a protective measure against the parasite. When this cyst is broken the parasite usually rolls out and is seen to be a thin-walled structure. By careful manipulation the head and its rather long neck may be squeezed out at one end of the "bladder" (fig. 15).

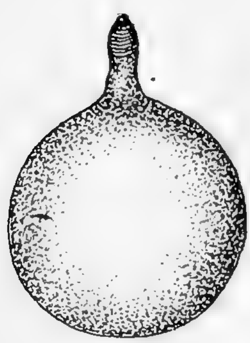

FIG. 15.—Thin-necked bladderworm (*Cysticercus tenuicollis*). Natural size. (From Stiles, 1898.)

Life history.—If one of these bladderworms is fed to a dog the cyst wall will digest, but the tapeworm head and neck will pass on to the small intestine of the dog and begin to grow segments back of the neck. In this way it will form a tapeworm, one of the largest of the dog tapeworms[11] (fig. 16). This tapeworm attains a length of a yard or more, becoming mature and beginning to liberate egg-bearing segments in the course of 10 or 12 weeks. When dogs infested with these tapeworms run over pastures used by sheep, they leave feces containing the tapeworm eggs on the pastures, and these eggs are spread by rain and washed on to the grass and into streams and puddles where the sheep drink. When the sheep get these eggs in food or water, the embryo escapes from its surrounding shell, makes its way to the liver of the sheep, and begins to develop. In time it slips out of the liver and becomes attached to the mesenteries or omenta. At first it is a bladder without a head, but later the head and neck develop, and it is then ready to infect any dog that eats it.

Distribution.—This parasite is quite generally distributed over the United States, but the indications are that the worm is becoming less common as a result of improvements in disposal of viscera and offal at slaughterhouses during the last 15 years. It is most likely to be present where sheep are associated with dogs, either when herded by them or where stray dogs are common, and where sheep are slaughtered on farms or at small country slaughterhouses at

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[10] *Cysticercus tenuicollis.*

[11] Commonly called *Tænia marginata*, and more properly *Tænia hydatigena.*

which little care is exercised in disposing of the viscera and of diseased portions of carcasses.

Symptoms and lesions.—Light infestations with these bladderworms seem to do very little damage. Severe infestations, such as a sheep would get by eating grass that had an entire segment full of eggs on it, will make a sheep very sick and may kill it. Under these conditions sheep usually die at a rather early stage of the disease, and at a time when the embryos are wandering around in the liver, the immediate cause of death being hemorrhage from the liver, or peritonitis. Post-mortem examination under these conditions would seldom be sufficiently minute to reveal the exact cause of the trouble, and it would seldom be charged to the account of this parasite.

On post-mortem examination the bladderworms are usually readily observed in the mesenteries or omenta, or in earlier stages, in the liver. When the liver has just recently been invaded, the presence of the parasite is usually indicated by serpentine markings showing the course of the wanderings of the young worms.

Treatment.—There is no treatment for infestation with the bladderworm in sheep.

Dogs should be kept free from tapeworms of any sort, including the one responsible for this bladderworm in sheep. For removing these tapeworms, fast the dog from noon of one day until the following morning and then give one of the following treatments:

Oleoresin of male fern.—The dose for dogs is 15 minims to 1 dram (a quarter of a teaspoonful to a teaspoonful), according to size. This may be given in capsules and followed immediately by an ounce of castor oil.

Areca nut.—This may be given in the same amounts as the oleoresin of male fern, and will usually not need a purgative, as

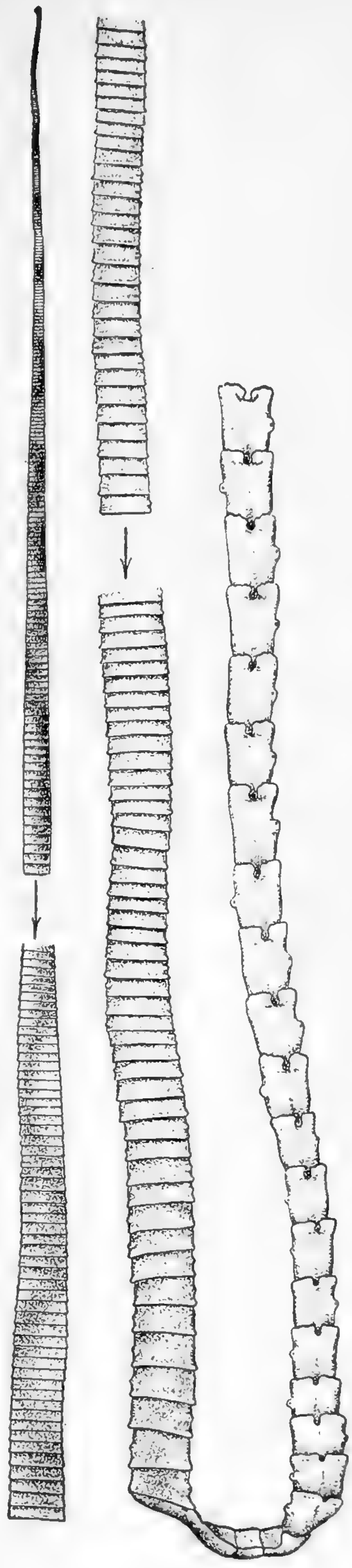

FIG. 16.—Tapeworm (*Tænia hydatigena*) of dog, developed from thin-necked bladderworm of sheep. About natural size. (From Stiles, 1898.)

areca is itself purgative. If feces are not passed in the course of four or five hours, it is advisable to give castor oil or some other purgative. As noted previously, areca nut must be freshly ground to be efficacious.

Kamala.—This may be given in doses of half a dram to 2 drams (a half teaspoonful to 2 teaspoonfuls). The powder may be given in sirup and will not need to be followed by a purgative, as kamala itself is a purgative. As in the case of areca nut, if feces are not passed in four or five hours castor oil or some other purgative should be given.

FIG. 17.—Sheep muscle showing measles (*Cysticercus ovis*). Natural size. (From Ransom, 1913.)

Any tapeworms that are passed and the feces with them should be burned. On the farm this is easily done by using hay or straw for fuel.

Prevention.—This consists in preventing dogs from eating uncooked meat, especially diseased and parasitized meat and viscera. Slaughterhouse refuse should be tanked and not left where dogs can have access to it. The use of the tank has apparently resulted in a diminution in the number of cases of this parasite in sheep and dogs, and the extension of this measure will probably eradicate it in time. Dogs should be kept free from tapeworms by suitable remedies, whenever necessary, and it would be advisable to give such treatment as a routine procedure about four times a year where there is any chance of dogs eating infective material. Stray dogs should be kept off farms and suppressed by appropriate measures.

SHEEP MEASLES.[12]

Location.—Parasites known as sheep measles occur in muscles, including the heart, and intermuscular connective tissue, and as degenerate cysts in the lungs, walls of the first and fourth stomachs, and the kidneys.

Appearance.—This parasite occurs in the meat (measly mutton) as oval cysts 3.5 to 9 mm. (one-seventh to one-third of an inch) long by 2 to 4 mm. (one-twelfth to one-sixth of an inch) wide. These cysts have a thin external membrane inclosing a clear fluid. On

[12] *Cysticercus ovis.*

one side of the cyst is an opaque white object, which is the head and neck of a tapeworm (fig. 17). When degenerated the cysts appear as cheesy or hard nodules, the hardness being due to lime salts.

Life history.—The life history of this parasite is similar to that of the thin-necked bladderworm, the adult being a certain species of tapeworm of the dog (*Tænia ovis*).

Distribution.—In the United States this parasite appears to be most common in the West, especially in Montana, Idaho, Washington, Oregon, California, Colorado, and Nevada. It has been found abroad in England, France, Germany, Algeria, German Southwest Africa, New Zealand, and South America.

Symptoms and lesions.—When sheep have but a few of these cysts no symptoms are likely to be observed, although it has been suggested that sheep measles may be responsible for the many stiff lambs found during spring and summer on the western sheep ranges. When many cysts are present sheep will become very sick, and if all the eggs from one segment are eaten the sheep are likely to die. On post-mortem examination the cysts are the principal thing observed, though in badly infested cases the meat may be watery and discolored.

Treatment and prevention.—These are the same as for the thin-necked bladderworm (pp. 25 and 26) and its adult tapeworm.

THE GID PARASITE.[13]

Location.—The gid parasite occurs in the brain or spinal cord. Degenerate cysts that failed to reach the central nervous system may be found in muscles and other tissues.

Appearance.—This worm occurs as a large cyst or bladderworm, attaining the size of a hen's egg or larger, and is composed of a thin membrane containing a rather large amount of fluid. On the bladder membrane are a number of small white objects about the size of a grain of wheat, projecting, as a rule, into the bladder fluid (fig. 18). These are the tapeworm heads. A parasite of this sort is called a cœnurus.

Life history.—When such a bladderworm, or cœnurus, is eaten by a dog or coyote the bladder membrane digests, releasing the attached tapeworm heads. These heads then pass into the small intestine, where they form the adult tapeworm by the addition of segments back of the head (fig. 19). Ordinarily the worm is fully grown and 2 or 3 feet long in the course of a month or two, though occasionally a longer period is required. The full-grown tapeworm produces minute eggs, which pass out in the feces of the dog on to the pasture or range. Under favorable conditions these eggs are taken in by sheep with contaminated food or water. The shell

[13] *Multiceps multiceps*, Synonym, *Cœnurus cerebralis*.

digests from the egg and releases an embryo, which is armed with six hooks. By means of these hooks the embryo cuts its way through the tissues of the sheep and into the blood stream. In the blood the embryos are carried to various tissues, but only those that reach the brain or spinal cord are able to attain the full larval development, the others dying and degenerating by the time they reach the size of a pea. Those that reach the central nervous sys-

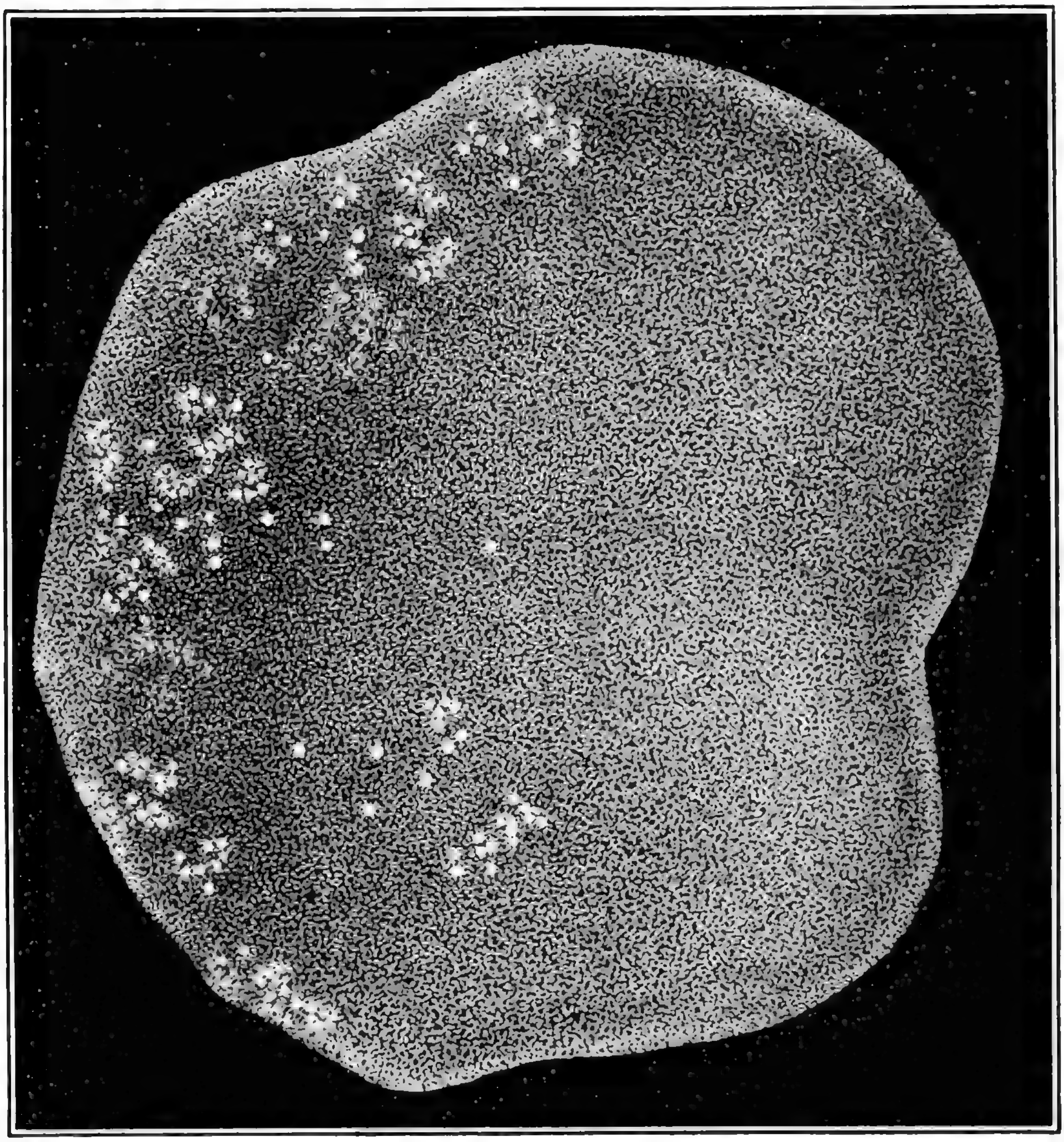

FIG. 18.—Gid parasite (*Multiceps multiceps*) from brain of sheep. Natural size. (From Hall, 1910.)

tem at first move about on or in the brain or spinal cord, forming curving channels. At a suitable point the wandering ceases and the bladderworm grows and completes its development in about seven or eight months, the sheep dying in nine months or earlier.

Distribution.—In the United States this parasite has been found chiefly in northern Montana, where it has been established for about 30 years, possibly longer. There have also been outbreaks of gid in Arizona and in New York. Cases have been observed also in various localities to which sheep have been shipped from infested regions. Occasionally cases are imported from Europe. Outside the United States the disease is known to occur in England, Scotland, Ireland, France, Germany, Austria, Hungary, Italy, Sardinia, Switzerland, Greece, Spain, Holland, Denmark, Iceland, Shetland, Morocco, Cape Colony, German Southwest Africa, South Australia, New Zealand, Argentina, Chile, and Canada.

Symptoms and lesions.—At the time that the young worm gets to the brain there are usually slight symptoms of fever and restlessness, which are easily overlooked. If the sheep dies at this time, as a result of severe infestation, an examination of the brain will show a number of curving channels on its surface. As a rule the symptoms of this stage abate and there is no further indication of the presence of the parasite until it has grown to the point where the heads form. This will take place about the seventh or eighth month after infection. The head of the worm can be evaginated from the bottom of its tubular neck, just as a glove finger may be turned inside out, and this brings its hooks and suckers into contact with the brain. From this irritation and from the pressure of the growing bladderworm there arise the very striking symptoms indicative of gid. Affected sheep very commonly walk in a circle, turning toward the side corresponding to the affected portion of the brain when the parasite is on the surface of the cerebrum. When the parasite is located at other points the symptoms are somewhat different. In these cases sheep may walk with the head held high and may step high, or with the head held low and with a stumbling gait, or may show other odd symptoms in the way of unusual locomotion. Such animals gradually lose interest in food and water and finally cease eating or drinking. In consequence they become very much emaciated. They may move about continuously or stop at times and gaze fixedly at nothing in particular. They are difficult or impossible to herd and tend to lag behind the flock or become lost. The

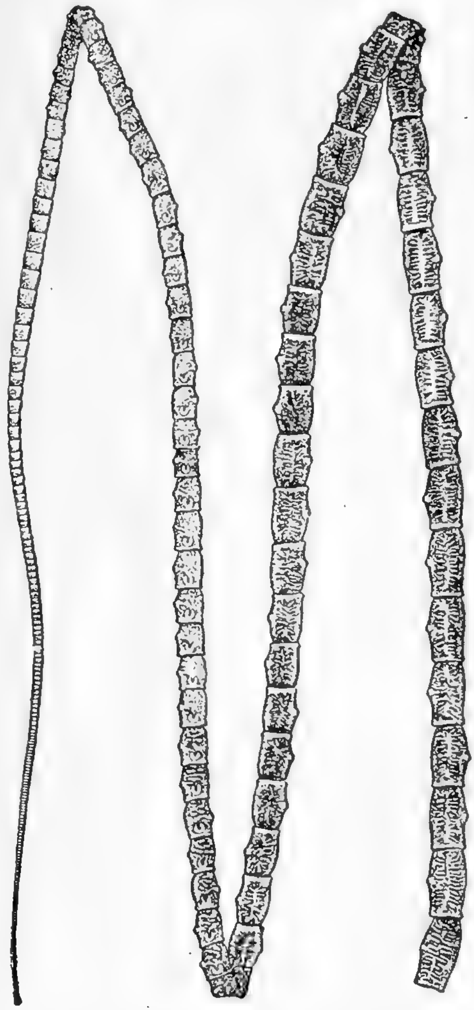

Fig. 19.—Tapeworm stage of *Multiceps multiceps* in dog. Actual size. (From Hall, 1910.)

head is often carried to one side and the animal may become blind or appear to be blind.

Unless surgical treatment or accident frees the sheep from its parasite, the animal will die, usually in the ninth month. When examined after death, the brain or spinal cord will be found to have on or in it a bladderworm, or more than one, and an equal amount of brain or cord tissue will be found to have disappeared or been crowded aside by the growth of the cyst. The skull adjacent to the parasite is often softened or even absorbed to the point where it has a hole or several holes through it. In the late stages sheep are so emaciated that the meat is unfit for food.

Treatment.—The treatment for gid is surgical. This is satisfactory only when the cyst is on the surface of the brain. Operation may be performed with a trocar and cannula or with a trephine. In the trocar and cannula operation the wool is sheared over the affected area, as determined by the symptoms and by palpation to find a soft spot or one where the sheep reacts violently to pressure. Under local anesthesia the trocar and cannula are driven through the skull and the trocar withdrawn from the cannula. If the cyst is struck, a watery fluid will issue from the cannula. This fluid is syringed out and the cannula withdrawn. Suitable cannulas are provided with a cleft to catch the bladder membrane and pull it out. If this fails, it is necessary to remove the membrane with forceps or by some other means. This operation, like operations generally, should be conducted under aseptic conditions. The median line of the skull should be avoided.

With the trephine outfit the wool is sheared over the proper area and under local anesthesia and aseptic conditions a V-shaped incision is made through the skin and the skin dissected back. A piece of skull is then cut out with a five-eighths-inch trephine and the hard membrane covering the brain is cut with bent scissors. The parasite will usually push out and may be grasped with forceps and removed. If it does not appear, it may be necessary to explore for it with the finger. After removing the parasite and controlling the hemorrhage, the skin flap may be sewed back along one side of the tip of the V, and the wound covered with a pledget soaked in some antiseptic. The animal should be kept quiet in a dark shed for several days after operation.

Some sheepmen cut the skull with a pocket knife or puncture the cyst with a knife. In such cases the sheep is apt to die of infection, even if the worm is removed. The operation for gid calls for care and should be performed by a competent veterinarian. If operation does not seem to be feasible, it is advisable to kill giddy sheep for mutton or send them to market before they become emaciated and unfit for food.

Prevention.—The most important preventive measure is to destroy the heads or at least the brains of giddy sheep. This may be done by burning. Where wood is scarce the skull may be split with an ax or cleaver and the brain put on a forkful of hay or straw and burned. Where this is not feasible the brain may be removed from the skull, crushed, and covered with formaldehyde, turpentine, or a coal-tar or tobacco dip. The essential thing is to destroy the parasite and prevent dogs, coyotes, or other animals from eating it.

Another measure of importance is to keep dogs, especially sheep dogs, free from tapeworms. To this end it is advisable that they be given tapeworm treatment four times a year. For the treatments that may be used see page 25. Measures against coyotes and other noxious wild animals are valuable in controlling gid as well as in keeping down the destruction of stock. Stray dogs should be eliminated on the same grounds.

THE HYDATID.[14]

Location.—The preferred sites of the hydatid parasite in sheep are the liver and lungs, but it may occur in practically any organ or tissue.

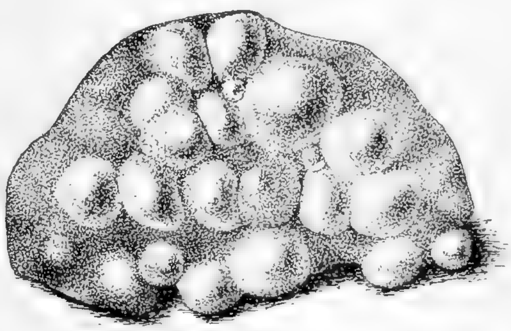

Fig. 20.—Hog liver infested with hydatid (*Echinococcus granulosus*). Greatly reduced. (From Stiles, 1898.)

Appearance.—The parasite occurs in sheep usually as a multiple bladderworm, varying from the size of a nut to the size of a child's head, sometimes as a spherical object and sometimes irregular in shape (fig. 20). It has a very thick, laminated bladder wall, and in the simplest form of the parasite this bladder contains a clear fluid and minute objects resembling grains of sand lying unattached in the fluid. These grains are brood capsules, and each of them contains a number of very small tapeworm heads. Sometimes the bladderworm develops other bladderworms, attached or unattached, on the inside or outside.

Life history.—When the brood capsules from a hydatid are eaten by a dog, cat, or other suitable animal, each tapeworm head in the brood capsules develops into a tapeworm by the addition of segments back of the head. This tapeworm is a very small one, less than half a centimeter (about one-fifth of an inch) long (fig. 21). As the hydatid may form thousands of such heads in its brood capsules, dogs may become infested with large numbers of these worms on eating hydatids. The eggs produced by the adult tapeworms in the dog pass out in the feces. When taken in by a sheep or other animal the egg hatches and releases an embryo which makes its way to some

[14] *Echinococcus granulosus.*

suitable tissue and develops to the hydatid. This hydatid may develop in man if an egg of the tapeworm is swallowed, and a large percentage of hydatid infestations in man result in death. It is therefore a very dangerous parasite to human beings.

Distribution.—This parasite has been found at a number of places in the United States proper and in Alaska, as well as in other parts of the world. Certain regions are found to send a large number of infected swine to the slaughterhouses, though its occurrence in sheep is comparatively rare in the United States. Where it is locally prevalent, its abundance may be attributed to infected dogs which have probably become infected through carelessness in the disposal of diseased carcasses and viscera of slaughtered animals. Careless persons may feed diseased portions of carcasses to dogs or leave them where dogs will get at them and eat them.

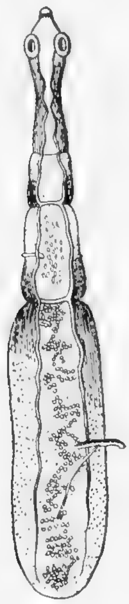

FIG. 21.—Hydatid tapeworm (*Echinococcus granulosus*). Highly magnified. (From Stiles, 1898, after Leuckart.)

Symptoms and lesions.—The symptoms in sheep affected with hydatid depend on the location of the parasite and its size, and so are very variable. Where the parasite is small or has room to develop without crowding important organs, few symptoms may be noticed. On the other hand, the parasite may develop in such structures as the brain or heart and cause very marked symptoms and sudden death from pressure or rupture. As a rule, infestations will not be detected and correctly diagnosed during the life of a sheep and they will be found only on post-mortem. In such cases the large, thick-walled bladders are readily found.

Treatment.—The only treatment for this condition is surgical, and this is not apt to be feasible in sheep, even if the disease should be diagnosed ante-mortem.

Prevention.—The most important measure in the way of prevention of this disease is the proper disposal of carcasses and portions of carcasses of animals dying on the farm or killed there or elsewhere. The "condemned" tank at the modern slaughterhouse has been one of the greatest factors in destroying parasites of this sort, and the lack of an equally good arrangement at the small country slaughterhouse and on the farm is one of the important conditions which permit such parasites to persist. Where diseased viscera, such as livers infested with hydatid, are thrown out where dogs can get at them, parasites of this kind are liable to be prevalent. The next measure of importance in controlling this disease is to keep dogs free from tapeworm by administration of tapeworm treatments four times a year. For these treatments, see page 25.

FLUKES.

Flukes are usually flat, leaflike animals, provided with suckers, but not segmented like the tapeworms. They occur in the adult stage in various locations, the stomach, intestines, liver, lungs, blood vessels, and may occur in immature stages in such tissues as the muscles. The adult flukes produce eggs of microscopic size which pass out and hatch in water. The embryos released from the eggs infect snails in which they transform into a succession of larval stages. The parasites finally escape from the snails and may penetrate the skin of the final host or may be swallowed, sometimes after encysting, in food or water.

Sheep in certain localities in the United States, as well as in other parts of the world, suffer considerably from fluke infestation. The common liver fluke and the large liver fluke occur in American sheep.

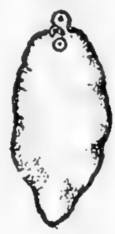

FIG. 22.—Common liver fluke (*Fasciola hepatica*). Natural size. (From Stiles, 1898.)

THE COMMON LIVER FLUKE.[15]

Location.—These flukes are found usually in the biliary canals and the ducts of the liver, though they may occur as wandering parasites in the lungs and elsewhere.

Appearance.—The common liver fluke is a flattened, leaflike, brown animal, usually about an inch long (fig. 22). There is a sucker at the anterior, or front, end, on a cone-shaped extension, and just behind this is a ventral sucker. Through the skin or cuticula covering the animal one can see the branching intestine and the uterus filled with eggs.

Life history.—The eggs produced by the adult flukes pass out in the feces and on getting to water release a ciliated embryo. This embryo attacks certain species of snails and on entering the snail undergoes certain changes, which in time give rise to a form called a cercaria. This is like a small fluke, provided with a tail by means of which it swims about. Finally it loses the tail and encysts. The encysted cercariæ may float about on or in water or may be attached to grass blades or other vegetation. When these are swallowed by sheep, or other suitable host animals, the larval flukes escape in the digestive tract and bore their way through the intestinal

[15] *Fasciola hepatica.*

walls to the body cavity. Here they wander over the surface of the viscera and the walls of the body cavity and as a rule finally perforate the capsule of the liver and reach the extremities of the biliary canals. A few go astray and perforate the diaphragm, getting to the lungs. In the liver the young flukes grow and make their way down the canals, the larger ones being found in the bile ducts, and begin again the life cycle with the formation and passage of eggs.

Distribution.—This parasite occurs over a large part of the world, where low, wet pastures and the presence of suitable snails make it possible for it to exist. In the United States it occurs on the Atlantic and Pacific coasts in places, and along the Gulf of Mexico. In these regions it occurs in wet pastures, especially along rivers and tributary streams. The States in which the fluke is most prevalent are Washington, Oregon, California, Texas, Arkansas, Louisiana, Alabama, and Florida. It is also prevalent in Porto Rico and Guam.

Symptoms and lesions.—Sheep are likely to put on fat and seemingly improve in condition in the early stages of liver-fluke disease, usually in the summer and fall, apparently as a result of a stimulation of the functions of the liver. Later, however, they lose in condition. The skin and mucous membranes are paler and the animal is less lively. The animal feeds less and ruminates less. Edema appears as the composition of the blood is altered, and may be seen as swellings along the pendant portions of the body, for example, in the region under the jaw. During the winter the sheep becomes leaner, breathes rapidly and feebly, and is dejected. A diarrhea is usually present at a late stage of the disease.

Animals may die at any stage of the disease, but if they survive the attack the flukes leave the sheep in the spring and a part of the damage is repaired. Total recovery is hardly possible, as the liver is burdened with scar tissue in the areas where the flukes have been. The disease may be diagnosed from its symptoms, if one is familiar with it, but a safer diagnosis is based on the finding of the worm eggs in the sheep manure.

For the purposes of the farmer and sheepman the surest diagnosis is made by killing a sick sheep and making a careful post-mortem examination. If the ducts of the liver are carefully slit and examined, the flukes will be found as dark, leaflike objects which, if watched a short time, will show movement. The liver may be washed in a plentiful supply of clear water as it is cut up, and the water examined for the flukes that may wash out. The liver of infected sheep is softened and roughened, and may show channels under its capsule. In old cases puckered scar areas are present.

The softening of the liver is what gives the name of "liver rot" to the disease. The biliary canals and gall ducts are much thickened and enlarged and often are marked by ridges on the surface of the liver.

Treatment.—The two remedies which have been found satisfactory are male fern and kamala. According to some writers, however, kamala is much less efficacious than male fern.

Oleoresin of male fern is administered as follows: Give by mouth 3 to 5 grams of the male fern (from ¾ of a teaspoonful to 1¼ teaspoonfuls), according to the size of the sheep, in 10 mils (2½ teaspoonfuls) of a nonpurgative oil, in the morning, two hours before feeding. Administer the treatment on five consecutive mornings. The male fern should contain 24 to 25 per cent of filicine and 3.5 per cent of filicic acid.

Powdered kamala is administered as follows: To yearlings and older sheep give 15 grams divided into two doses of 7.5 grams (2 drams) each, and give at 12 to 24 hour intervals. The entire 15 grams may be given in one dose to a strong animal or divided into five doses for weak ones. After treatment sheep are dull for 3 to 5 days, they lie down a great deal, eat little or may stop eating for a day or two, and have a diarrhea. The flukes are said to die in 3 to 8 days.

It is advisable to have these drugs administered by a competent veterinarian.

Prevention.—The manure from infected sheep should not be put on pasture, especially on wet ground. Sheep should be kept off wet pasture in places where fluke is prevalent and swampy areas should be drained, filled, or fenced off. Dressings of lime and salt on pastures in June, July, and August have been recommended for killing the embryos and larvæ of the fluke and for killing and repelling snails. It is said that sheep never become infected with flukes on salt marshes. Infected sheep should be isolated and either treated for fluke or butchered before they have lost condition and become unfit for food. Where fluke is present in a flock, it is advisable to treat the flock at the beginning of winter after the danger of fresh infestation is past. Frogs, toads, and carp are useful in the control of snails. Safe drinking supplies must be provided for sheep as the infection may be water-borne.

The Oregon agricultural experiment station has recently recommended the addition of copper sulphate (bluestone) to standing water or streams in pastures to destroy the snails which are the necessary intermediate hosts of liver flukes. After ascertaining the volume of standing or running water to be treated, add one ounce of copper sulphate to 7,800 gallons of water or about one part of copper sulphate to one million parts of water. This will kill snails in 48 hours, but will not not kill the eggs. Repeat this treatment in two or three months, after the eggs hatch. The solution is not injurious to the higher plants and animals or for bathing, drinking or irrigation, but it may injure fish.

THE LARGE LIVER FLUKE.[16]

Location.—The large liver fluke occurs in the liver, commonly lying in cysts which contain one to several flukes and a quantity of dark-colored fluid filled with débris. While these cysts may originate in a biliary canal, they extend into the tissue, and the fluke is habitually found as a parasite in the liver substance in cysts and not as a parasite of the canals and ducts. Wandering flukes may be found in the lungs or elsewhere.

Fig. 23.—Large liver fluke (*Fascioloides magna*). Natural size. (From Stiles, 1898.)

Appearance.—This is a large, thick species, which may attain a length of 10 cm. (4 inches) (fig. 23). The anterior, or front, sucker is not carried on a distinct cone, as in the case of the common liver fluke, but in its general appearance otherwise it resembles an overgrown specimen of the common liver fluke.

Life history.—The life history of the large liver fluke has not yet been ascertained, but there is every reason to suppose that it is much the same as that of the common liver fluke, with snails of some sort, perhaps the same as those which carry the common liver fluke, as intermediary hosts.

Distribution.—North America appears to be the home of this fluke, although it has been transplanted elsewhere. In the United States it is most prevalent near the Gulf of Mexico, especially in Arkansas and along the coasts and river valleys of Texas. It also occurs along the west coast in both the United States and Canada and seems to have obtained a foothold at some inland points, as in part of Colorado. Cases are also reported from Wisconsin and New York.

Symptoms and lesions.—This parasite is much more common in cattle than in sheep. It seems to do rather little damage in cattle apart from rendering the livers unfit for use as food. In sheep, however, it may do considerable damage. Infected sheep lose condition, but the appetite persists up to the time of death. Edema is present in the form of watery swellings of the dependent portions of the body. Abortions have been reported as prevalent in a flock of infested sheep, though it is unsafe to associate this with the fluke without further evidence.

[16] *Fascioloides magna.* Synonym, *Fasciola magna.*

On post-mortem examination the livers show the characteristic cysts or else dark-bluish scars where the flukes have been and where healing has taken place. The flukes apparently die in the liver instead of passing out in the spring, as the common liver fluke does. The cysts take on the character of abscesses and may be present in the lungs and spleen as well as in the liver. Affected livers and other organs contain more or less coal-black pigment characteristic of the presence of this parasite. The worms may set up peritonitis, and the omentum may show black markings.

Treatment.—No treatment is known for this disease, though the use of oleoresin of male fern or kamala is indicated as for the common liver fluke.

Prevention.—The same measures that are used in the case of the common liver fluke (see p. 35) are indicated here. As already noted, while we do not know the life history of this fluke, the probabilities are that the measures indicated will apply.

ROUNDWORMS.

The parasitic roundworms or nematodes are elongated, cylindrical, unsegmented worms. Some of them may be properly characterized as threadlike or hairlike. The body wall is usually rather transparent, and when the worms are examined with a microscope the internal organs are readily seen, usually in the form of a number of tubes. The sexes are generally separate and the males are usually smaller than the females. In general the females produce large numbers of eggs, though sometimes the eggs hatch in the body of the female and some roundworms produce embryos without the previous formation of an egg with its yolk material and shell.

Most of the roundworms of sheep reach the animal in which they develop to maturity through the direct swallowing of the eggs or young worms without passing through part of their development in some intermediate host, as the tapeworms do. In some cases the young worms that have hatched in the fields penetrate the skin of the host animal, entering the body in this way instead of by the mouth. Other worms have an intermediate host and undergo a certain development in this host before getting to the final host. The intermediate host harboring the larval worms may be eaten by the final host, thus infecting it through the digestive tract, or such intermediate hosts as mosquitoes may infect the final host by inoculating it with the larval worms which then penetrate the skin.

Even in the case of direct infection, when eggs or young worms are swallowed by the host animal, nematodes which develop to maturity in the intestine may not go directly there and develop immediately. They may pass through the walls of the digestive tract and get to the blood stream, leave the blood stream for the air passages of the lungs, crawl up the windpipe, and then pass down the esophagus or gullet, and thus reach the intestine again, where they continue their development to maturity.

THE STOMACH WORM.[17]

Location.—This worm is a parasite of the fourth stomach. It may be found elsewhere in the digestive tract, but such occurrences are of little significance.

Appearance.—Stomach worms (fig. 24) are from one-half to $1\frac{1}{4}$ inches long and about as thick as an ordinary pin. The females are the larger and have a spiral striping. In the rear half of the body of the female there is a projecting portion, which may be seen on close examination. The smaller male may be distinguished by the fact that the posterior or tail end of the body is flattened and expanded.

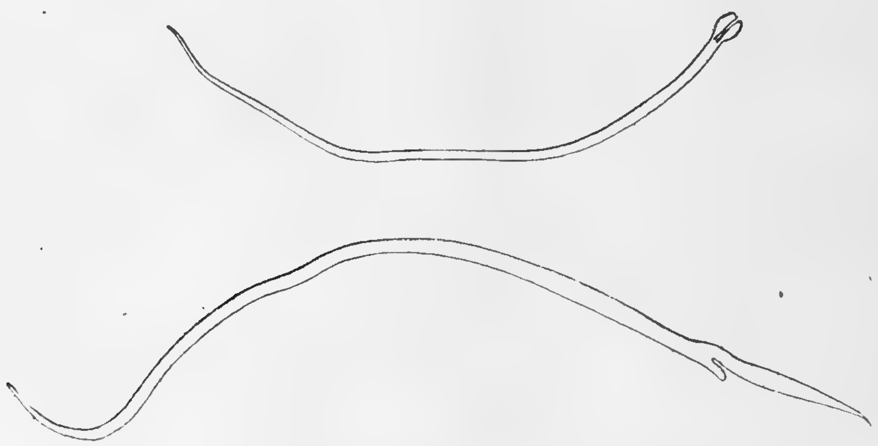

FIG. 24.—Stomach worms (*Hæmonchus contortus*). Upper figure, male; lower, female. Magnified five times.

Life history.—The eggs produced by the female worms pass out in the manure and hatch in a few hours under the most favorable conditions of warmth and moisture. Under less favorable conditions hatching may require a number of days or even weeks. The embryo which leaves the egg undergoes further development until it becomes an ensheathed, infective larva. In this condition it is inclosed in a double skin and is very resistant. Whereas drying and low temperatures may kill the egg or embryo previous to this stage, the ensheathed larva can withstand severe cold and long periods of dryness. When the grass is wet with rain or dew, these larvæ crawl up the blades. Here they are swallowed by sheep as they graze. In the stomach the worms become mature in the course of two to three

[17] *Hæmonchus contortus.* For additional information see Department Circular 47 on "Stomach Worms in Sheep."

weeks, but do not begin to produce eggs in large numbers until about a month after they are taken in by the sheep.

Distribution.—The stomach worm occurs over almost the entire world, wherever there are sheep, cattle, or other suitable host animals. In the United States it is most plentiful in the South, where it is favored by abundance of warmth and moisture, but it is quite a common and serious pest in the Middle West and in low, wet areas throughout the entire country. It is present in smaller numbers and does less damage in the high, dry, and cool areas of the Rocky Mountain States.

Symptoms and lesions.—The first things noticed about infested sheep are dullness and lack of thrift. Diarrhea may be present. Later, the more characteristic features of stomach-worm disease become evident in the form of anemia and edema. The anemia is manifested in the paleness of the skin and of the linings of the mouth and eyelids, and is due to the impoverishment of the blood from the bloodsucking habit of the worms. The edema is manifested in a swelling of the pendant portions of the body, especially of the portion under the jaw, causing what is called "bottle jaw." Sheep may become emaciated and finally die.

If the fourth stomach of a sheep infested with stomach worms is opened (the fourth stomach is the one to which the upper end of the small intestine attaches), the worms can usually be seen as wriggling red objects. When the contents of the stomach are poured out many of the worms will usually remain attached to the lining of the stomach. A little careful washing will reveal the worms if they are covered by the stomach contents. Close investigation of the lining of the fourth stomach will also reveal the pin-point punctures caused by the bites of the worms. There are usually a number of these for every worm, as the worm has the habit of attaching at one point for a time and then moving away and attaching at another point, leaving the old point of attachment bleeding for some time. The carcass of a sheep seriously infested with stomach worms is liable to be emaciated and the meat pale.

Treatment.—A satisfactory treatment for this disease is the use of a 1 per cent solution of copper sulphate in water. A dose which has been found satisfactory is 100 mils (about 3 ounces) for yearlings and older sheep and half as much for lambs 3 months old or older. To make this solution, dissolve one-fourth pound of copper sulphate in 1 pint of boiling water, then add cold water to make a total of 3 gallons of the solution. Porcelain or enamel-ware receptacles should be used for the solution, as bluestone (copper sulphate) will corrode metal. This amount will dose 100 adult sheep, allowing 10 per cent waste. Use only clear blue crystals of copper sulphate.

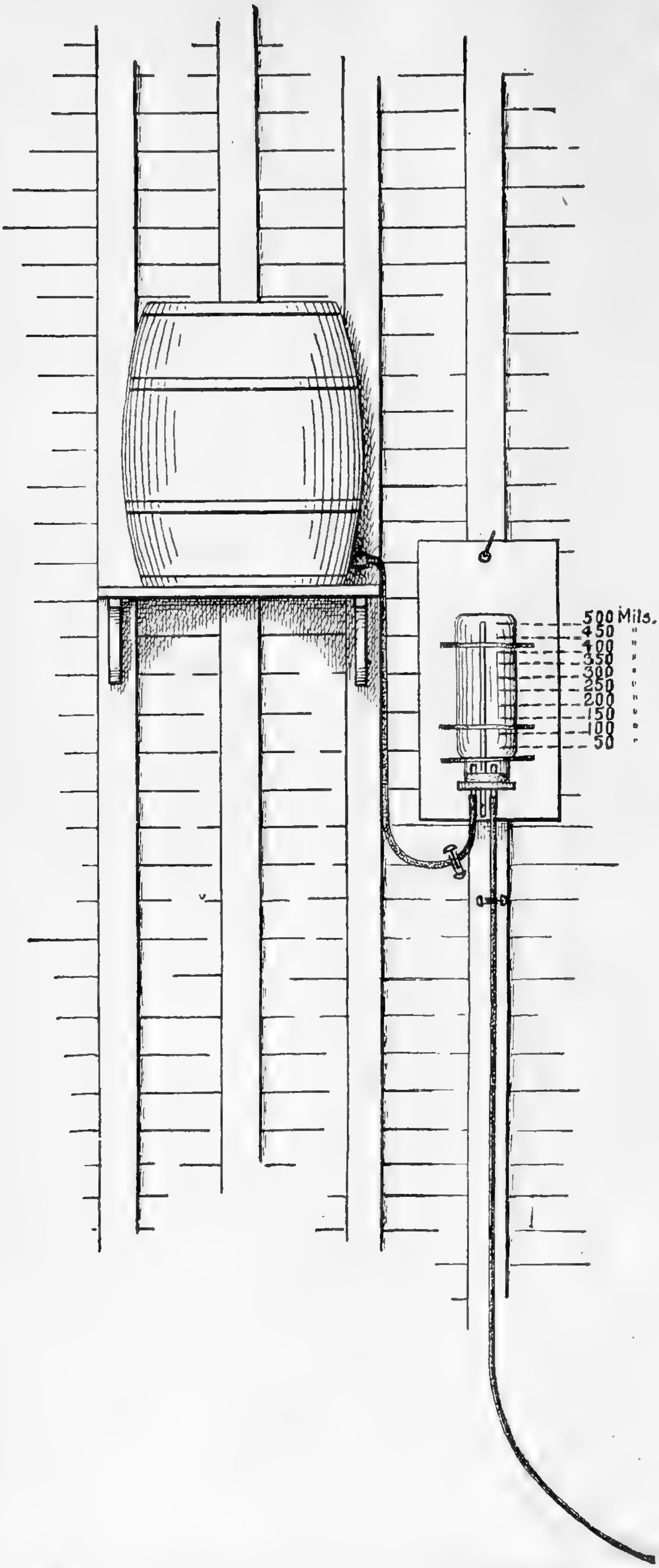

FIG. 25.—Dosing device for administering copper-sulphate solution.

discarding the pieces that have turned white. Crushing the crystals will hasten solution. In dosing, one may use a rubber tube with a funnel on one end and a piece of metal tube at the other. The metal tube is placed in the sheep's mouth and the solution slowly poured through the funnel. If large numbers of sheep are to be treated, the apparatus figured (fig. 25), or something similar to it, may be used. The copper-sulphate solution is fed from a high reservoir, by siphoning or by a tube or spigot near the bottom, through a rubber tube into an open graduated glass tube, which may be made from a large olive jar, and allowed to escape in measured doses through the other rubber tube to the metal tube in the sheep's mouth. Instead of an open graduated glass tube, a large bottle or jar may be used if a third tube is put in the jar, through the cork, one end being open to the outside and the other opening near the bottom of the inverted jar, to equalize air pressure. This is shown in figure 25. The flow into and out of the glass tube is controlled by pinchcocks, one person attending to this and one holding the metal tube in the sheep's mouth. The sheep should remain on all four legs, with the head held horizontally while it is being drenched, which decreases the danger of getting the drench into the lungs and killing the sheep. The solution should be allowed to flow slowly and the metal tube be moved about slightly in the mouth at the same time in order to keep the sheep swallowing. It is essential that the copper-sulphate solution be made up accurately, be given in suitable doses, and be administered with care, and it is advisable to have a competent veterinarian give this treatment or the ones noted below in order to insure a maximum degree of safety.

The sodium-arsenite and copper-sulphate mixture and the copper-sulphate and tobacco solution, recommended for tapeworm, have also been recommended as effective against stomach worm (p. 22).

Prevention.—Preventive measures are based on the life history. We know that the disease is spread by eggs produced by the female worm, which escape in the manure on to the pastures. Infested sheep must be regarded as a danger to young and uninfested sheep. The manure from the infested sheep is likewise dangerous. Consequently, young animals and uninfested sheep should be separated from older or infested animals and not exposed to contact with the manure from these animals. Furthermore, pastures which have been used by infested animals are dangerous to young animals and uninfested ones. When animals that have stomach worms, either in a light or heavy infestation, are put on clean pasture, the eggs of the stomach worm will hatch on the ground and the infective stage of the worm will be present on the grass in considerable numbers in from 10 to 20 days, or even earlier in warm weather. The longer the sheep are on that pasture under ordinary weather conditions the more dangerous it will become from the increasing number of worms. To prevent getting dangerous infestations, it is advisable that sheep be moved every two weeks to clean pasture. Inasmuch as pastures probably remain infected for about a year after sheep, goats, or cattle are moved from them, the program of moving sheep to new pasture, where permanent pastures are used, is a rather difficult one and calls for more land than is usually available. Consequently a modification of this program is necessary.

The first essential is to protect the lambs. Young animals are more susceptible to parasitic infestation than older ones. They also suffer more from parasites when they are infected. Growth must be made during youth; it can not be made up in mature years. Parasites interfere seriously with growth and lead to the production of runts. Consequently the safest pasture should be furnished to the lambs, the older sheep taking the more dangerous pasture, where it is necessary for sheep to go back to old pasture within a year. It may be mentioned in passing that hillside pastures are apt to be safer than bottom land, as they benefit by the cleansing action of heavy rains and the following run-off, as well as holding less moisture, lack of moisture being very unfavorable to the worms. Rich bottom pastures, on the other hand, are the ones which are least likely to have an infection washed off and are apt to have the eggs and larvæ from the hillsides above washed on to them. The more or less abundant moisture, moreover, is highly favorable to these worms. It is precisely these bottom pastures which are likely to be used for young animals, as they present the best growth of grass and are most attractive.

In a plan of rotating pastures to keep down stomach worms, the sheep may be moved over cornfields, hayfields, and stubble of various sorts. During freezing weather, the eggs and nonresistant early stages of the young worms on pasture diminish as they are killed by freezing, so that the pastures at this time, while still infected, do not become increasingly dangerous. Plowing is a means by which infestation may be controlled, the young worms being turned under and buried; apparently they do not get back to the surface in numbers sufficient to cause serious trouble. Such plowed land may be sown to forage crops and the sheep turned in on these crops with safety. When different kinds of stock are rotated on pastures, sheep may safely follow horses or swine, but not cattle or goats as these latter also may be infected with stomach worms and a number of other worms common to sheep, goats, and cattle.

If the preventive measures outlined here are not possible, sheep may be given the copper-sulphate treatment, preferably in doses three-fourths as large as those where one treatment is given, once every six weeks from spring until freezing weather.

THE NODULAR WORM.[18]

Location.—The adults of the nodular worm live in the large intestine of the sheep. The larval worms live in nodules in the wall of the large and small intestine, and occasionally make their way to the mesenteric lymph glands, the omentum, or the liver. The nodules are most numerous in the wall of the large intestine.

Appearance.—The female worms attain a length of 15 mm. (about five-eighths inch), the males being a little shorter (fig. 26). Both sexes have a characteristic solid white color. The head is bent over and forms a hook with the body.

Life history.—The details of the life history of this worm are not completely known. The eggs from the female in the large intestine

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[18] *Proteracrum columbianum.* Synonym, *Œsophagostomum columbianum.*

of the sheep are passed in the manure. The subsequent development of the worm up to the time it is again found in the sheep has not been determined. When the young worms are first found in the sheep they are encysted in the wall of the intestine. These cysts commonly reach a considerable size and contain a necrotic material, usually yellowish or greenish in color, cheesy in consistence or often hard and almost stonelike (fig. 27). After a time the larvæ leave these nodules and become adults in the lumen of the large intestine. Usually larvæ can be found only in the smaller and more recent nodules. Those larvæ which get to the mesenteric lymph glands, the omentum, and the liver probably die in these places and never get back to the intestine to complete their development.

Distribution.—This parasite was originally present in this country only in the Southern and Eastern States, but it has been spreading westward, probably with infested sheep introduced into western localities for breeding purposes, and there is reason to fear that it will become generally distributed over the country. It has become rather common in the Middle West, and is a serious pest in the Northeastern States. It is still uncommon in the Rocky Mountain States, and as yet has not been reported from a number of these States.

FIG. 26.—Nodular worm (*Protcracrum columbianum*). Upper figure, male; lower, female. Magnified five times.

Symptoms and lesions.—According to one investigator (Curtice) the symptoms of this disease may be only those of general debility—a pale mucous lining of the eyelids and mouth, emaciation, dry wool, etc. In severe cases diarrhea and emaciation may be excessive. In some places sheep raising has been abandoned on account of the damage done by this worm. It is evident that the injury due to numerous intestinal nodules, which prevent large areas of the intestine from functioning properly in the work of secretion and absorption, which act as persistent irritants to the sensitive nervous system of the digestive tract, and which serve to supply poisonous material from worms, bacteria, and dead tissue to the adjacent absorbing tissues of the intestines, can not fail to have a bad effect on the host animal. The resultant loss can not be accurately stated, but it occurs in terms of meat, wool, decreased growth, and poorer quality of animals and from the fact that nodular intestines, or so-called "knotty guts," are unfit for sausage casings.

The post-mortem lesions are easily seen, the principal ones being the nodules, which may be larger than a good-sized pea, on the walls of the large and small intestines, or in the mesenteric lymph glands, the omentum, or the liver. The nodules may be small, elevated objects, or may be larger and contain cheesy or limy matter, white, greenish, or yellowish in color. These nodules are sometimes mistaken for lesions of tuberculosis, a disease almost unknown in sheep.

Treatment.—As yet we have no satisfactory treatment for this disease. The larval worms in the nodules are beyond the reach of any remedies as yet known to us. Even the adult worms in the large intestine are difficult to remove. There is some difficulty in getting a suitable drug past the four stomachs of a ruminant and into the large amount of food matter in the large intestine in sufficient strength to remove these worms. Experiments in the Bureau of Animal Industry have indicated that gasoline, in doses up to an ounce, given in milk, may remove some of the worms, but in half-

FIG. 27.—Sheep intestines showing lesions of nodular worm disease.

ounce doses may fail to remove any. Gasoline is a rather dangerous substance owing to its inflammability and the danger of getting it into the lungs and killing the sheep, and the efficacy noted is so low as hardly to warrant its use.

Prevention.—Pasture rotation, as given in the case of the stomach worm, is a valuable control measure. Dalrymple found that he could practically prevent the nodular-worm infection of lambs by raising them in bare lots, where there would be no temptation to graze and where surroundings would be unfavorable for the development of the parasite. The ewes were let into these lots whenever necessary to nurse the lambs. The lambs were given other feed from raised racks and watered from raised troughs. The racks and troughs were protected from fecal contamination and the floor of the yard cleaned frequently to keep it free from litter and manure, thereby preventing the development of the eggs in the manure in the yards. As in most parasitic diseases, the young animals suffer more than older ones and measures must be directed especially to the protection of the lambs. If persisted in, these measures and pasture rotation should keep the infestation down to a point where it does little damage.

THE SHEEP HOOKWORM.[19]

Location.—Hookworms of sheep are found in the small intestine.

Appearance.—The female hookworm attains a length of 2.6 cm. (about 1 inch), the male attaining a maximum length of 1.7 cm. (fig. 28). The worms are about one-half to three-fourths as thick as an ordinary pin. At the head end is a mouth capsule armed with teeth. The tail end of the male is expanded and flattened.

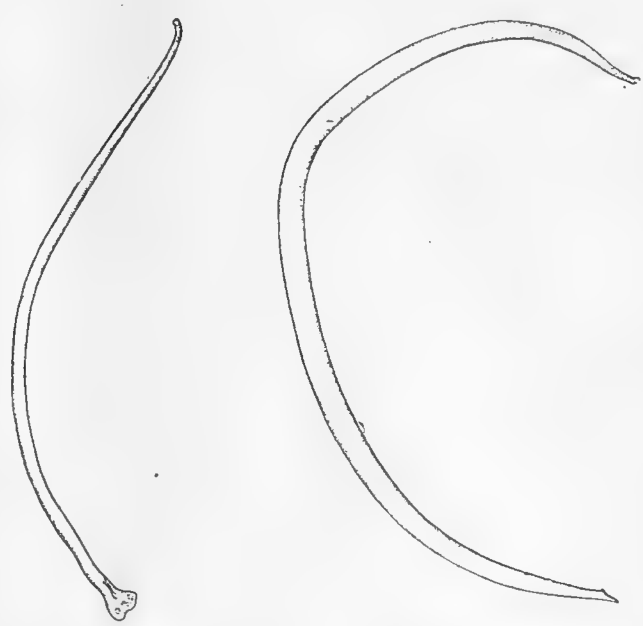

FIG. 28.—Sheep hookworm (*Bunostomum trigonocephalum*). Female at right; male at left. Magnified. (From Ransom, 1911.)

Life history.—The life history of the sheep hookworm has received little attention, but, judging from the life history of related forms, it is probably about as follows: The eggs produced by the female worm in the intestine of the sheep pass out in the manure and hatch on the pasture. Under favorable conditions of temperature and moisture the young worms develop to a resistant form capable of infecting sheep. Possibly most of the infection takes place by way of the skin, the larval worms boring through the skin of the lower part of the legs and making their way to the near-by blood vessels. In the blood the worms would be carried to the lungs, where they would escape from the blood and get into the air passages. Here they would make their way up the windpipe and then down the gullet into the stomach and intestine. When they reach the intestine they develop to adult worms and the two sexes mate. In addition to the possible entrance of larvæ through the skin, many of the infective larvæ on the pasture are undoubtedly swallowed by the sheep in food or water, but even in this case it is possible that the larvæ make their way to the blood stream

[19] *Bunostomum trigonocephalum.* Synonym, *Monodontus trigonocephalus.*

from the digestive tract and return by way of the lungs again before developing to maturity.

Distribution.—This parasite is common in sheep in the Southern States and has been found as far north as New York. Additional studies in various localities would doubtless show a wider distribution. It is apparently fairly common in Europe.

Symptoms and lesions.—The symptoms resulting from infestation with the sheep hookworm have not received much attention, but its habits are similar to those of the hookworm in man and in the dog, and these are known to cause very serious damage, so that there can be little question as to the damage that hookworm may do in sheep. The worms are bloodsuckers, with the habit of attaching for some time at one place and then moving to another, leaving the first puncture still bleeding. This bleeding persists for some time, as the result of a secretion from the mouth parts of the worm which has the power to dissolve the blood corpuscles and prevent clotting.

With hookworms in general it is not uncommon to see 10 or 12 hemorrhages associated with a single worm. This loss of blood results in its impoverishment, as well as in a net loss in amount of blood present. This in turn causes a seepage of the thinned blood out of the blood vessels and into the tissues, causing watery swellings, or edema, of the pendant portions of the body, as well as an associated condition, or dropsy, within the body. With the impoverishment of the blood the nutrition of the animal is impaired—a a very serious matter with young animals. We may safely infer that there is serious damage to the sheep's nervous system, preventing its smooth functioning and making for poor animals and poor offspring.

The things that may be looked for in connection with hookworm disease are paleness of the mucous lining of the eyelids and mouth, pale skin, dry wool, watery swellings under the jaw and along the abdomen, and a general condition of unthriftiness. The condition is very similar to that found in stomach-worm disease, as the two worms affect the host animal in substantially the same way. As it is usually complicated with stomach-worm disease, hookworm infestation is not apt to be recognized as a distinct disease. The only way to make a satisfactory diagnosis between the two conditions is by a post-mortem examination of the fourth stomach and the small intestine in order to ascertain which of the worms is present. In some cases both species of worms will be found and the results may be attributed to the mixed infestation. The lesions caused by the hookworm are red spots, or small hemorrhages, in the small intestine, while similar spots in the fourth stomach are caused by stomach worms.

Treatment.—Oil of chenopodium (American wormseed oil) in doses of about 1 dram (1 teaspoonful) in about 5 ounces of milk has been found experimentally to remove about two-thirds of the hookworms present, and petroleum benzine (a high-grade gasoline) has been found to remove about three-fourths of the worms when given in doses of a half-ounce in milk. In view of the greater safety in the use of chenopodium, this remedy seems preferable. A second treatment may be given after a lapse of two weeks. The copper-sulphate and tobacco solution recommended for tapeworms has also been recommended for hookworms.

FIG. 29.—Thread-necked strongyle (*Nematodirus spathiger*). Male, greatly magnified. (From Ransom, 1911.)

Prevention.—Pasture-rotation methods, as outlined under the subject of stomach worms, will be found of great value in controlling sheep hookworms. Proper disposal of the manure, which carries the eggs of the worm, is also important. In view of the fact that this worm possibly enters the sheep through the skin of the legs as well as through the mouth while the animal is grazing, boggy land and loose, wet, sandy soil may be looked on with suspicion as apt to convey the infection by bringing the larvæ in contact with the skin in mud or wet sand.

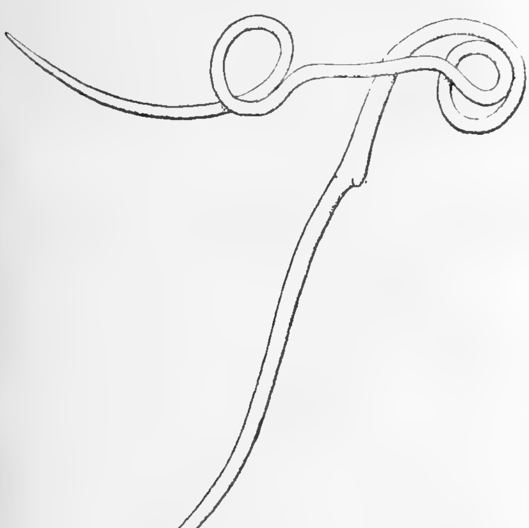

FIG. 30.—Thread-necked strongyle (*Nematodirus spathiger*). Female, greatly magnified. (From Ransom, 1911.)

THE THREAD-NECKED STRONGYLES.[20]

Location.—The thread-necked strongyles are found in the small intestine.

Appearance.—These are slender worms, the anterior portion more slender than the posterior. The head and the neck end are transversely striated. In *N. spathiger* the male worm attains a length of 1.5 cm. ($\frac{3}{5}$ inch). The female attains a length of 2.3 cm. (about 1 inch).

Life history.—The eggs produced by the female worm pass out in the feces and an embryo develops in them. This worm molts twice in

[20] *Nematodirus filicollis, N. spathiger*, etc.

the shell, the skin that separates at the second molt, however, remaining on the larva. The larva hatches under the influence of alternate moistening and drying or of temperatures of 24° to 32° C. (75° to 90° F.). Like the stomach worm, the ensheathed larva then ascends blades of grass under favorable conditions of temperature and moisture, and is taken in by sheep as they feed. These larvæ are very resistant to cold and drying, and have also been found to live in water for over 11 months. In the intestine of the sheep the larvæ develop to adult worms.

Distribution.—At least one species of these worms (*N. spathiger*) appears to be quite common in sheep in the United States.

Symptoms and lesions.—When present in small numbers it is unlikely that these worms do much damage, but sheep infested with large numbers have been found to be unthrifty. So far the only symptoms that may be attributed to them are those commonly associated with gastrointestinal parasitism in general—those of malnutrition. No definite lesions have yet been described for this worm.

Treatment.—The treatment for infestation with this worm has not yet been worked out. Oil of chenopodium, as given for hookworm, is worth trying. As previously noted, the removal of these worms may prove difficult.

Prevention.—The same measures that are of value against stomach worms will probably be of value against the thread-necked worms.

THE WHIPWORM.[21]

Location.—The whipworm occurs in the large intestine, usually in the cecum, but rarely elsewhere in the digestive tract.

Appearance.—The body of this worm is thick posteriorly and very slender anteriorly, the anterior portion of the body being two or three times as long as the posterior portion, from which fact it receives the name of whipworm. The thick portion is comparable to a whip handle and the thin portion to a whiplash (fig. 31). The male is 5 to 8 cm. (2 inches to over 3 inches) long, with the anterior portion of the body three times as long as the posterior portion. The male spicule is 5 to 6 mm. long, and has a long sheath, covered with spines, and terminating in a bulbous enlargement. The female is 5 to 7 cm. long, with the anterior portion of the body twice as long as the posterior portion. The eggs of the whipworms are characteristically lemon-shaped.

Life history.—So far as is known this worm has a simple life history. The eggs produced by the adult worm pass out in the feces

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[21] *Trichuris ovis.*

and an embryo develops in each egg under suitable conditions of temperature and moisture. When these eggs are swallowed by sheep, the embryos develop to adult worms.

Distribution.—These worms are very common in sheep in the United States and many other countries.

Symptoms and lesions. — It has been found that whipworms in man set up a low-grade inflammation, with distinct symptoms of discomfort and distress. In animals, inflamed areas are quite commonly found where whipworms attach. The head end of the worm is usually found sewed into the mucosa, and, as the mouth is unarmed, it appears that the penetration of the mucosa is perhaps due to the digestive action of a substance secreted by the worm. There is likelihood of the lining of the intestine being infected by bacteria through the entrance of the worm, or of the burrow becoming infected subsequently. Though there are no well-defined clinical symptoms for whipworm infestation in sheep, it can not be doubted that the worms exert an injurious effect, more pronounced when the worms are numerous. On post-mortem examination the thick posterior ends of the worms will be found in the lumen of the intestine, the anterior ends being in the mucosa.

FIG. 31.—Whipworms (*Trichuris ovis*). Female at left; male at right. Magnified. (From Curtice, 1890.)

Treatment.—There is no satisfactory treatment yet known to us for whipworm in sheep.

Prevention.—Prevention of whipworm in sheep is a matter of sanitation and pasture rotation. The same measures that are useful in controlling stomach worm will be found of value in controlling whipworm.

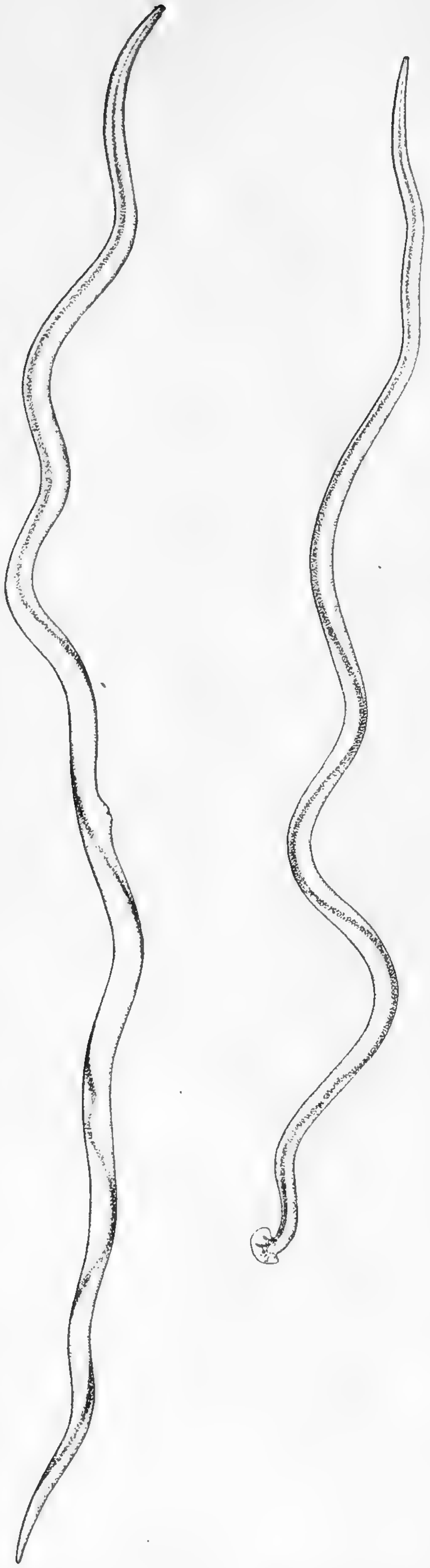

FIG. 32.—Thread lungworms (*Dictyocaulus filaria*). Male at right; female at left. Highly magnified. (From Curtice, 1890.)

THE THREAD LUNGWORM.[22]

Location.—The thread lungworm is found in the air passages, bronchi and bronchioles of the lungs.

Appearance. — These are rather long worms, easily observed. They are white and the intestine shows as a dark hair line throughout the length of the worm (fig. 32). The male is 3 to 8 cm. (from more than 1 inch to more than 3 inches) long. The female is 5 to 10 cm. (2 to 4 inches) long, with a straight, conical tail. The eggs contain an embryo when they leave the body of the mother worm.

Life history.—The eggs deposited by the female hatch in the lung of the host animal, probably in the course of 24 hours, and are expelled in coughing, or swallowed and passed in the feces. The newly hatched larva has a rounded head and a rather blunt tail. It molts twice in the course of the next few days, the time varying with temperature and moisture, and, under ordinary circumstances, is infective within 10 days. This larva then climbs up grass blades, when they are wet and the weather is warm, as does the larva of the stomach worm and thread-necked worm, and here it is taken in by grazing sheep and makes its way to the lungs. In the course of a month the sheep begin to show symptoms of lungworm, and in about five weeks embryos appear in the manure.

Distribution. — These worms are widely distributed over the world and are comparatively common in the United States, especially in the South and where there is plenty of moisture and warmth.

[22] *Dictyocaulus filaria.* Synonym, *Strongylus filaria.*

Symptoms and lesions.—The worms and their eggs and larvæ set up an irritation of the lung tissue at the point where they are located, causing inflammation and a catarrhal condition, the latter manifested in the production of a frothy mucus, sometimes containing traces of blood. Bacterial infection of the weakened lung tissue may follow, and the lungs may show pus and consolidated areas. Usually the latter conditions are not present. The symptom first noted is a husky cough, and if the invasion is extensive this may be followed by difficulty in breathing. If left alone some animals are likely to die of weakness or suffocation. The disease may be diagnosed from the clinical symptoms by an experienced veterinarian or stockman who is familiar with it; the diagnosis may be confirmed by a microscopic examination of the saliva from the back of the tongue or from the pharynx, though occasionally one may not find larvæ, especially in recent infections, in spite of the presence of worms in the lungs. On post-mortem the lungs show inflamed patches, and the worms can be found in the air passages.

Treatment.—Most of the treatments by intratracheal injections that have been used for lungworm disease of cattle are not very satisfactory and are rather dangerous to sheep. A treatment which has been used on a large number of animals with reports of satisfactory results consists in injecting chloroform in 3-mil doses (about three-fourths of a teaspoonful) into the nostrils of the sheep by means of a medicine dropper, the head of the sheep being tilted back. The nostrils of the sheep are then held with the fingers until the animal is somewhat groggy. This treatment may be repeated at intervals of three to five days, if necessary, for a total of not more than three doses. It is recommended that a dose of Epsom or Glauber's salt be given two hours after the treatment.

Nursing treatment is always advisable in this disease. Sheep should be taken off wet pasture and placed on high, dry pasture or put up and fed dry feed. A safe supply of drinking water and plenty of good feed are of value in tiding the sheep over the critical stages of the disease and allowing the worms to die out.

Prevention.—The same general rules that apply in the case of the stomach worm apply here. Sanitation and pasture rotation, isolation of infested animals, and special precautions in regard to the pasturing and watering of lambs and young animals are all measures of value.

THE HAIR LUNGWORM.[23]

Location.—These worms occur in the small bronchioles and in the lung tissue.

[23] *Synthetocaulus rufescens.* Synonym, *Strongylus rufescens.*

Appearance.—Hair lungworms (figs. 33 and 34) are much smaller than the thread lungworms. The body has a characteristic brownish-red color, due to the color of the intestine. The male is 1.8 to 2.8 cm. (about two-thirds inch to a little more than 1 inch) long and terminates at the tail in a corneus arc, followed by the small bursa (fig. 33). The female is 2.5 to 3.5 cm. (1 to 1.4 inches) long, with a moderately pointed tail.

FIG. 33.—Hair lungworm (*Synthetocaulus rufescens*). Tail of male, viewed from side. (From Railliet, 1893.)

Life history.—The life history of the hair lungworm has not yet been worked out, but it is probably similar to that of the thread lungworm.

Distribution.—The parasite is widely distributed and has been found to be fairly common in the United States. It is perhaps less common than the previous species or is possibly found less often because it is smaller.

Symptoms and lesions.—These worms occasion various forms of verminous pneumonia. The adult worms cause a lobular pneumonia; the eggs and larvæ cause a diffuse pneumonia, or when aggregated in the pneumonic areas may cause a pneumonia with areas resembling tubercles. These areas show as grayish-yellow tumors, which may attain a diameter ranging from a few millimeters to 2 centimeters (four-fifths of an inch). Careful post-mortem examination of these pneumonic areas will disclose the reddish worms, and the eggs and embryos may be found by microscopic examination of such tissue. The weakened tissues afford lodging for disease-producing bacteria, sometimes leading to pus formation, in which case the evil effects are considerably increased. Sheep will survive an infection with worms which prevents only a small amount of lung tissue from functioning, but heavy infections reduce the amount of living tissue available for breathing to an extent that often proves fatal, and bacterial complications add to this and to the toxic material which is absorbed to the injury of the animal.

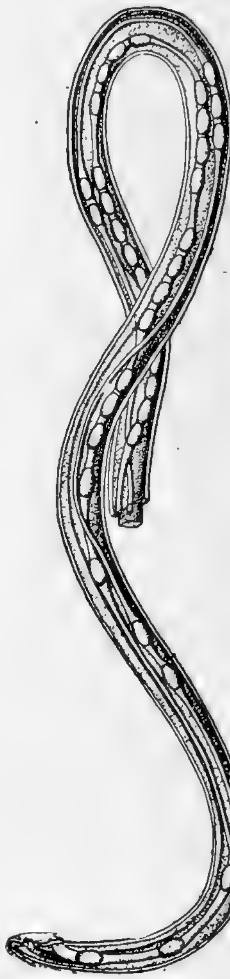

FIG. 34.—Hair lungworm (*Synthetocaulus rufescens*). Tail of female, viewed from side. (From Curtice, 1890.)

Treatment.—We have little evidence in regard to a satisfactory treatment for this worm, but the treatment, including nursing treatment, given for the preceding species would be worth trying.

Prevention.—The preventive measures outlined for the thread lungworm apply here.

OTHER INTERNAL PARASITES.

Various other kinds of roundworms besides those that have been mentioned infest sheep, and some of them at times prove very injurious. The methods of prevention recommended for stomach worms, hookworms, and others in this bulletin, will help to protect sheep also from these other roundworms. There are also certain species of flukes, tapeworms, protozoa, and arthropods, other than those discussed here, which are omitted because they are relatively less important, so far as we are aware at present.

PUBLICATIONS OF UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO PARASITES OF SHEEP.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Sheep Scab. (Farmers' Bulletin 713.)

The Sheep Tick: Its Eradication by Dipping. (Farmers' Bulletin 798.)

Screw-Worms and Other Maggots Affecting Animals. (Farmers' Bulletin 857.)

The Spinose Ear Tick and Methods of Treating Infested Animals. (Farmers' Bulletin 980.)

Stomach Worms in Sheep. (Department Circular 47.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

The Nematodes Parasitic in the Alimentary Tract of Cattle, Sheep, and Other Ruminants. (Bureau of Animal Industry Bulletin 127.) Price, 20 cents.

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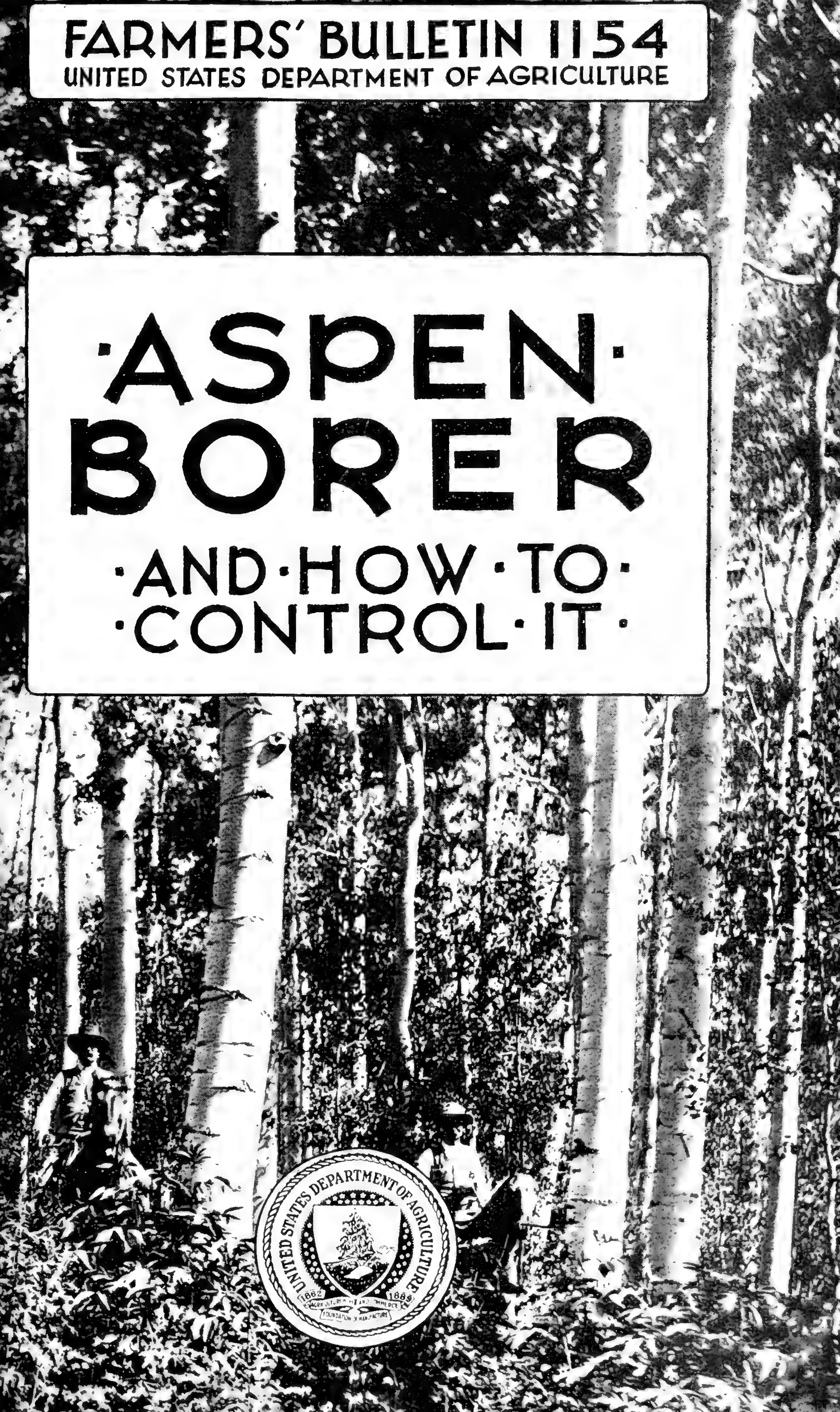
FARMERS' BULLETIN 1154

UNITED STATES DEPARTMENT OF AGRICULTURE

·ASPEN· BORER

·AND·HOW·TO· ·CONTROL·IT·



POPLARS, aspens, and cottonwoods, which are widely distributed over the United States, are everywhere subject to serious injury by wood-boring insects. One of the chief of these is the aspen borer, which feeds in the trunks or larger branches, so weakening the wood that the tree is readily broken off by windstorms. Plantations for paper pulp are often completely destroyed.

This bulletin gives methods of controlling the aspen borer or reducing its damage to a minimum. It is based on extensive studies made in the Pikes Peak region of Colorado, but the data in general apply to all regions of the United States where the poplars are native. The introduced Lombardy poplar is very seldom injured, but the commercial cottonwood of the Mississippi Valley seems to be the only native species of poplar which is at all immune to the attack of this insect.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. October, 1920

THE ASPEN BORER[1] AND HOW TO CONTROL IT.

By George Hofer,
Entomological Ranger, Forest Insect Investigations.

CONTENTS.

TREES ATTACKED BY THE ASPEN BORER.

EXTENSIVE deadenings in aspen trees, due primarily to the work of larvæ of woodboring beetles, occur throughout the Pikes Peak region of Colorado. The most common and widely distributed insect causing this injury is the aspen borer;[1] but at higher elevations and attacking only the base of the tree another roundheaded borer[2] plays an important part, causing a large percentage of windfalls.

Aspen shade trees are equally susceptible to injury by the aspen borer and are frequently killed or so riddled that they break off in the wind.

Among the native or introduced species of poplars[3] growing in this region none is immune from the ravages of the borer. A very large percentage of the various species of poplar in Colorado Springs, Colo., and adjacent city parks, together with those in the forests of this region, are affected by this insect.

The heartwood of trees which are repeatedly attacked becomes honeycombed, causing dead limbs and tops which are easily broken off by the wind, finally resulting in the death of the trees.

Aspen and poplars generally are looked upon as short-lived trees. This is true in a measure, but on Cheyenne Mountain, in Colorado, at an elevation of 9,000 feet, the writer recorded over 75 aspen trees, growing in mixture with Douglas fir and Engelmann spruce, that had attained a size of from 15 to 23 inches in diameter and from 70 to

[1] *Saperda calcarata* Say.

[2] *Xylotrechus obliteratus* Lec.

[3] *Populus deltoides* (common cottonwood); *P. angustifolia* (narrowleaf cottonwood); *P. acuminata* (lanceleaf cottonwood); *P. fremontii* (Fremont cottonwood); *P. occidentalis* (western cottonwood); *P. nigra* var. *italica* (Lombardy poplar).

100 feet in height, with clean, sound trunks without a limb for 50 feet. These trees are from 65 to 100 years of age. (Figs. 1 and 2.)

The common aspen[4] comes up from seed scattered broadcast by the wind, and is an exceedingly valuable cover for watersheds and areas devastated by fire. It acts as a nurse to conifers which succeed it. The wood is used for fruit boxes, fence posts, and poles, and, when sound and free from insect work, for props and cribbing in coal mines. Of late years it is being used to a great extent for cabins and summer homes. (Fig. 3.)

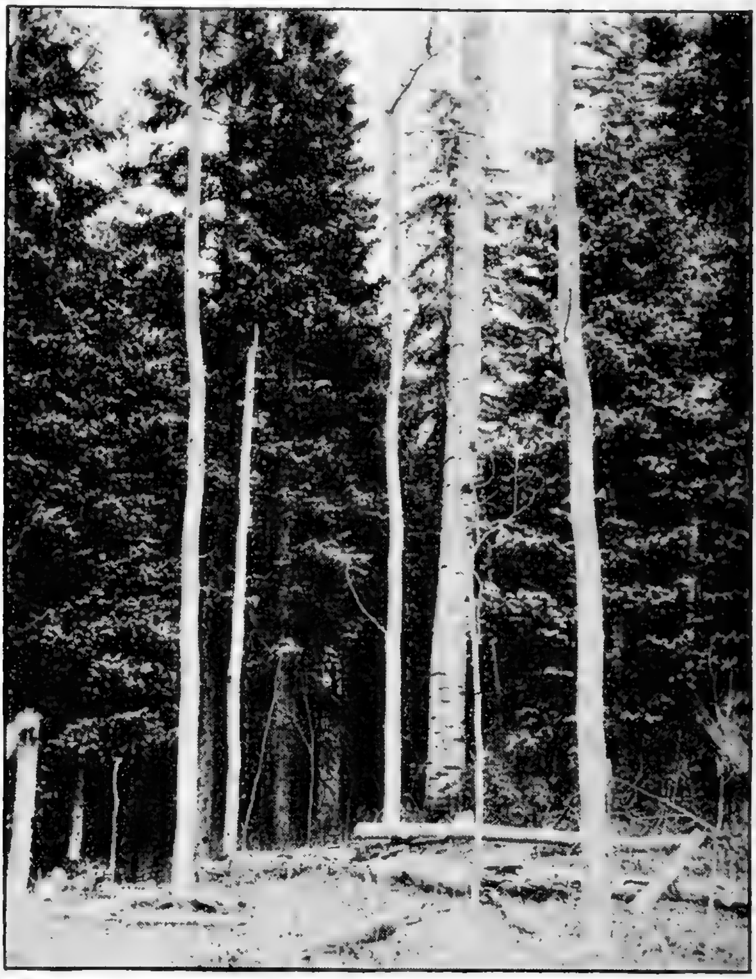


Fig 1.—Aspen growing in mixture with Douglas fir and Engelmann spruce, on Cheyenne Mountain, Colo., at an elevation of 9,000 feet.

The wood of the poplars is one of the materials used for pulp making. The trees are largely planted for shade and ornament, for windbreaks, and to hold the banks of streams.

CHARACTER AND EXTENT OF INJURIES.

The primary work of the aspen borer begins with an oblong scar made by the adult in the bark of living, healthy, and injured trees, in which the eggs are deposited, as shown in figure 4. The tiny grub or larva on hatching from the egg at once begins its destructive work by feeding and mining between the bark and wood, in which it re-

[4] *Populus tremuloides.*

mains for from 90 to 100 days. It then enters the sap and heartwood, where it excavates an oval-shaped longitudinal gallery 6 to 14 inches in length, as shown in figure 5.

The egg scars, whether the eggs hatch or not, are favorite places for entrance of other wood-boring insects and for fungi which hasten the death of such trees.

Throughout the forests of the Pikes Peak region many trees have died during the last 25 years. The old standing dead trees and those

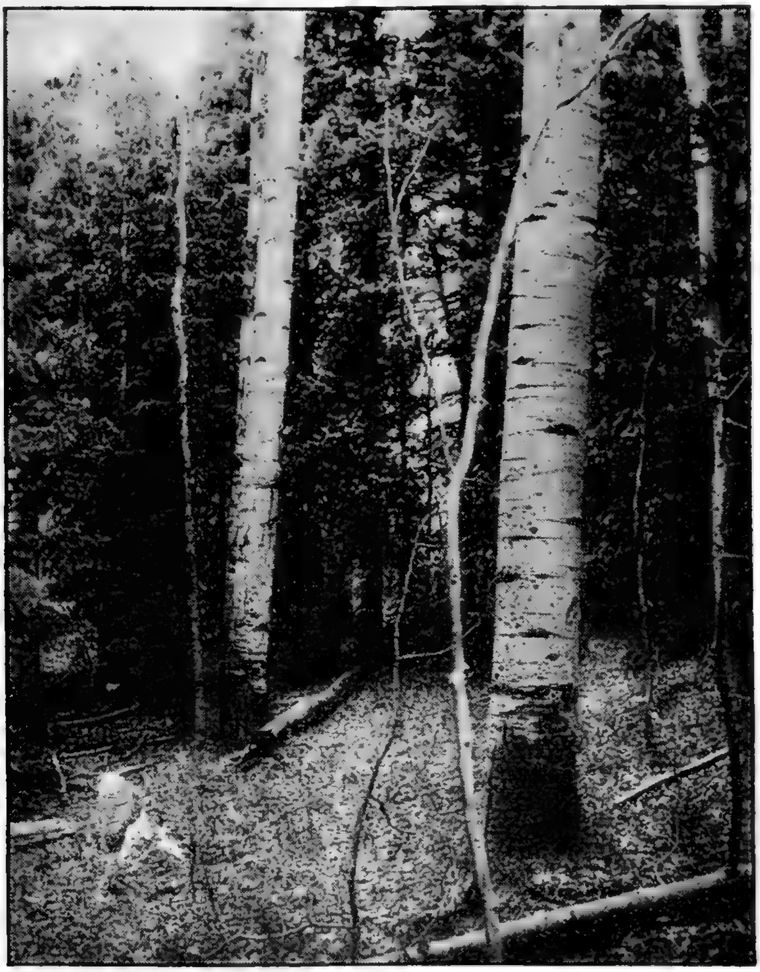


Fig. 2.—On Cheyenne Mountain, Colo., aspen which have attained a size of from 15 to 23 inches in diameter and from 70 to 100 feet in height.

which have fallen bear evidence of the primary attack of the aspen borer in the conspicuous large scars, exit holes, and deformed trunks. (Fig. 6.)

In some localities the standing dead, fallen, and dying trees exceed 50 per cent of the total stand. A count made on an area of about 2 acres near Wade, on Cheyenne Mountain, Colo., in an even-aged stand of aspen gives the following figures:

Total number of trees	667
Number of living trees	260
Number of dying trees	34
Number of dead trees	340
Number of infested trees	33

Deformed trees, 40 per cent of total.

Trees of from 2 inches up to the largest diameter are attacked by this borer. The large trees are frequently attacked close to the limbs, while smaller trees are attacked from the base up.

One of the characteristic features of the injury caused by this insect is that it is concentrated on trees that have been previously injured. In every clump of aspens trees heavily infested, or what may be called "brood trees," can be found. This feature tends to limit the destruction by this borer by confining it to such trees, and at the

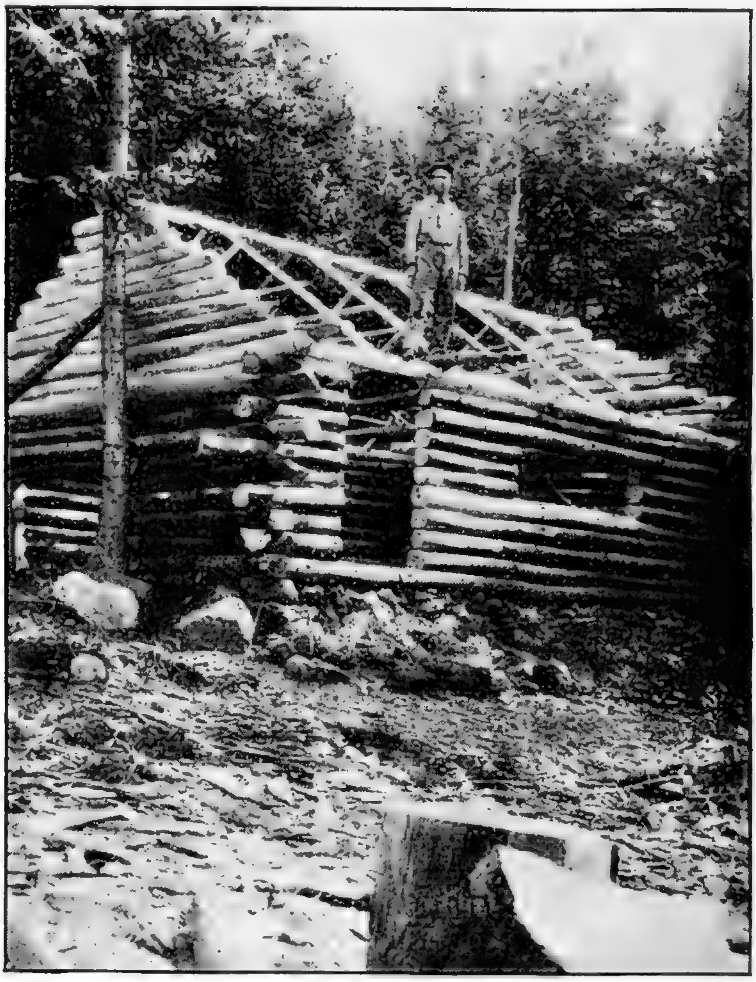


FIG. 3.—A summer home on Cheyenne Mountain, Colo., being constructed from aspen logs. These trees were cut within a radius of 200 yards of the structure. Elevation at this point, 9,000 feet.

same time it destroys many of the insects, in that these brood trees are frequently broken off by the wind or attacked by a fungus and a large percentage of the borers within fail to mature.

One of the chief causes of the rapid deterioration and death of trees attacked by this insect is a wood rot[5] or fungus which follows the work of the borer and destroys the heartwood. Following the opening made through the bark this fungus rapidly penetrates and destroys the heartwood, and so weakens the tree that it is broken off by the wind. The development of this disease is often so rapid that it envelops and destroys the borer larva before it matures.

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[5] *Fomes igniarius.*

DISTRIBUTION.

The aspen borer is found in all parts of the country, its distribution coinciding with that of the poplar.

SEASONAL HISTORY AND HABITS.

Normally this species has but one generation in three years. During the latter part of July and during August the adult female beetle gnaws in the bark an oblong scar, which slopes toward the center, penetrating the cambium or inner bark of the tree. Beneath the bark in this scar she deposits one or two eggs (fig. 4), which hatch into larvæ or grubs in from 20 to 25 days. Upon hatching, the young

a *b*

FIG. 4.—Aspen borer: *a*, Egg scar on living aspen trunk; *b*, bark removed to show eggs.

larva mines beneath the bark, remaining there over winter, and entering the sapwood and heartwood the following spring, where it is active until May or June of the second year following the egg laying. During this time the gallery is enlarged and an opening is maintained through the bark at the place where the egg was laid, and through this boring dust is expelled during the feeding period of the larva. The accumulation of these piles of fibrous frass at the base of the trees is one of the most characteristic features indicating the presence of the borer. On reaching full growth the grub (fig. 7) excavates the pupal cell near the lower end of the larval mine and remains inactive in this cell (fig. 5) until the following spring. It then pupates and remains as a pupa (fig. 8) 25 to 30 days before transforming to the adult. During the latter part of July [6] or during August of the third year the adult emerges through the hole which the larva used for expelling the frass.

[6] In the eastern United States, at an elevation of 500 feet, the beetles emerge from four to six weeks earlier.—F. C. C.

DESCRIPTION.

The adult (fig. 9) is an elongate, robust, grayish-green beetle, measuring from 21 to 30 mm. (about an inch) in length, and having faint yellowish spots on the wing covers. The antennæ or horns are very long, those of the female being about the length of the body, and those of the male even longer.

The larva is an elongate, cylindrical, footless grub of a whitish or yellowish white color. When full grown it measures from 30 to 35 mm. (about 1¼ inches) in length. It can be distinguished from all

FIG. 5.—Split sections of aspens showing larval mines and pupal cells of the aspen borer, and the character of the frass. The smaller holes on the bark section are exudation pores from which frass is expelled by the larvæ.

other wood borers in the trunk or large branches of poplars by the fact that it has the sides of the head parallel and the upper and lower surfaces of the body covered with fine horny points. On the first segment above, these are larger and curve backward. Two dark oblique lines are present on this segment in related species of poplar borers, but never on this insect.

The pupa, or intermediate stage between the larva and adult, has the same general form as the adult, but with its wings and legs folded along the side of the body. It is of a whitish color and the upper surface is provided with small horny spines.

NATURAL ENEMIES.

A tiny, wasplike, four-winged parasite which attacks the eggs of the borer has been reared and found very destructive to them.

Counts made on several areas show an average of about 25 per cent of the borer eggs destroyed by this insect.

Two-winged flies parasitic on the borer grubs were found to destroy 5 per cent of them; predacious insects and birds, less than 1 per cent. Fungous disease destroys 2 per cent of the mature larvæ, pupæ, and immature adults. The total annual mortality of the borer from these causes is from 30 to 38 per cent.

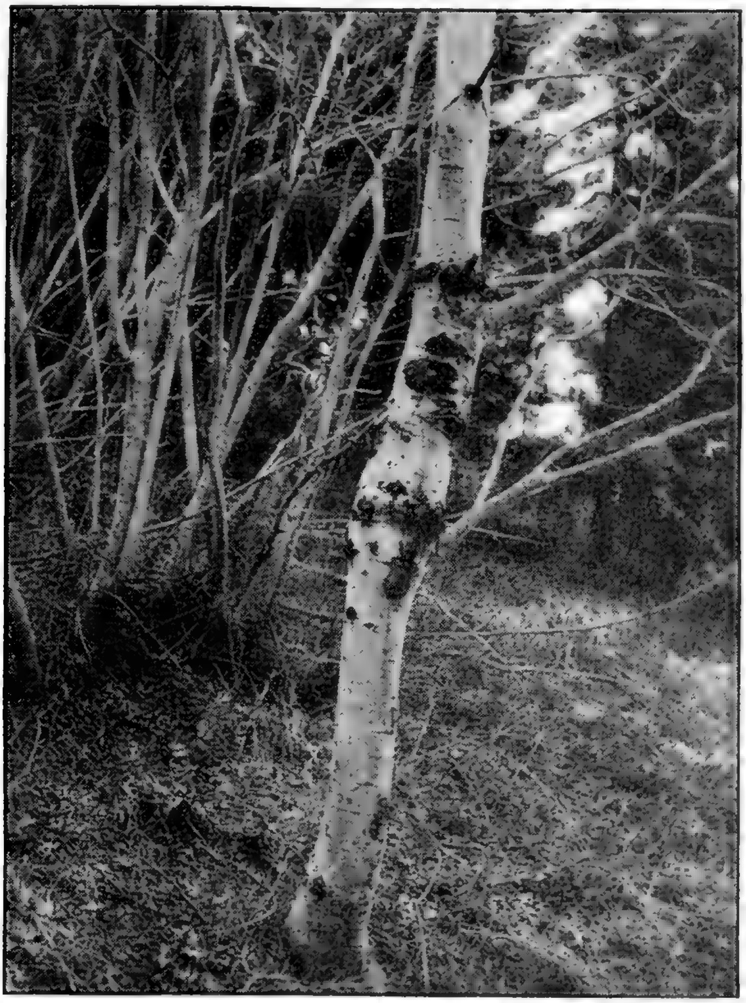

FIG. 6.—Living aspen, Cheyenne Mountain, Colo., altitude 7,000 feet. This tree is infested by 2 and 3 year old larvæ of the aspen borer. The swelling on the main trunk are the result of the work of these larvæ.

ASSOCIATED INSECTS AND DISEASE.

Generally associated with the injury of the aspen borer, there are the following insects and a fungous disease which more or less hasten the deterioration of the trees.

The bronze birch borer[7] attacks healthy, injured, and dying trees; it precedes and follows the attack of the aspen borer and may cause the death of the tree.

A flat-headed borer[8] deposits its eggs in the egg scars of the aspen borer, and in ax marks and bruises, and extends the damage in the heartwood.

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[7] *Agrilus anxius* Gory. [8] *Poecilonota cyanipes* Say.

Another flat-headed borer[9] attacks injured and dying trees. It deposits eggs in old egg scars made by the aspen borer and in other injuries, and it bores into the heartwood.

A large moth[10] which attacks the poplar and deposits its eggs in the borer egg scars is most frequently found in trees infested by poplar borers. Its altitudinal range is the same as that of the borer, none having been found above 9,000 feet.

A pinhole borer[11] attacks injured and dying trees in which the sap has begun to sour. It follows the attack of the aspen borer and is found also in trees otherwise injured.

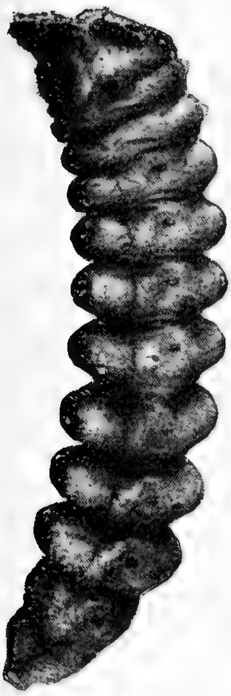

FIG. 7.—Side view of larva of the aspen borer.

FIG. 8.—Side view of pupa of the aspen borer.

FIG. 9.—Aspen borer: Adult female, from side and from above.

A roundheaded borer[12] which occurs at higher altitudes than the poplar borer is the chief depredator in the aspen. Large areas have been denuded as the result of its work.

A heart rot,[13] causing much deterioration and decay in aspen, follows the attack of the aspen borer and other wood-boring insects, gaining entrance through the wounds made by them. It is present in nearly all trees attacked by the aspen borer.

CONDITION OF TREES ATTACKED.

Living, healthy, and injured trees are attacked by the aspen borer. Dead trees are never attacked. A strong preference is shown for trees which have partially succumbed to former attacks.

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[9] *Dicerca prolongata*, Lec.
[10] *Cossus* sp.
[11] *Xyloterus* sp.
[12] *Xylotrechus obliteratus* Lec.
[13] *Fomes igniarius.*

SITUATION AND CONDITIONS FAVORABLE FOR ATTACK.

Trees on dry, rocky slopes appear to be more subject to attack than those on less exposed situations. Along the low, moist creek beds and mountain meadows the attack is not as severe as on drier slopes.

Infestation is most prevalent between altitudes of 6,500 and 8,000 feet. It has not been found to occur above 9,000 feet.[14]

CONTROL MEASURES.

Control experiments carried on from 1914 to 1917 in various localities and upon various clumps of aspen have shown that two methods are practicable and that the insect can be controlled if not entirely eliminated by either of them. The two methods recommended are the cutting of " brood trees " and the application of creosote or carbolineum.

" Brood trees " are those which are attacked for a number of years in succession and contain two or more generations of the aspen borer. These so-called " brood trees " can be readily distinguished from the healthy trees and those injured by other causes by the deformed main trunks, dead tops, limbs, and the brownish liquid and frass exuding from the egg scars during May and June each year, at which time the larvæ are active, extending and enlarging their galleries. As aspen usually grows in clumps, the main centers of infestation can be readily located.

First, locate a clump of aspen and determine the extent of the infestation, then with a sharp ax cut down the " brood trees." These can be laid in compact piles and burned or the main trunks split and exposed to the sun, which will dry out the wood enough to kill the brood. One man with a sharp ax can cut and treat 50 or more of these trees in a working day, as aspen as a rule is of small diameter.

Where it is essential or desirable to preserve the trees, the painting of the egg scars with carbolineum has proved a successful method of control, though not as effective or practicable in large and remote forested areas. On private lands and city parks, where poplars are valued for their shade and ornament, this remedy can be used to advantage.

Creosote should be applied to the egg scars with a 2-inch brush. It is important that this work be done thoroughly. October is the time to apply the creosote, after the adult beetles have deposited their eggs and most of these have hatched into tiny larvæ or borers.

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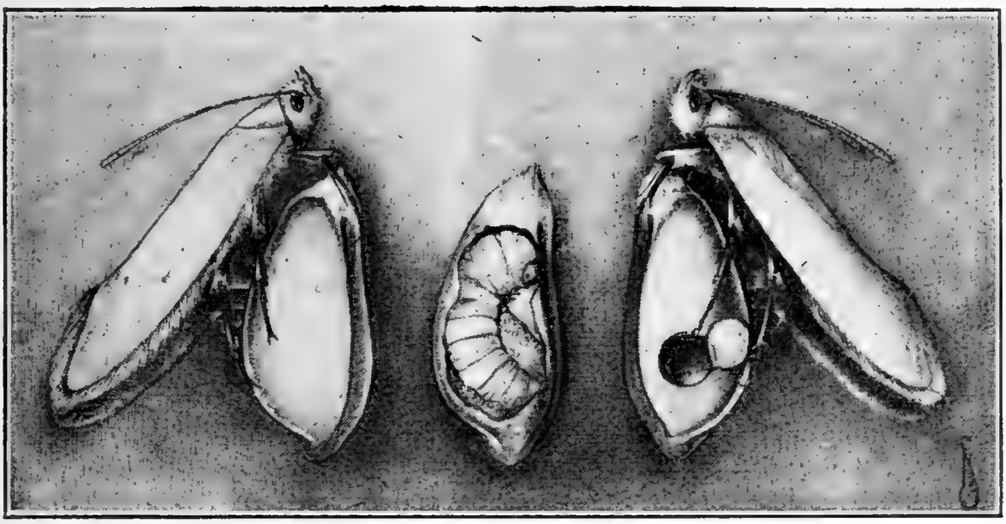
[14] In some sections of the country injury occurs down to sea level.—F. C. C.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

ANGOUMOIS GRAIN MOTH

E. A. BACK

Entomologist in Charge, Stored Product Insect Investigations



FARMERS' BULLETIN 1156

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. September, 1920

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

THE ANGOUMOIS grain moth, primarily a pest of wheat and corn in this country, attacks all cereal grains. It is particularly injurious throughout the Southern States. It does little harm north of central New Jersey except to cereals in storage.

It is second to the rice or "black" weevil in its capacity to damage grain. Often entire crops of corn and wheat are ruined. Millers are known to have refused to buy badly affected crops, as flour made from damaged wheat is not fit to eat. Wheat loses through moth attack about 52 per cent in weight. Corn, being larger, loses from 12 to 24 per cent in weight when kernels are attacked by a single insect only. As many as three or four moths, however, may develop in one corn kernel. The feeding of a single insect will completely ruin so small a grain as milo or sorghum.

Farmers suffer losses unnecessarily. Losses can be prevented by watchfulness and by application of measures advocated in this bulletin. Choose between prompt harvesting, early thrashing or shucking, proper storage, and little loss, and delayed harvesting, delayed thrashing in case of wheat, careless or improper storage, and large losses. Well-informed farmers are storing corn and wheat without loss by giving attention to cultural methods and treatment in storage by fumigation. Where one succeeds, all can.

All farmers can support campaigns to kill out the Angoumois grain moth. No pest can be controlled more effectively. If county agents will unite farmers to fight this pest they will save their counties grain worth many times the salaries paid them. Success awaits intelligent action.

ANGOUMOIS GRAIN MOTH.[1]

CONTENTS.

ESTABLISHMENT AND SPREAD IN AMERICA.

The Angoumois grain moth is a European pest that has become destructive to corn, wheat, and other grains in this country as a result of international commerce. It is called the Angoumois grain moth because long before the early days of the American Republic it had been a pest in the Angoumois Province of France. It is known also in America by the popular name of "fly weevil."

In the early days of American history there was no Federal Horticultural Board to protect our agriculture from foreign pests. The Angoumois grain moth is one of those pests that are easily carried in grain from place to place. It was brought many times to this country in seed introduced from Europe by the earlier settlers of the various colonies along the Atlantic seaboard. Since it is a pest that is easily killed out by very cold winters, it is natural that its establishment in this country occurred in one of the Southern States. The first report of the occurrence of the Angoumois grain moth in this country was in 1728, in North Carolina, where it was causing damage to wheat. It was first reported in Maryland about 1769. Between 1728 and 1775 it had spread northward into Virginia, Maryland, lower Delaware, and probably southern New Jersey. In 1852 Harris wrote that wheat in Kentucky and in the southern parts of Ohio and Indiana was already affected. Though exact records of spread are not available, it is enough to know that from the original North Carolina-Virginia infestation the Angoumois grain moth has spread, chiefly through the shipment of seeds,

[1] *Sitotroga cerealella* Oliv.

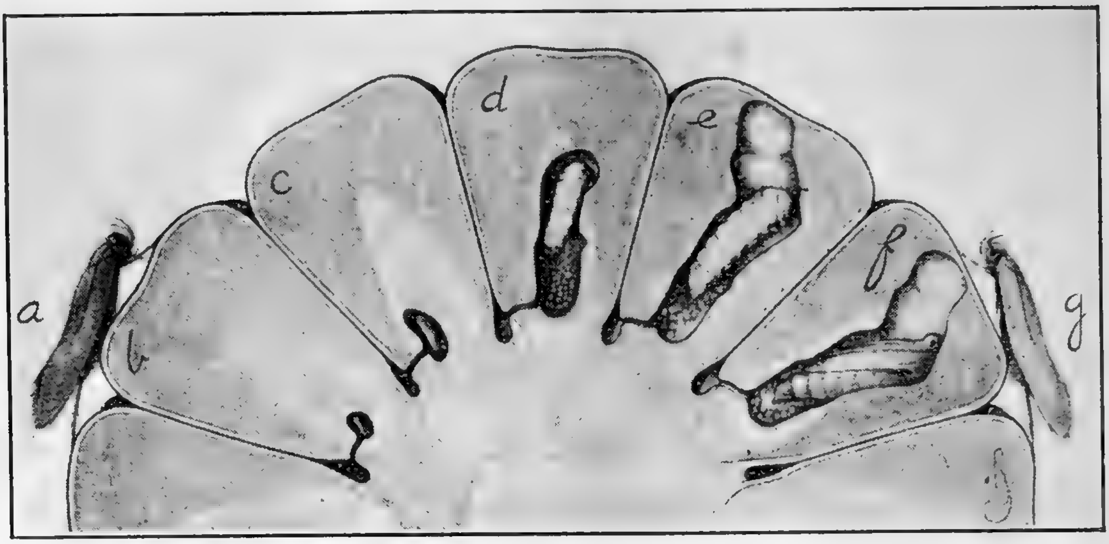

FIG. 1.—Life cycle of the Angoumois grain moth in corn. The adult moth is shown at *a* and *g*. The larva is shown in different stages of its growth at *b*, *c*, *d*, and *e*. Notice that it begins feeding at the soft germ end of the seed and as it becomes larger eats out into the harder part of the corn. The larva transforms to the pupa as shown at *f*. From the pupa develops the adult moth *g* of the second generation.

southward through all the Southern States and northward. The farther South it has spread the more destructive it has become, because it can multiply unhampered by long, cold winters. On the other hand, its spread northward has been limited by increasingly cold winter weather.

While the moth causes much injury to the wheat crops in the southern parts of the North Central States and New Jersey, Delaware, southeastern Pennsylvania, Maryland, and Virginia, crops grown still farther north are increasingly immune to attack in the field. After one passes the fortieth degree of north latitude injury from the Angoumois grain moth decreases rapidly. Because of the ease with which it can be carried in seeds the Angoumois grain moth is now and then reported from all States, even those possessing a climate far too cold to permit it to become a general pest.

DESCRIPTION.

The Angoumois grain moth passes through the usual insect stages—the parent insect or moth, the egg, the larva, and the pupa. The moth is shown in figures 1, 8, 11, and on title page. It varies somewhat in color from buff to grayish or yellowish brown. In size it varies with the size of the grain in which it matures, but is never more than 0.6 to 0.7 of an inch from tip to tip of wings when these are spread as shown in figure 8. The average wing spread of the moth is about one-half inch. Whenever moths of this size, closely resembling ordinary clothes moths, are seen flying about grain it is reasonably certain that the grain is infested with the Angoumois grain moth. The eggs laid by the moth are about one-fortieth of an inch long and are too small to be seen without the aid of a magnifying glass. They are laid on or near the grain. They are white when first deposited, but later turn a reddish color before the larva or grub hatches. A moth may lay as many as 150 eggs. An egg is shown in figure 8, *b*. The larva is shown in figures 1, 8, and on title page. When just hatched the larva is tiny, being no thicker than a hair. After feeding in the grain it becomes full grown and is then about one-fifth of an inch long, white in color, with a yellowish-brown head. The pupa or chrysalis is reddish brown and is shown in figures 1, 5, and 8.

INJURY.

Injury to grains by the Angoumois grain moth always takes place in the larval stage. Injury is more difficult to detect in the early stages of infestation because the grub or larva bores its way into the seeds when it is so small that the hole by which it enters can not be found without a close search with a magnifying glass. Usually after it has eaten its way into the seed, the larva turns about and spins a silken web over the opening by which it has entered, thus making it even more difficult to locate the entrance hole. Once within the seed, the grub eats out the interior where it feeds unseen and often unsuspected by the owner of the grain. Usually the first indication the average grower has that his grain is infested is the simultaneous appearance of moths and the round holes (figs. 2, 5, 7, 8, and 9) that appear in the individual kernels, or sometimes by the heating of the grain in the bin. Then he finds upon cutting open the seeds in which the holes have appeared that they have been hollowed out by the larva (figs. 1, 4, 5, and 8) and that his grain has not only lost heavily in weight but that it contains much excrement and webbing left behind by the insect. The larva has jaws called mandibles, and it uses them almost

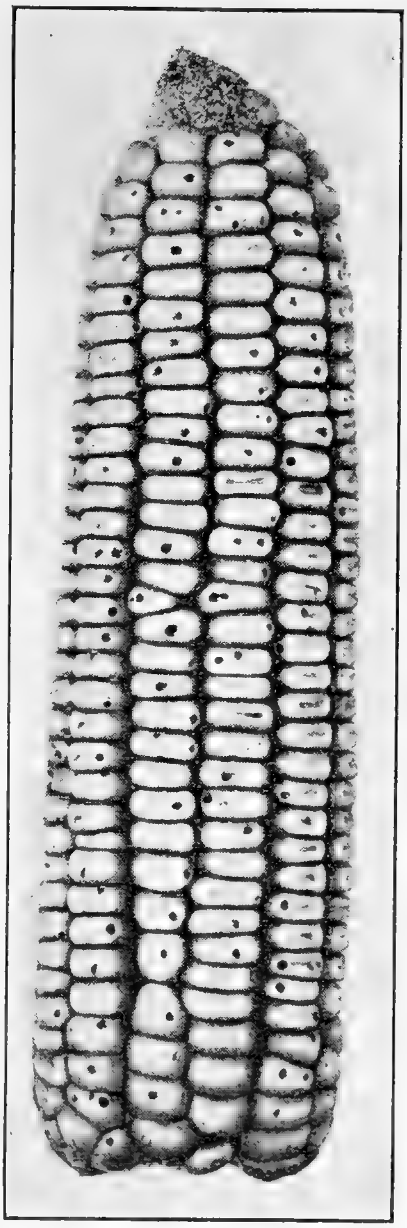

Fig. 2.—An ear of corn showing the emergence holes of the Angoumois grain moth. When these holes begin to appear in your corn and small clothes-moth-like millers are found flying when the corn is disturbed, you may be certain that the Angoumois grain moth is already damaging your corn.

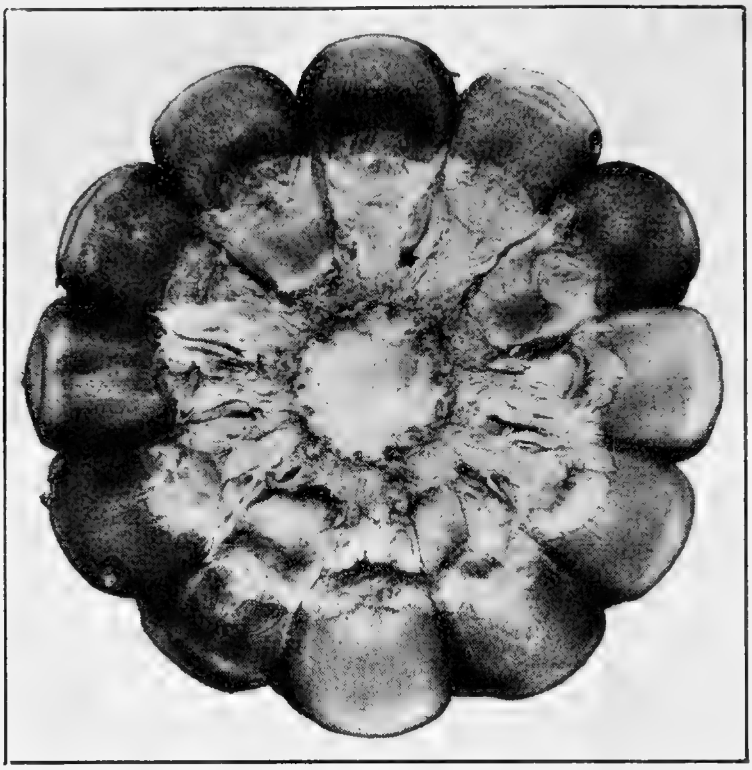

FIG. 3.—An ear of corn badly damaged by the Angoumois grain moth, broken in two to show how perfect the kernels may appear when viewed from the side.

continuously, first to gnaw its way into the seed and then to eat out the contents of the seeds to secure nourishment for its growth and to make the circular opening through which the moth itself emerges from the seed. The circular opening is not cut until the larva has become full grown. It then eats out a channel to the outside of the seed, leaving the merest film of the seed coat intact. The moth is strong enough to push off this "cap" when it leaves the seed. The opening is often called the emergence hole.

TIME REQUIRED FOR DEVELOPMENT.

Under ordinary atmospheric conditions, temperature has everything to do with the development of the Angoumois grain moth. All eggs, larvæ, pupæ, and adult moths are killed if the grain is heated throughout to a temperature of 120° F. Exposure of the eggs to a temperature of 1° F. for 24 hours has prevented their hatching. Ordinary winter storage temperatures below 60° F. in regions where the moth is a real pest will hold the moth in a quiescent or dormant state, but will not kill. Development goes on slowly between 60° and 70° F., and very rapidly between 70° and 95° F. It does not matter whether these temperatures obtain indoors or out of doors. This explains how the Angoumois grain moth can breed generation after generation in warehouses or rooms kept at a moderately high temperature in a cold climate with outdoor temperatures too low for the moth.

Experimental work has not determined the developmental period of the Angoumois grain moth for various temperatures. The eggs will hatch during the heat of summer in from 7 to 10 days. Eggs may not hatch in colder weather in 3 or 4 weeks. In general, the life cycle representing one generation from egg to adult requires in warm summer weather from 5 to 7 weeks, though the immature stages have been passed in as few as 4 weeks. During the cold of winter months the larva lies dormant for 4 or 5 months and the life cycle may be fully 6 months long. In the southern wheat belt of New Jersey there may be five generations of moths in a year under prevailing cultural conditions where wheat is left in the field until late in the season. The farther south one goes the greater is the number of generations, and in heated warehouses or rooms there may be as many as 10 to 12 generations.

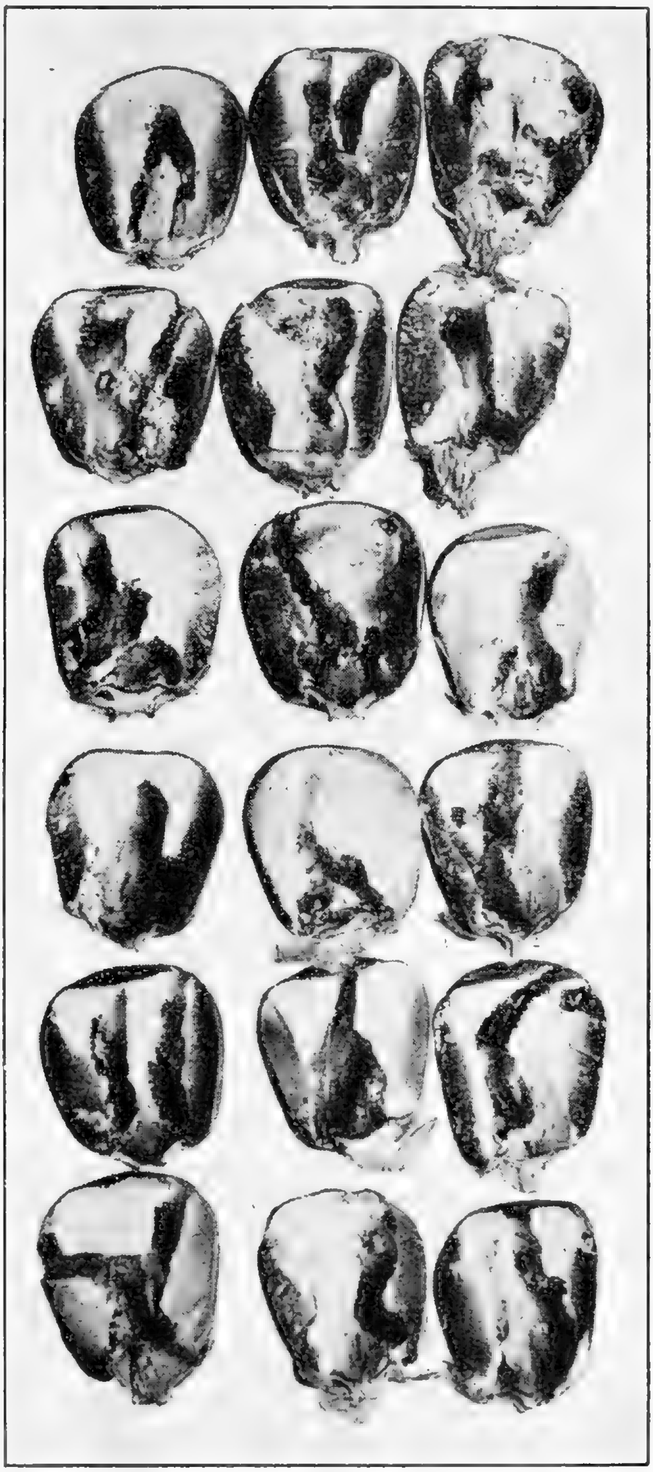

FIG. 4.—Kernels of corn cut in two to show the damage caused by the larva or worm of the Angoumois grain moth. The worm usually enters the seed at the base, destroys the germ, and then tunnels toward the tip of the kernel. Affected kernels nearly always are ruined for planting purposes.

ALL CEREAL GRAINS AFFECTED.

The Angoumois grain moth has been bred from wheat, barley, oats, buckwheat, corn, sorghum, milo, rice, beans, chickpeas, and cowpeas. It is a general feeder upon seeds of the cereal type. It causes greatest loss to wheat and corn in this country, though instances of serious attack are recorded frequently upon other grains. Beans, chickpeas, and cowpeas usually are not attacked, though if held in storage for considerable periods the Angoumois grain moth has been known to cause much damage, particularly in seeds already slightly injured by han-

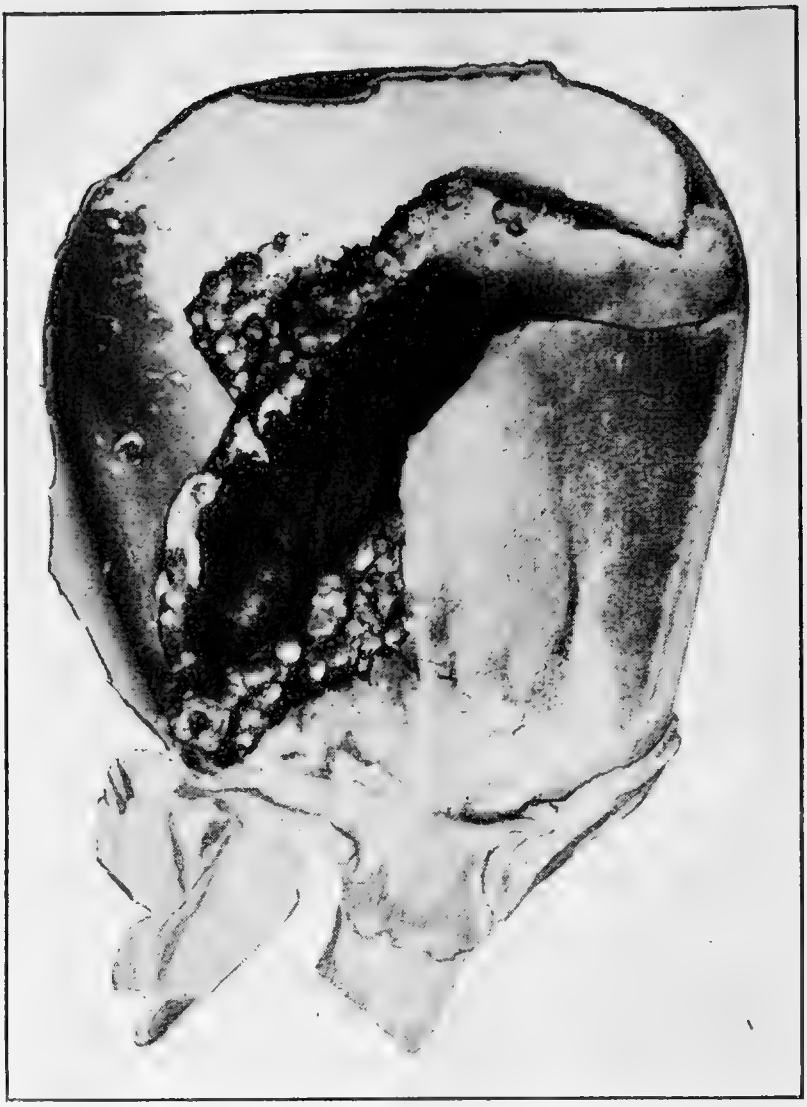

FIG. 5.—Cross section of one of the kernels of corn in figure 3, enlarged to show the cavity made by the larva of the Angoumois grain moth, the silken chamber formed by the larva, before transforming to the pupa. The large brown or blackish appearing object is the pupa from which the moth will emerge and crawl along the silken channel in escaping from the seed.

dling or by bean weevil attack. Rice handled under commercial conditions is very seldom affected.

LOSSES.

It is difficult to estimate the amount of loss caused grain growers, dealers, and millers by the Angoumois grain moth. Throughout the extreme South it is rated as a pest second only to the rice or "black" weevil.[2]

Throughout the wheat belt of Southeastern Pennsylvania, New Jersey, Delaware, and Virginia, it is the worst pest of ripening wheat and wheat in storage. Many crops have suffered a loss of 10

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[2] *Calandra oryza* L.

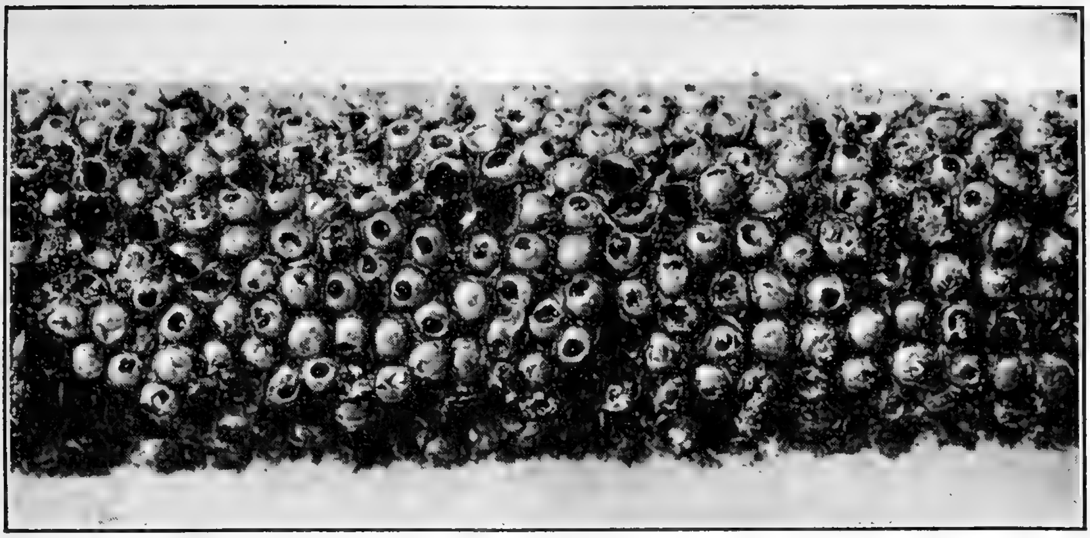

FIG. 6.—A spike of sorghum with each seed showing the emergence hole of the Angoumois grain moth. The moth completely ruins so small a seed as this.

to 60 per cent. Millers have not infrequently refused to purchase badly damaged grains because they contained so many dead insects and insect excrement. Flour made of badly infested seeds is not palatable. The actual weighing of 1,000 kernels of sound wheat and a like number of infested kernels showed a loss by weight of 56.2 per cent as a result of the development of a single moth in each of the infested kernels. (Fig. 9.)

Corn does not lose so great a percentage of its weight. The weights of an equal number of infested and perfect kernels representing seven varieties of soft dent and flint corn showed that where but one moth had developed in each infested kernel the infestation had caused a loss in weight amounting to 13.1, 13.2, 15.5, 17.3, 19.7, 23.5, and 24 per cent, respectively. The loss in weight varies with the ratio between the size of the kernel and the amount eaten by the individual insect in reaching its maturity.

FIG. 7.—A head of beardless barley showing the emergence holes of the Angoumois grain moth. Remember that unthrashed wheat, rye, oats, or barley are not at all protected from the moth.

MATURING GRAIN AND STORED GRAIN SUBJECT TO ATTACK.

The Angoumois grain moth feeds both in dried grains in storage and in grains matur-

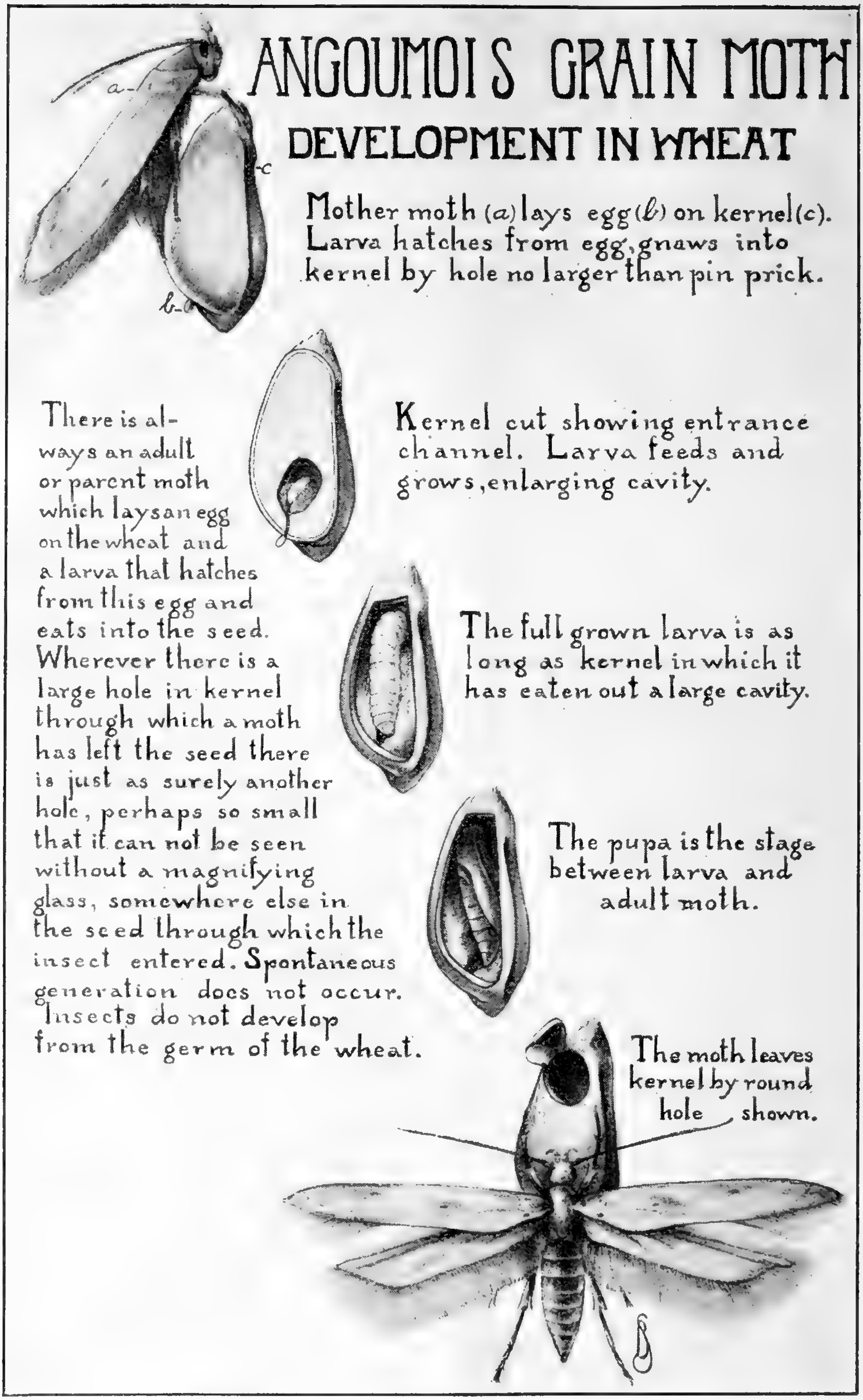

FIG. 8.—Development of Angoumois grain moth on wheat. Life cycle.

ing in the field. In storage the pest breeds generation after generation as long as the food supply lasts. This may be several years in what are commonly believed to be "air-tight" containers. In agricultural districts, especially where the pest is breeding in storage in open bins or mows, the moth is driven by instinct to leave the warehouse, barn, or crib in varying numbers and fly to the near-by fields in search of maturing grains in which to lay eggs for the first summer generation in the field. Of course many remain behind in the crib to multiply continuously throughout the year.

INFESTATION OF CORN.

Corn has an advantage over the smaller grains in that most of the kernels are covered during growth by the husk covering. It has already been pointed out that destruction by the Angoumois grain moth takes place in the larval stage. The parent which flies from grain in storage to the field to start the first generation in maturing grain can not eat into the shuck covering. Hence corn protected by a well-developed, uninjured shuck covering is never affected. But where the shuck is either loosely developed at the tip or damaged by smut, corn earworm,[3] or other insects, the moth can easily reach the kernels and lay her eggs upon them, thus starting an infestation.

These relatively few cases of infestation in the field serve as centers of infestation from which following generations of moths maturing in standing corn or corn shocked in the field, or corn that has been placed in the crib, will spread in large numbers and bring about a general infestation of the entire lot of corn in storage. There is practically no infestation of corn in the field except in the more southern States. As far north as Maryland instances of field infestation are very rare and there is little danger of infestation where corn is stored in ordinary slatted cribs until the coming of warm weather of the following summer. But in the Gulf Coast States, especially when the corn is growing on poor land, where shuck

FIG. 9.—Kernels of wheat showing the small round emergence holes that prove that an Angoumois grain moth has developed in the seed, thus reducing its weight somewhat over 50 per cent.

[3] *Chloridea obsoleta* Fab.

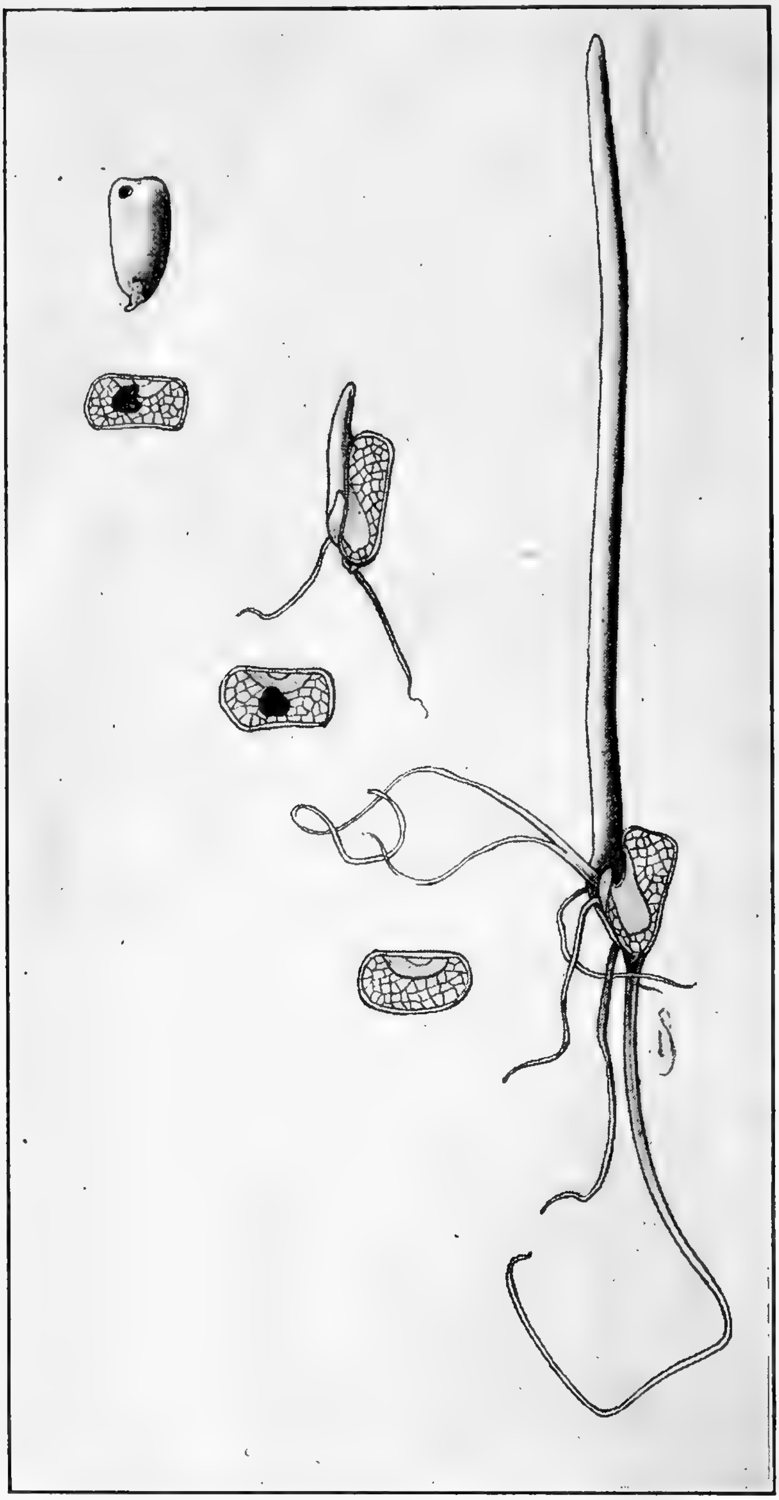

FIG. 10.—Three kernels of corn, the lowest one free from attack and sprouting normally. The larva of the Angoumois grain moth has completely destroyed the germ of the upper kernel and it has failed to sprout. The germ of the middle kernel has been affected but slightly by the developing moth yet notice how small its shoot is as compared with that of the normal seed; it will die or produce a sickly plant. Do not plant seed infested with the Angoumois grain moth.

development is poorest, the infestation of maturing ears may be very general and result in heavy losses in storage.

Figures 1 to 5 and 10 illustrate the manner in which corn is injured. The moth lays her eggs usually between the kernels on the cob. On shelled corn the eggs may be laid anywhere. The newly hatched larva usually crawls to the germ end of the seed, bores in through the seed coat, which is there more tender, and thus finds itself in the softest part of the kernel. From the illustrations it will be seen that the larva usually eats out and destroys the embryo or germ of the seed, and then bores its way outward into the harder part of of the seed (figs. 1 and 4). More often the emergence hole is found on the outer portion of the kernel, though this is not always so. Ordinarily, development occurs entirely within a single kernel, yet the larva may begin its feeding in one kernel and finish it in the adjoining one. In some varieties of corn many larvæ form their emergence holes at the base of the kernel, so that the moth in attempting to escape from the kernel finds itself wedged in by the surrounding kernels and forced to starve, since only the larva of the moth can feed on grain. Although many moths in an ear may lose their lives in this way, yet enough emerge normally to cause heavy infestations.

It is interesting to record that while the young larva can not eat through corn shucks to reach the kernels, those hatching from eggs laid through breaks in the shuck covering may be so numerous, particularly in storage, that they spread to and enter nearly all the kernels on an ear, even those kernels well covered by the shuck. While the newly hatched larva can not eat through the shuck to the kernel, the mature larva, which is much stronger, may bore its way out from the kernel through the shuck covering to the exterior. Instances have been found where the larva of the Angoumois grain moth has eaten through eight and nine thicknesses of shuck covering, though ordinarily escape is not effected where there are this number of thicknesses. Infestation of kernels at the tip of an ear may take place if the silk has been eaten out, thus leaving a channel down which either the moth or the newly hatched larva can crawl. While the infestations that occur through eaten-out silk channels and through breaks in the shuck covering are not in themselves usually of importance from the standpoint of grain actually destroyed, they are of immense importance as "leaven" for the subsequent infestation of entire crops held carelessly in storage.[4]

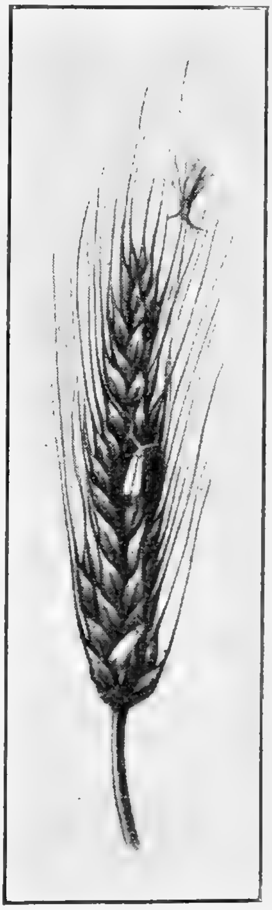

FIG. 11.—A head of maturing wheat showing three adult Angoumois grain moths that have flown from the crib to the field of ripening grain and are seeking to lay eggs upon the head.

FIELD INFESTATION OF WHEAT.

It has been stated already that the adult of the first generation of the Angoumois grain moth instinctively flies from the crib or storage house to the near-by fields of grain as the crop is approaching maturity. It also has been stated that the

[4] If the Angoumois grain moth were the only pest farmers had to contend with it would be better to keep corn in storage with the shucks on, as good shuck cover is a great aid to conservation of corn against this pest. Unfortunately in sections where the moth is a serious pest of corn, the corn is also attacked by the rice or "black" weevil against which shucks are of far less protection. If corn is shucked at harvest and fumigated at once, so practical experience on the southern farms is proving, losses are either greatly reduced or entirely prevented in storage.

moth can not infest the corn if the shuck covering is well developed and uninjured. The planting of varieties of corn developing a long, tight shuck, as recommended by the department,[5] will greatly lessen moth injury in the field. But this advantage which corn has is not shared by wheat, barley, and similar small grains. The female moth upon flying from bin to field may lay from 20 to 30 eggs upon the head of wheat chosen for attack. The larvæ hatching from these eggs scatter over the head, only one entering each kernel. The thin membranes covering the kernel are no hindrance to the entrance of the larvæ. This starting of infestation in the field may take place, as King[6] has so recently proved beyond doubt, even while wheat is "in the milk." Infestations of growing wheat are most heavy nearest places where infested wheat has been stored throughout the winter and spring.

EARLY FIELD INFESTATIONS AND DELAYED HARVESTING INCREASE OPPORTUNITY FOR DAMAGE.

There is a direct relationship overlooked by many wheat growers between early field infestation, delayed harvesting, and damage caused by the Angoumois grain moth. In southern New Jersey, Maryland, and southeastern Pennsylvania the first moths appear in the wheat fields about the time the wheat is "in the milk." In other words, the moth may begin to lay eggs in the wheat heads at any time after the kernels are well set. As each moth may live five days, during which she flies about the field laying eggs in batches of 1 to 20 or more until she has laid a total of about 150 eggs, it will be understood that a field of grain may have many heads infested by the early summer flight of moths from near-by cribs or granaries. Ordinarily, however, these first early summer infestations are very slight and cause no appreciable loss if the crop is handled correctly.

SECOND AND THIRD GENERATION IN FIELD SPREADS LIKE WILDFIRE.

The first generation of moths in the maturing heads of wheat, as just stated, usually is not a large one. But for each female moth of the first generation that reached the field in late May and June, there may be 150 moths of the second generation maturing in middle July and August. Ordinarily the moths of the second generation begin to appear soon after the grain is ready to cut, though a few may mature before the grain is ripened. The moths for the third genera-

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[5] For further discussion of long tight shuck, see U. S. Department of Agriculture Farmers' Bulletin 915, "How to reduce weevil waste in southern corn," by C. H. Kyle.

[6] KING, J. L. THE ANGOUMOIS GRAIN MOTH. Pa. Dept. Agr., Bur. Plant Industry Circular No. 1. 14 p., 2 figs. 1920.

tion appear during late August and during September. Granting that the sexes are evenly divided, for each female moth flying to the field in May or June there are about 11,250 moths, or 5,625 female moths ready to start the third generation of infestation in late August and September, and these moths are capable of laying 843,750 eggs. As only one Angoumois grain moth usually develops in a single wheat kernel, for each infested kernel in May and June there may be in late August and September 843,750 infested kernels. And if the grain is stored unthrashed in the barn where the moths can easily reach the kernels, or is left unthrashed in the field during warm weather, infestation may increase to 63,281,250 kernels in October for each infested kernel in May or June.

PROMPT THRASHING MEANS SAVING.

It is known that grain standing in the field uncut, grain stacked in the field, or mowed away unthrashed in barns, is not protected from so small an insect as the Angoumois grain moth. The moths are so small that they can crawl into unthrashed grain and lay their eggs. They prefer the more exposed outer heads but they can infest the inside heads. It is also known that the Angoumois grain moth while very small is too weak to force its way down into wheat or any grain when it is stored in bulk in large quantities. When stored in bins only the upper one or two inches of grain become infested. Since the moth is too weak to burrow down into a mass of wheat, it is also too weak to push the kernels aside and crawl to the top of the bin if it comes out of a kernel more than two or three inches below the surface of the grain.

TAKE ADVANTAGE OF THE INSECT'S WEAKNESS.

Farmers can turn this weakness to their advantage. If wheat is cut as soon as ripe, thrashed as soon as dry, and placed at once in storage in deep bins where only a relatively small surface of wheat is exposed, the Angoumois grain moth will not ordinarily cause trouble. The relatively small amount of wheat that is infested by the time wheat is ripe and can be thrashed is not great enough to cause heating in the bins as a result of moth infestation. The moths that develop in the kernels well below the top of the bin die without reproducing because they are too weak to extricate themselves. The same result is obtained when the wheat is placed in closely woven sacks that are well secured. *The early harvesting and proper storing of wheat nips in the bud the first early infestations that occur in the field, without cost or material loss to the grower.*

DELAYED THRASHING RUINS MANY CROPS.

The greatest argument against early thrashing of wheat is the difficulty of getting a thrashing machine just when it is needed. Where a community depends upon a traveling thrashing machine, farmers must wait their turn. A period of wet weather after cutting may prevent thrashing though it does not prevent the moth from multiplying. Wet weather can not be overcome, but farmers can combine more effectively in arranging for the prompt thrashing of their wheat. The amount of wheat saved by early thrashing during occasional bad "fly weevil" years will often pay many times over for the investment required to own a thrashing machine. *The farmer can choose between prompt harvesting, early thrashing, proper storage, and little or no loss, and delayed harvesting, late thrashing, and great loss.* It will pay him to provide against loss.

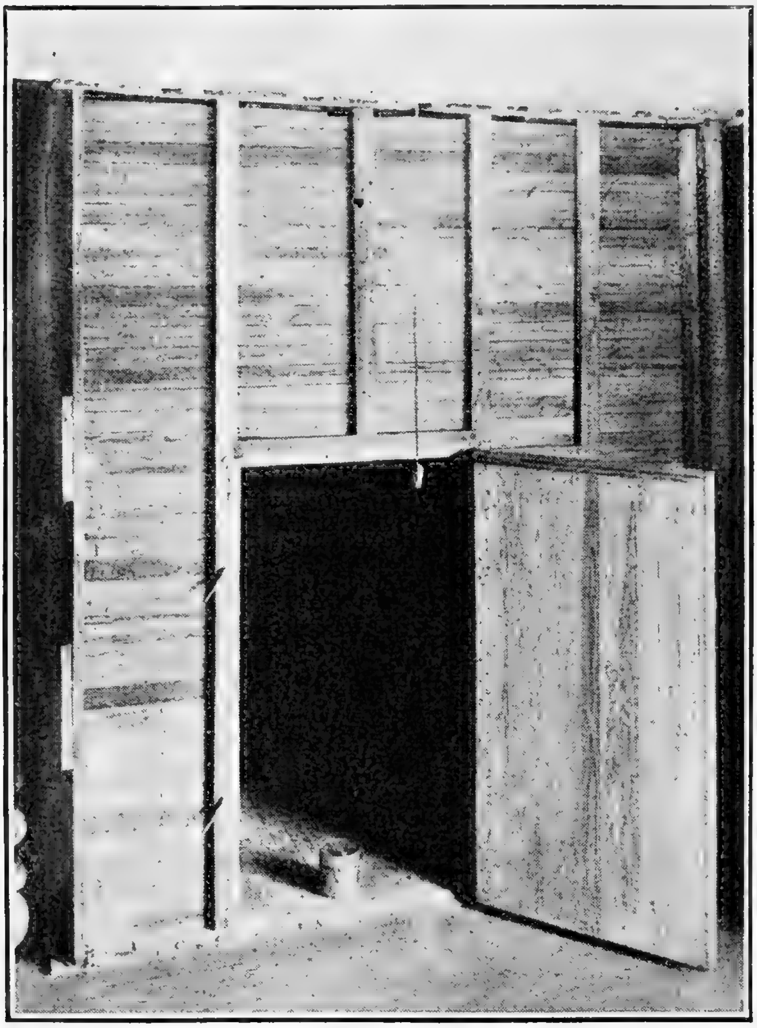

Fig. 12.—Front view of a specially constructed fumigating room used for killing insects in corn, wheat, and other substances. It is made of double thicknesses of matched boards with building paper between. Such a room is valuable in fumigating with carbon disulphid grain stored in sacks.

REMEDIAL MEASURES.

The most satisfactory method of controlling the Angoumois grain moth attacking almost any crop, but especially wheat, is, as just stated, prompt harvesting and storing under conditions unfavorable to the moth attack. (See figs. 12–16.) The great losses that are reported throughout wheat areas affected by the pest are the result of delayed harvesting, thrashing, and storing. *The storing of wheat unthrashed in barns or stacking it unthrashed in the field increases the loss. Prompt harvesting, thrashing, and storing in deep, tight bins, or in tight sacks, is effective.* Wheat should never be left spread in thin layers on barn floors except when too wet to store. Such a practice makes it easy for the moth to lay eggs on kernels.

DRYNESS.

It is stated that where practicable to store grain under dry conditions, the amount of damage done by the Angoumois grain moth

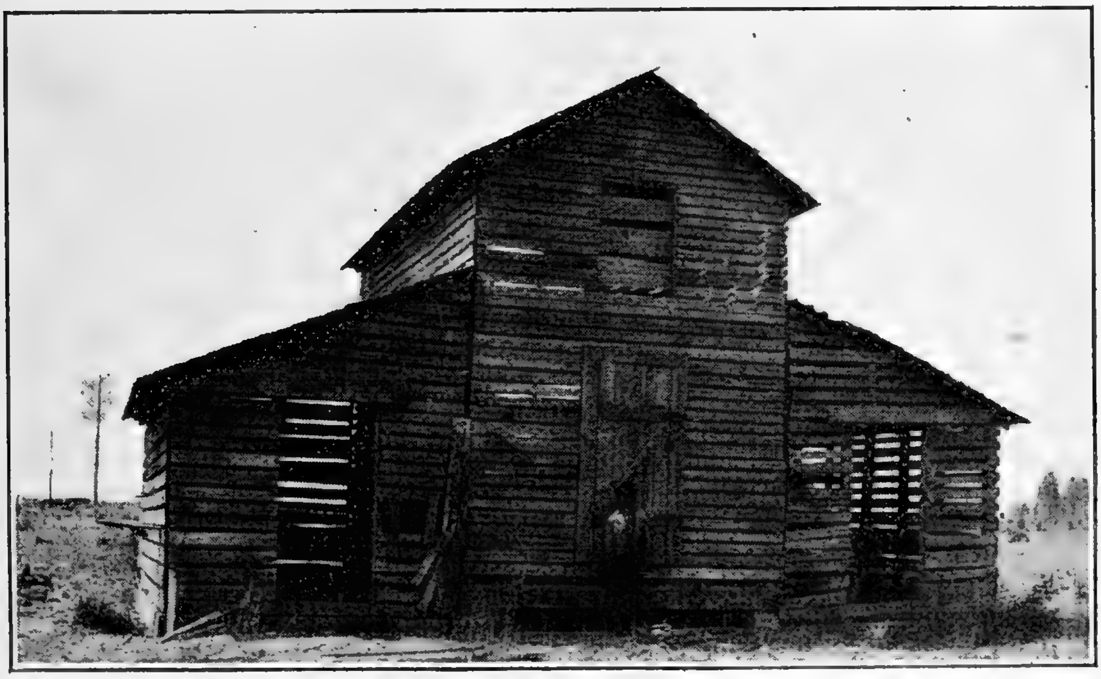

FIG. 13.—A slatted corn crib. Such corn cribs are no protection from insects to corn stored in them in the extreme South. Corn stored in slatted cribs from Maryland northward is safe from Angoumois grain moth attack at least until the summer following harvest, as the cold of winter is usually sufficient to prevent moths from surviving the winter in slatted cribs.

will be reduced greatly. If the atmospheric moisture can be reduced to 26 per cent or below, all infestation will be destroyed.

FUMIGATION.

If grain is found badly infested with the Angoumois grain moth it should be fanned and screened. Such treatment will remove about half of the infested kernels of wheat, but will not remove infested kernels of corn. Remember fanning only removes adult moths, débris, and light kernels. *To kill the moth in the remaining crop the seeds must be fumigated or heated. The best two fumigants are hydrocyanic-acid gas and carbon disulphid.* Hydrocyanic-acid gas is lighter than air, very deadly to man as well as insects, and

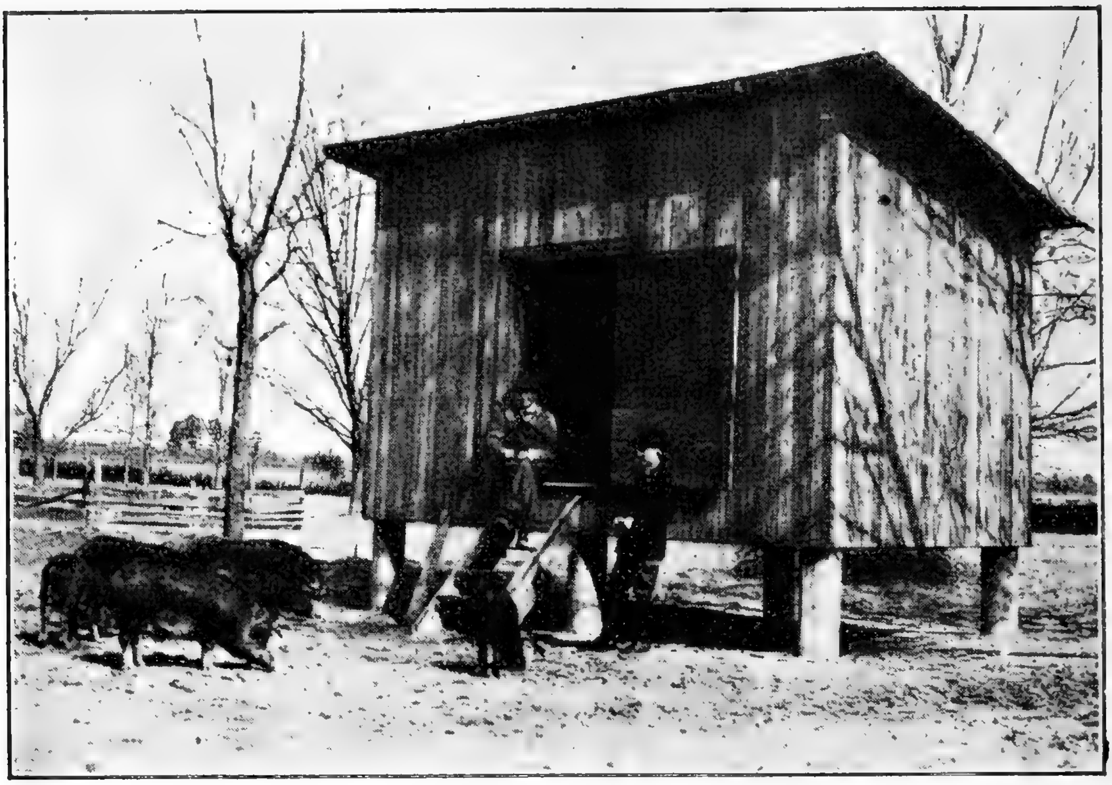

FIG. 14.—Corn crib belonging to farmer in Georgia. This was originally a slatted crib, but the weevils were so destructive that he covered it with building paper and a layer of tongue and groove boarding, made his floor tight, and fumigated with carbon disulphid. He no longer fears weevils. Anyone can make their cribs tight with the aid of the county agent.

FIG. 15.—An old-style barn with lean-to sheds. The owner could not store corn or wheat and keep it free from weevils. At the advice of the county agent he sealed the barn on the inside with tongue and groove boarding, and filled the space between the rough outer boards and sealing with packed sawdust. He then fumigated with carbon disulphid and killed all weevils. Use your ingenuity to tighten your old crib or build a new one, according to the advice of your county agent.

useful in killing the moth in grain stored unthrashed. It is not recommended for the treatment of thrashed grain in bulk.

Thrashed grain in bulk should be fumigated with carbon disulphid. This gas is heavier than air and is a standard gas recommended to kill moths in grain stored in bins, tight rooms, etc. It will not injure the seed for planting if the seeds are thoroughly dried when fumigated. Information regarding hydrocyanic-acid gas and carbon disulphid is given in Farmers' Bulletins 699 and 799, which may be had free by writing to the Secretary of Agriculture, Washington, D. C.

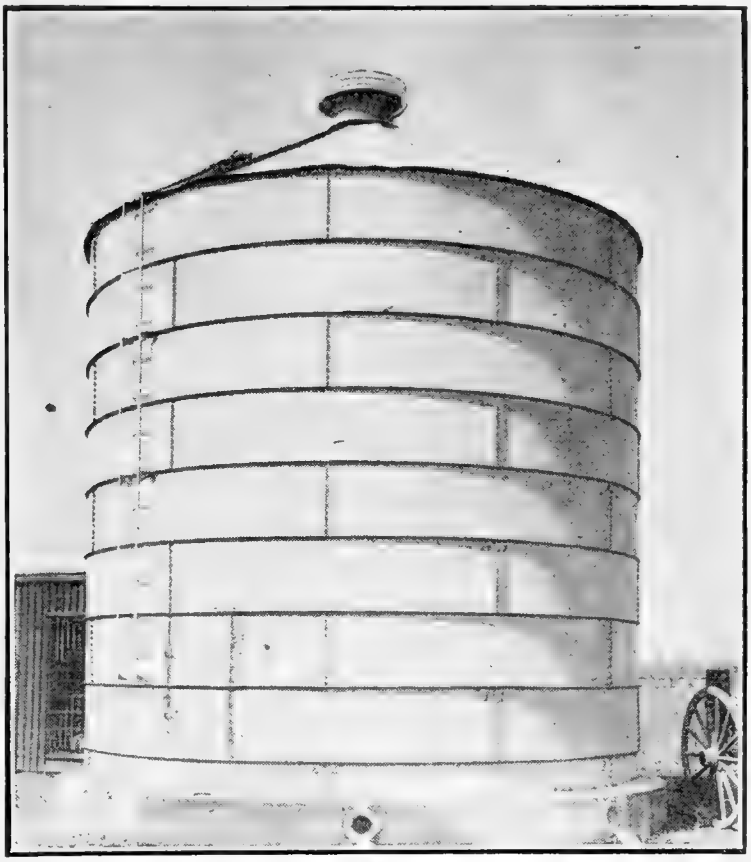

Fig. 16.—A modern galvanized-iron corncrib planned and erected by a progressive dairyman of Louisiana. Soft white dent corn has been kept in this crib in perfect condition for over a year. Weevils breed in such cribs as fast as in any, but are easily killed by fumigation with carbon disulphid. (Photograph by Jones.)

HEAT.

The average farmer is not equipped to use heat in controlling the Angoumois grain moth. Millers and grain dealers who have dryers can heat wheat to 120° F. *If grain is heated to a temperature of 120° F., all insects in it will be killed.* Heating to 120° F. will not injure its germinating power.

PARASITES.

Parasites[7] and a mite[8] often come to the farmers' aid and kill large numbers of the moth. Ordinarily, however, they do not become of service until the moth has caused much damage. It is not practical at present to depend upon parasites to reduce losses in field or storage.

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[7] *Pteromalus gelechiae* Webster. [8] *Pediculoides ventricosus* Newport.

COMMUNITY EFFORT IN INSECT SANITATION.

The Angoumois grain moth has never been fought vigorously by farmers. Certain few men protect their crops and reap a saving. Many farmers wake up too late and find their crops already badly affected. Lack of labor and thrashing machines force some farmers to do the best they can. *But all farmers can support a campaign in their own communities to kill out the Angoumois grain moth.* Experiments have proved that the moth in the region of winter wheat can not live through the winter in the grain sown in the fall. Hence farmers can center their attack upon the pest in the cribs and granaries. Farther South the pest may live through the winter in grain left in the field. *The county agents representing both State and Federal departments of agriculture should interest farmers in their counties in campaigns along the lines of insect sanitation. No pest can be more effectively controlled than the Angoumois grain moth.* Success in this mode of attack in the northern range of the habitat of the pest depends upon the thoroughness with which farmers combine to treat infested grain in storage, and in cleaning out their cribs in the spring. In the more southern States success depends upon removing the crop thoroughly from the field as well as attending to disinfection in the crib and cleanliness of the crib after the crop has been removed from it. Dr. L. O. Howard first recommended control of the Angoumois grain moth through community effort over 25 years ago.

If county agents in sections where the moth is injurious can unite farmers in a campaign of control they will save the farmers of their counties grain worth many times the salaries paid them. Intelligent insect sanitation pays handsome returns.

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INSECTS INJURIOUS TO DECIDUOUS SHADE TREES AND THEIR CONTROL

JACOB KOTINSKY
Assistant in Forest Entomology

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Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

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HEALTHY APPEARANCE is of the utmost importance in shade trees, and no agency is more potent in marring the appearance of these trees than are insects. A defoliated or otherwise bedraggled shade tree is not only worse than none at all but, when a result of insect injury, it is a menace to the health or life of similar trees in the neighborhood.

Practical ways of controlling most of the injurious shade-tree insects are known. This bulletin discusses the more important insects affecting deciduous shade trees in the eastern two-thirds of the United States with the exception of the gipsy moth and the brown-tail moth and gives the remedies for them. The gipsy moth and brown-tail moth and their control are considered in Farmers' Bulletin 845.

INSECTS INJURIOUS TO DECIDUOUS SHADE TREES AND THEIR CONTROL.

CONTENTS.

INTRODUCTORY.

WHY INSECT INJURY IS PREVALENT ON SHADE TREES.

The original home of the trees we plant along our highways and byways is the forest. There, whatever disadvantages they are exposed to, they have acquired a certain degree of resistance to and immunity from insect and probably other normal enemies. Transplanted to our streets, parks, or home grounds they are relieved of the keen competition and other adverse conditions of wild forest life but lose most of the natural advantages of their customary association—sun and shade, moisture and humus—and their proper growth is hampered besides, especially in our cities, by a variety of unfavorable conditions. Hard packed ground, frequently disturbed, often poisoned with oils or gases or charged with electric current, and uncertain or erratic water supply handicap the roots, while constant struggle with thoughtless or reckless man and greedy beast, limited sunshine, and other vicissitudes above ground render their struggle for existence uphill work indeed. Trees so hampered lose much of their native power of resistance and are thereby rendered inviting, easy prey to a variety of disintegrating agencies most prominent among which are insects. This is promptly reflected in their appearance, which is a prime consideration in the usefulness of shade trees. No kind of tree or any part of it is wholly immune from insect pests. Indeed, some parts of trees harbor a large variety of them, and trees are known to be subject to more or less severe attack by hundreds of kinds of insects. In a world thus swarming with these creatures, intent on sharing in practically every one of his enterprises, it is inevitable that man should have to contest every foot of his ground, especially when he adapts nature to his needs, convenience, or comfort.

EXTENT OF INSECT INJURY TO SHADE TREES.

As the growing season advances all shade trees apparently otherwise perfectly healthy will be found on more or less close inspection to show cumulative signs of insect injury, particularly in their foliage. This is inevitable when we consider the great variety of plant-eating insects they harbor. In most cases the injury is too insignificant for treatment. But from this point on the other extreme is not infrequent, when, as a result of abnormal increase of some insect species, the injury may be so severe as to menace the very life of its favorite host tree. Indeed, instances on record are not uncommon in which entire rows of certain trees and most trees of a given kind in communities and regions have been killed by insect pests within a few seasons. Certain trees are more subject to attack and injury and by a greater variety of the seriously injurious insects than others, so that, as a result of a process of selection, such trees are either no longer planted or sparingly, especially where their serious insect enemies are dominant. On the other hand, some of the injurious shade-tree insects, like the white-marked tussock moth, are almost omnivorous, so that practically no deciduous shade tree is immune to their attack and very severe defoliation.

PRIMARY AND SECONDARY INSECT INJURY.

Insects injurious to shade trees may be roughly grouped in accordance with the condition of health of the tree they normally attack. Certain species—and this is especially true of leaf-chewing insects—show a decided preference for perfectly healthy trees. Others—and this is the case with most wood and bark boring insects—can inhabit trees only when the health of these has been previously impaired, whatever the agency responsible for this. These more or less distinctive groups of insects are designated as *primary* and *secondary*, respectively. From the viewpoint of control it is as important to know to which of these an insect found on a tree belongs as it is to know whether it is injurious, beneficial, or indifferent. It is wasted effort to proceed against an insect, even if found injurious, if its presence is conditioned by previous or primary injury or death of the tree. It is the cause of this primary injury that must be discovered and dealt with. On the other hand, there are still a number of insect species that are primary under some conditions and secondary under others, so that they can not be definitely assigned to either group.

GENERAL LIFE OF INSECTS.

Like other living objects, the insects we encounter are the offspring of parents that preceded them—males and females in most cases. Between the time of hatching from the eggs and maturity the growing insects molt, or cast off their skins, three or more times. In some forms, as in the aphids and bugs generally, these immature stages differ little from the adults. In others, as in the beetles, moths, etc., the immature insects, or *larva* stages, as they are called, differ radically in appearance from the adults, and there is, besides the *egg*, another nonfeeding stage or form, known in moths and butterflies as the *chrysalis* and in all of them as the *pupa.* The pupa or chrysalis stage immediately precedes that of the *adult.* The larva of the moth or butterfly is generally known as a *caterpillar*, that of the beetle as a *grub*, that of the fly with two clear wings as a *maggot*, and that of the fly with four clear wings as a *grub*, *slug*, or *false caterpillar*. These forms generally differ sufficiently among themselves for fairly ready assignment to the proper group. Any one of them, except the egg and pupa, may be the injurious form or the one in which the given insect is most advantageously fought; the two—the injuring form and the one treated—not necessarily always being the same. Intelligent control of insect injury, therefore, involves at least a general knowledge of the habits of insects. Among these none is more important than the feeding habit, since this determines largely the control measures to be adopted.

MANNER OF INJURY AND PARTS OF TREE AFFECTED.

In the great majority of cases the mouth of the injurious form of the insect is adapted for feeding either by sucking the sap of the plant (plant-lice or aphids, scale insects, etc.) or by biting off bits of the leaf, bark, or wood (caterpillars, slugs, beetles and their grubs, etc.). The work of the biting insects usually can not be mistaken and, in the case of those feeding on the outside of the host, is often a guide to the remedy, even when the insect is not caught in the act of eating. The sap-sucking insect, on the other hand, must be discovered and its identity or at least the group or family to which it belongs ascertained before the most suitable remedy can be determined.

Injury by either group of insects is manifested in many different ways. Thus, the fine rootlets may be eaten up and the larger roots barked or bored; the trunk and larger branches may be tunneled or their sap sucked; the twigs may be deformed or cut off; the buds and leaves may be deformed; the leaves may have pieces bitten out of them or they may be skeletonized or mined. Some kinds of insects make their home and feed on a large variety of plants; many other kinds, however, utilize only one part of one kind of plant for sustenance.

NATURAL CONTROL OF SHADE-TREE INSECTS.

One of the forces which affects insects adversely or otherwise is the weather, this depending upon whether it favors the host tree or the insect. Directly engaged in checking undue multiplication of any given insect are parasitic plants (fungi and bacteria), birds and other vertebrates, spiders, mites, and insects. The insect enemies of insects are usually the most powerful and effective agency in the reduction of a noxious insect. All stages of an insect, from egg to adult, are subject to their attack. These insect enemies operate in two ways, according to their build and habit. Some of them are predacious, in that they seize their prey and eat it either by sucking it dry or by devouring it bodily (fig. 1). Ladybirds are among our best friends among predacious insects. Plant-lice or aphids particularly, but also scale bugs and other soft-bodied insects, are to their liking. Their active young as well as adults feed on these insects. Lace-wing flies, numerous bugs, and certain mites and spiders are among the other recognized predacious insects man has learned to regard with favor for their active feeding on injurious insects. The other group is known as parasitic insects (figs. 2, 3). These are by far the most numerous in variety. By special adaptations some of them are capable of prodigious multiplication and their presence has again and again been found to have saved plants from destruction in situations where man, left to his own devices, was helpless.

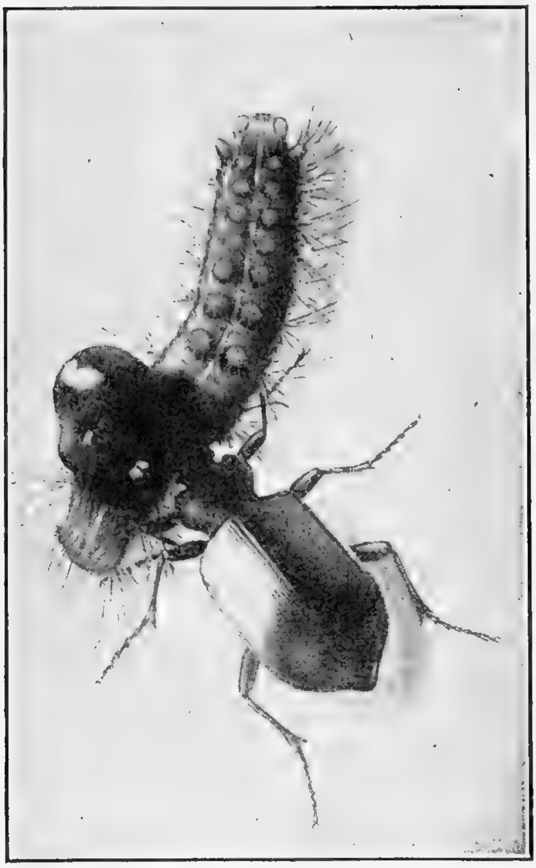

FIG. 1.—Caterpillar of gipsy moth (*Porthetria dispar*) attacked by the Calosoma beetle, *Calosoma sycophanta*. (Burgess and Collins.)

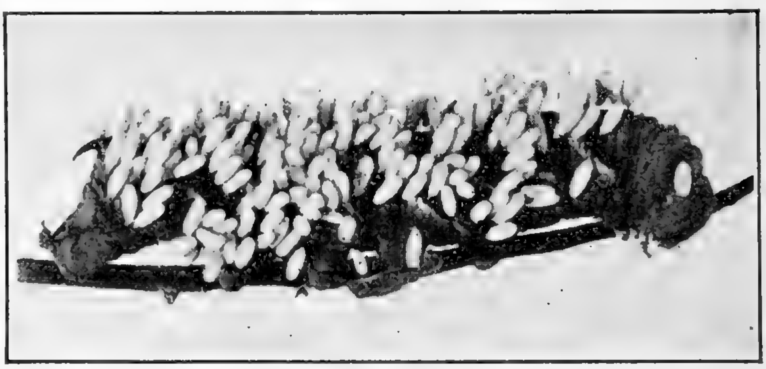

FIG. 2.—Sphinx caterpillar bearing cocoons of small, four-winged wasplike parasite. (Quaintance and Siegler.)

The work of these beneficial insects brings it about that no native insect is ever present in destructive numbers for longer than a year or two, being by the end of that period greatly outnumbered by its enemies and rendered practically harmless. This is particularly noticeable in insects feeding on leaves and on the outside of the plant generally. This is true of all native insects, but not of those that have reached our shores from abroad. In the great majority of cases these were not accompanied by their home enemies, and this accounts for their uninterrupted destructiveness during long periods of time, generally until our native insect parasites and predators develop a taste for them, or until their more effective home enemies have been discovered, imported, and established in their new home, or until these have reached us as accidentally as did their hosts.

PREVENTION OF INFESTATION.

Many shade-tree pests are likely to reach the community by way of the nursery stock. It is imperative, therefore, to insist that young trees be thoroughly cleansed before they are taken from the nursery and certainly before they are planted. Inspection alone, however, can not always be depended upon, for some insect pests are very minute and are apt to hide beyond reach of eye or lens. Fumigation with hydrocyanic-acid gas is at present in general practice in nurseries and is the most reliable means of freeing stock from infestation. If a tree is clean and uninfested at the start, it has stored up vitality which will enable it more successfully to resist subsequent attacks.

FIG. 3.—Ichneumon fly, Itoplectis, in the act of egg-laying on cocoon of apple-tree tent caterpillar. Enlarged. (Fiske.)

CONTROL, PART OF ROUTINE.

Just as the potato grower in sections of the country invaded by the Colorado potato beetle considers spraying a regular, essential part of successful potato culture, so the municipality must learn to regard regular, periodic inspection of trees for evidence of insect injury, and treatment for it, as necessary to the proper care of its shade trees. The enlightened, efficient tree warden, after a little experience, systematizes this work and dovetails it in with his other duties in such a way as to utilize the labor at his command to best advantage without neglecting other important work. Thus, careful examination of the trees while they are being trimmed, to ascertain the presence or absence of their customary insect enemies and their abundance or scarcity, is good practice and should lead to discovery of many of the insects that are, or in course of the following summer will be, giving trouble. Especially is this true when the warden and his help are familiar with the principal types of shade-tree insects and their more important habits and forms.

TREE "DOCTORS" OR SURGEONS.

The work of the experts on tree pests in the State and Federal Government services is limited to the study of the causative organisms, the discovery and determination of practical methods of controlling them, and the publication of these for general information. The actual work of controlling the pest is thus left to the individual or community, and the limited knowledge of the causes of tree troubles possessed by the general public and the frequent necessity of using rather costly spraying outfits for the control of insects and diseases has created a call for the private enterprise of experts. This requires a knowledge on the part of the expert of the fundamental facts of economic entomology and particularly of the more common injurious insects to be encountered on the trees and the remedies for them as established by the experts in the Government service. His knowledge must, of course, be coupled with integrity, and he must be equipped with adequate spraying and other outfits.

THE CITY OR COMMUNITY ENTOMOLOGIST.

The extension of tree, shrubbery, flower, and vegetable planting in and around cities, both in private yards and along highways, with the attendant insect problems on the one hand and the numerous health and sanitation questions in which household and other insects enter as a vital link in the transmission of disease, point to the advisability for such communities of engaging specialists—entomologists they are called—to look after their individual and collective insect problems. The services of such specialists would more than pay for the outlay in the improved health of the citizens and their surroundings, and especially in the prevention of insect-borne epidemics, like malaria, typhoid fever, etc., as well as defoliation and other destruction of plant life.

STATE AND FEDERAL GOVERNMENT HELP.

Every State and Territory in the Union maintains a staff of competent entomologists glad to assist every citizen in the struggle with insects. The Federal Government does likewise. All inquiries on insects receive ready, intelligent, scientific attention at the hands of these officers, and the information furnished is as complete and accurate as can be given. The labors of these specialists are greatly simplified, however, and the answers can be more direct and prompt if inquiries are accompanied by specimens of the insect, its work, or both, and a description of the extent of the injury and other pertinent information. These officials are glad to receive specimens and information, as it often adds to the knowledge of the distribution of the insects, their habits, etc. A note on the results of treatment is also always welcome.

DIRECTIONS FOR PACKING AND SHIPMENT OF SPECIMENS OF INSECTS AND THEIR WORK.

To receive specific information on insects, insect injury, and remedies promptly—

(1) Address inquiries and specimens to the State entomologist of your State or to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C. This bureau is the only organization in the Federal Government service that is charged with the study of insect problems, so that correspondence on such matters must reach this bureau before it can be given proper attention. Addressing communications to any other office only delays matters.

(2) *The name and address of the writer* should appear plainly on wrappers. *Specimens of live insects and their work*, preferably fresh, should accompany inquiries and should be packed about as follows: (*a*) *Wood and bark borers* are best left in their burrows and the wood or bark containing them cut into convenient sections, tied, and wrapped in two thicknesses of stout paper; (*b*) *leaf-eating insects* (separated by kind, if more than one, to prevent cannibalism), in tight wooden or tin containers or mailing tubes manufactured for the purpose, stocked with their favorite food (holes are unnecessary); (*c*) *underground insects*, in earth; (*d*) *scale insects*, attached to the bark or leaf; (*e*) *leaves and other small specimens* showing insect work inclosed with letters.

When more than one kind is sent, each should be accurately labeled with locality, name of sender, and a number or letter for ready association with corresponding marks in letter or note and with one another. Labels for insertion with alcoholic specimens should be written with soft pencil. Tight, stout containers, properly wrapped, addressed, and tied, prevent escapes, breakage, and loss in transit. Tags must be securely fastened to packages.

(3) *Notes.*—It is very important that specimens be accompanied by information giving as accurately as possible (*a*) name of host tree and part attacked, (*b*) locality, (*c*) date of collection, (*d*) character and extent of injury, (*e*) facilities for disposal of infested timber, and

(*f*) any other information that may help in identifying the insect and determining the proper remedy or control measure suitable to the condition of the correspondent. Notes should readily correspond to labels on specimens, and may be separate or embodied in the letter.

(4) *Shipping specimens.*—Packages not exceeding 4 pounds in weight are most conveniently and cheaply sent by parcels post. Bulky packages may be sent by freight; fragile, by express. They must always be sent prepaid unless otherwise authorized.

THE PRINCIPLES OF SHADE-TREE INSECT CONTROL.

As elsewhere stated, the feeding habit of the insect that is doing the injury is the main factor in determining the kind of remedy to be applied. This is particularly true of the insects that feed in the open, i. e., above ground and on the outside of the plant. In most such instances the principle is very simple: We poison the food of the insect that bites its food before swallowing it and kill the sap-sucking insect with external applications—*contact insecticides* as they are called—which are usually caustic or oily liquids. In a great many cases, however, and especially in insects that live in the interior of the plant tissue, like leaf-miners, gall-makers, borers, and underground workers, be they biting or sucking insects, our method of attacking them must necessarily be different. A vital principle of successful insect control is *wholesale destruction* of them. In emergencies, however, and especially where a single insect is capable of doing serious harm, we do not hesitate to undertake their destruction singly, as in the case of root or stem borers. Again, we often find through a knowledge of their habits that some biting insects, for instance, are more cheaply and effectively fought in some other stage of their lives than in that in which they feed; for example, the destruction of the white-marked tussock moth in the egg stage.

It is evident from what has been stated above that in spraying promptness and thoroughness are vital elements. The earlier in its life the insect is killed the more quickly it is killed and the less harm it will have done; the more completely the foliage is covered with spray the more certain is the early killing of the insects and the more of them will be killed. Likewise, with the sap-sucking insects the more thorough the application the greater the number of the insects that will be hit and killed. *Thoroughness means the complete covering of the insect's food in one case and of all of the insects in the other.*

TREE INJECTIONS: WORTHLESS OR WORSE.

A word on the subject of tree injections is imperative. Perhaps in no other respect are unsophisticated tree owners more imposed upon than in the matter of injection of various cure-all preparations under the bark. Suffice it to say here that *such treatments are entirely without merit* in controlling insects and often are decidedly injurious to the trees treated.

THE STOMACH-POISON SPRAYS.

The standard poisons used at present for killing chewing insects are *arsenate of lead* and *arsenate of lime* (*calcium arsenate*). Both are procurable in the market, usually in seed stores, and come in either paste or powder form. The powder form is preferable for a number of reasons. While these poisons may be prepared at home, it is usually more convenient to buy the prepared article, which only needs to be stirred into water or Bordeaux mixture before being used. The directions for dilution are usually given on the containers. The amounts to be used in small quantities are given in Table I, page 30.

Other poisonous substances are used occasionally, while some, like Paris green, were used extensively, almost exclusively, until superseded by arsenate of lead and arsenate of lime. The lower cost and greater fineness and adhesiveness of the last two make their use most general now.

Being violent poisons, these substances should be stored and handled with due caution, especially as regards live stock and children.

THE CONTACT SPRAYS.

As elsewhere stated, contact sprays are used to kill sap-sucking insects, like scale bugs, aphids or plant-lice, etc. Death is produced by the coating and clogging of their breathing pores, by affecting the nervous system, or by caustic action on the tissue of the insect, or by combinations of these. Lime and sulphur compounds, soaps, petroleum oils, and tobacco extracts are the active agents in these preparations.

Lime-sulphur, *miscible oil*, *kerosene emulsion*, and *40 per cent nicotine sulphate* are contact sprays. With the exception of kerosene emulsion, which must be prepared at home, all of them are procurable commercially, where each is sold under a variety of proprietary names. All that they require to be made ready for application is to be stirred into water, with the addition of a little soap in the case of the nicotine. Directions for dilution are usually printed on containers and should be followed carefully. For small quantities see Table I, page 30

LIME-SULPHUR.

Lime-sulphur, as an insecticide, is used almost exclusively against the so-called armored scale insects, like the San Jose and oyster-shell scales, and principally as a dormant or early spring spray. It is the cheapest of the scale-killing sprays, but unfortunately it *discolors paints* and, as most shade trees are located in greater or less proximity to buildings, its use is limited to trees not so located and to nursery stock. Wherever practicable to apply it with a paint brush, its cheapness may offset the labor cost. The concentrated preparation as bought should have a density of about 33° on the Baumé scale. At this strength it should be used at the rate of 1 pint in each gallon of spray. See Table I, page 30.

MISCIBLE OR WATER-SOLUBLE OILS.

In shade-tree work the miscible oils are used especially against scale insects and are the only ready-prepared substances available on the market that will effectively control all kinds of scales as does kerosene emulsion. These preparations come under a variety of proprietary names and vary somewhat in strength, so that directions for dilution as given on the containers must be followed carefully. The miscible oils are primarily winter sprays, being used at this season on account of the absence of foliage, which they are apt to injure. Since they are used principally in the control of scale insects, their application while the plants are dormant is most satisfactory anyway, because, in the absence of foliage, the insects are more easily reached, the covering with spray can be more complete, less spray solution is required, and the spray can be more safely applied at greater strengths, thereby killing the insects with greater certainty.

CREOSOTE OIL.

Creosote has been found very useful in daubing tussock-moth eggs. It is apt to thicken in cold weather and is then thinned with turpentine.

KEROSENE.

Kerosene is also useful on a mop at the end of a pole for daubing tent caterpillars and webworms or tussock-moth eggs, or, with proper caution, the kerosene on the mop may be lit and used as a torch to burn out the caterpillars in the tent or web.

KEROSENE EMULSION.

Kerosene emulsion is a standard contact spray, composed of kerosene, soap, and water in certain proportions. By varying the proportion of water, this spray can be used both summer and winter against scales and soft-bodied insects. The emulsion, as the concentrated mixture is called, is likely to deteriorate in storage, by breaking up into the kerosene and soap solution from which it was made. For "homemade" emulsion the best procedure is to prepare a stock mixture first and then dilute it as needed. This stock mixture may be made up in quantities, and if properly prepared it should keep for some time.

Kerosene-emulsion stock is most conveniently prepared as follows:

Kerosene	gallons	2
Fish oil or laundry soap (or soft soap, 1 quart)	pound	$\frac{1}{2}$
Water	gallon	1

Put the water and soap into a wash boiler or similar vessel and heat until the water boils and the soap is dissolved; remove from the fire, add the kerosene, and stir vigorously for about five minutes until the mixture is creamlike in consistency. A convenient way to make the mixture thorough is to pour the soap solution and kerosene into the tank of the spray pump and, through the nozzle, to pump the mixture back into the tank for several minutes.

For spraying, this stock mixture is diluted with water, which is best done at the time and in quantities needed. For summer spraying, on trees in foliage, add $5\frac{2}{3}$ gallons of water to each gallon of the stock preparation. For winter use, on dormant trees, $1\frac{2}{3}$ to $2\frac{1}{3}$ gallons of water are added to each gallon of the stock. For smaller quantities see Table I, p. 30.

POISONED CONTACT SPRAY.

In this preparation the contact solution is used as a conveyer of the poison in situations where the ordinary water solution of the poison could not penetrate. It was specially devised to reach and kill borers while they are still feeding in the bark, and is prepared as follows:

In each gallon of water used for diluting the contact preparation, be it kerosene emulsion or water-soluble oil, dissolve 1 ounce of sodium arsenite, before making the mixture. Sodium arsenite is readily soluble in water and is procurable in drug stores. The crude or commercial product, which is cheaper, will answer the purpose. This preparation is injurious to foliage, which should be borne in mind when applications are made with it.

NICOTINE SULPHATE.

Nicotine sulphate is a specific remedy for aphids or plant-lice, but other soft-bodied insects can also be killed with it. It is a liquid extract of tobacco procurable in a variety of stores under a variety of trade names and varying in strength. The preparation is merely diluted with water before use, and the proportions are usually given on containers. The 40 per cent nicotine sulphate is the most commonly available; although when properly diluted, any strength of the stock preparation will answer. It is necessary to add 1 ounce of soap to each gallon of the spray to insure its spread and adhesion.

CARBON DISULPHID.

Carbon disulphid is a heavy, ill-smelling liquid, procurable in drug, seed, and other stores. It evaporates readily at the normal temperature, and as its vapor is heavier than air, it sinks. *It is highly inflammable and has a poisoning effect when inhaled freely, so that caution in handling it is necessary.*

In shade-tree work it is used for killing borers, being injected by means of an oil or other squirt can or dropper into the borer opening, the hole being promptly plugged with putty, grafting wax, or similar substance. In similar manner it may be used against carpenter ants.

FISH-OIL OR LAUNDRY SOAP.

Fish-oil soap, sometimes known as "whale-oil" soap, is procurable commercially and is an effective insecticide for such insects as aphids, scale bugs, and other sap-sucking kinds. Common laundry soap may also be used for this purpose. For summer spraying, dissolve 1 pound of the soap in 3 to 4 gallons of water. For winter spraying on scale insects, dissolve 2 pounds of the soap in each gallon of water over the fire and apply the spray before the solution is cold and congeals, which it is apt to do in this concentration.

Soap has other uses in the treatment of trees. Thus, with nicotine solutions it is used as a "spreader" or adhesive (see p. 13). In connection with injections of carbon disulphid it may be used to plug the treated holes to prevent loss of the fumes.

TREATMENT OF TREE WOUNDS.[1]

Tree wounds due to removal of large limbs, or to injury from any cause, as by rabbits, field mice, horses, vehicles, etc., around the base of trees, should be promptly disinfected and treated with a waterproof covering. An exposed surface is subject to attack by fungi and invasion by wood-boring insects unless properly cared for. When a limb is cut off, the edge of the bark and the cambium should be coated with shellac as soon as the surface is sufficiently dry to permit it to stick, otherwise the value of the shellac is practically lost. The wound is then ready to be treated with a disinfectant, such as common creosote, which will penetrate and sterilize the wood. This may be applied with a small brush. After creosoting, the wood should be protected from moisture by means of a heavy coat of coal tar. Instead of using the materials separately, they may be combined in a mixture containing about one-third creosote and two-thirds coal tar. One coat of the mixed materials may be sufficient, but if not, a heavy application of the coal tar should be used, and the surface recoated

[1] Adapted from Farmers' Bulletin 908.

whenever it is found cracking or breaking away from the wound. A pure white-lead and linseed-oil paint is sometimes employed for tree wounds, and, while not as satisfactory as the coal-tar-creosote paint, it is a good deal better than nothing. Ordinary grafting wax will give good results for small surfaces.

FILLING TREE CAVITIES.[2]

Decayed scars and cavities in the trunk or limbs are frequently infested with wood-boring larvæ or are the retreat of different species of ants. Such cavities are objectionable, for not only do they favor gradual decay and weakening of the trees, but they afford an excellent winter harbor for certain injurious insects. As noted elsewhere (p. 16), cavities in the trunk usually are the result of improper pruning and neglect to care for wounds from other causes. Such cavities may be filled with cement and the condition of the trees materially improved.

The first operation is to remove all of the decayed wood, and this can be done by means of a gouge, chisel, mallet, and knife. In cutting around the edge of the cavity nothing but very sharp tools should be employed, as dull instruments will injure the cambium. As soon as the cambium has been cut to a proper distance it should be covered with a coat of shellac. After the cavity has been thoroughly cleaned out it should be treated with creosote and coal tar, as described under the preceding heading, and it is then ready to receive the permanent filling.[3]

PRUNING AS RELATED TO INSECT INJURY.[4]

Certain twigs and branches, when heavily infested with or injured by insects, frequently can be removed to best advantage in the course of pruning operations. Also, in the work of pruning, thought should always be given to maintaining the shape of the trees to facilitate the application of sprays.

In case of severe insect injury, large trees may sometimes be severely cut back or "dehorned" to advantage. With old trees, however, too much wood should not be removed at one time, and the dehorning process should be extended over two or three years. Small limbs and twigs incrusted with scale insects or punctured by the periodical cicada, or tree-hoppers, etc., usually may be removed to advantage. Pruning should be done preferably before the application of dormant tree sprays, since it is a waste to use spray materials on limbs and branches that are to be removed later.

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[2] Adapted from Farmers' Bulletin 908.

[3] For full information on this subject, see "Tree Surgery" by J. F. Collins, Farmers' Bulletin 1178, U. S. Department of Agriculture.

[4] Adapted from Farmers' Bulletin 908. The general subject of pruning shade trees is discussed in Bulletin 816, U. S. Department of Agriculture, and in Farmers' Bulletin 1178.

All dead and dying trees and limbs should be promptly removed and burned, as they attract wood-boring insects which may become abundant and attack and injure healthy trees. When limbs of trees are being removed they should be sawed as closely to the trunk as possible to insure rapid and complete healing over. Stubs of limbs should not be left, as these decay, later resulting in a cavity which permanently injures the tree and will afford a hiding place for noxious insects. In cutting large limbs special care should be taken to prevent stripping of the bark from the trunk. A large limb is best removed by first sawing the limb from the underside at a distance of 6 to 8 inches from the trunk until the saw is pinched, by which time the cut should have reached from one-fourth to one-half through the limb. The second cut should be made on the upper side of the limb an inch or two farther from the base of the limb than the first one, sawing being continued until the limb falls. It is then easy to saw off the remaining stub close to the tree trunk and in line with its woody surface, taking care, however. to support the stub until completely severed.

STIMULATION OF GROWTH BY FERTILIZATION, ETC.[5]

Unthrifty trees are thought to be more subject to the attack of certain insects than plants in a healthy condition. Weakened trees are frequently killed by wood-boring insects which do not attack trees growing vigorously. Such trees sometimes can be saved by prompt stimulation with a nitrogenous fertilizer, as nitrate of soda, stable manure, etc. This treatment, in connection with severe pruning and adequate cultivation, often will result in marked improvement.

MISCELLANEOUS INSECT-KILLING IMPLEMENTS.

Elsewhere in this bulletin the point was made that wholesale destruction is an essential consideration in the profitable control of insects wherever this is practicable. In the case of large trees the insects are generally beyond unaided reach and usually too numerous for profitable individual hand picking. Hence, mechanical devices of some sort, ranging from the ordinary paint or whitewash brush or pole and mop to the most complicated power drawn and propelled spraying outfit, are generally employed in this work. Local conditions and the insect involved largely determine the sort of instrument to be used in any given case.

THE PAINT OR WHITEWASH BRUSH.

In the absence of spraying machinery or for other reasons a single shade tree or small number of them requiring treatment of trunk and

[5] Adapted from Farmers' Bulletin 908.

larger branches, as for scale insects, may often be saved from serious injury or utter ruin by the application of an insecticide with a paint or whitewash brush. With proper protection of the painter's hands and face even lime sulphur, which is somewhat caustic to the bare skin, may be used to advantage, for it is considerably cheaper than other preparations, and a brush application will insure against possible injury to paints on buildings near by. The brush has also the advantage of being perhaps least costly and it is certainly the simplest tool for the purpose.

THE MOP.

The mop may consist of nothing more than a bundle of rags tied to the end of a pole. Saturated with kerosene or creosote it may be used for daubing tent caterpillars and webworms or tussock-moth eggs, which are thus killed most rapidly. If lighted, the kerosene-soaked mop may be converted into a torch and webs burned out. provided it is handled deftly so that the live wood is not burned.

TREE BANDING.

INDISCRIMINATE USE OF BANDS FUTILE.

The habit of some insects, at certain definite stages of their lives, of traveling in mass along the tree trunk has suggested the use of bands as barriers or traps. Against certain wingless female moths, also, like cankerworm moths, this method of control may be made operative. Various materials are serviceable for this purpose, gunny-sacking, cotton batting, and fine-mesh wire screen being employed and, in recent years, certain sticky substances have come into quite general use.

It is evident that the usefulness of such bands is restricted to tree-infesting insects having the habits above mentioned. Unfortunately many people have gained the erroneous impression, especially since the use of sticky bands has come into vogue, that these bands are a panacea for all tree troubles caused by insects. The result has naturally been the indiscriminate use of bands, often with the disastrous consequences that might have been expected under the circumstances. There is no royal road to insect control. The bands, even where the insect's habit allows of their usefulness, will be effective only when watched constantly so that clogging, bridging, drying up, and other contingencies may be guarded against. Banding should be resorted to only after consultation with an entomologist. Wherever applicable, the following bands are recommended:

COTTON BATTING.

Take a band of cotton batting 6 to 8 inches wide and a little longer than sufficient to encircle the trunk of the tree at a convenient height, wrap it around the tree, and tie the bottom edge of it securely, turning the upper edge down over the string so as to form a flange of loose cotton all around the tree. (Fig. 4.) It should be borne in mind that this barrier will remain effective only so long as the cotton remains fluffy, and even then, especially if the insects are very numerous, frequent examination of the band is necessary if it is to be kept in proper working order.

FIG. 4.—Barrier of cotton batting on tree trunk to prevent ascent of caterpillars, wingless moths, etc. (Quaintance and Siegler.)

WIRE SCREEN.

Wire screen may be used to trap nonflying moths like those of the cankerworms and tussock moth to prevent them from crawling up the tree. Ordinary 12-inch 12-mesh fly screen is cut on a bias into pieces long enough at the top to overlap an inch or so after encircling the tree trunk at the desired height and about 6 inches longer at the bottom. Fasten the upper edge snugly around the tree with small carpet tacks and let the ends meet on a bias, so that the looser edge of the band stands away from the trunk about an inch all around and admits the ascending insects freely. Where a number of uniform sized trees are to be banded at the same time, the wire strip may be cut up as suggested on the accompanying outline (fig. 5).

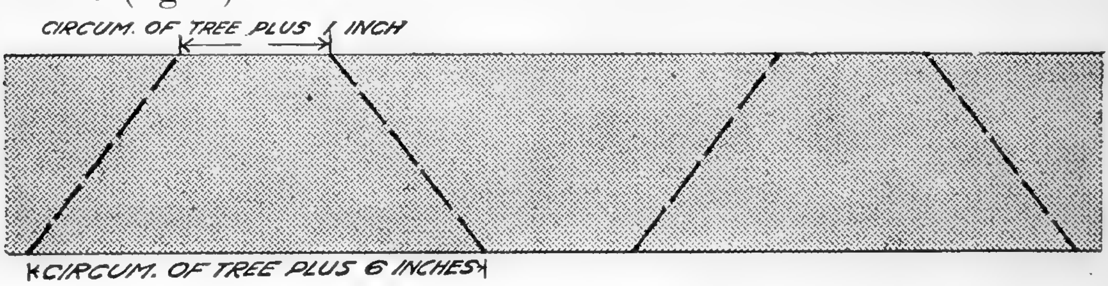

FIG. 5.—Diagram of strip of wire screen with broken lines showing how to cut it for insect guards.

These bands must be examined daily and moths collected under them crushed, as the tiny larvæ hatching from eggs they may lay will readily penetrate the screen. Because of this necessity, the use of wire bands is practicable only in limited instances.

STICKY BANDS.

Applied directly to the bark of the tree sticky bands may be injurious. The injury may be prevented, however, by applying the preparation on a strip of heavy paper. As such paper can not be made to fit snugly, cheap cotton batting may be used underneath it.

The process then is as follows: Cut a strip of cotton about 2 inches wide and wrap it around the tree trunk so as to fill all the crevices of the bark. Over the cotton place a strip of 1-ply building tar paper about 5 inches wide, draw it tightly, and tack it securely where it overlaps. The adhesive is then spread out on the paper. (Fig. 6.)

The sticky preparation is apt to become dry or covered with dust and insects and, in consequence, fail to function, so that it should be either renewed from time to time or it may be renovated by combing it so as to remove obstructions and bring the fresh material to the surface.

FIG. 6.—Barrier of sticky material on tree trunk to prevent ascent of caterpillars, wingless moths, etc. (Quaintance and Siegler.)

Sheets of sticky fly paper may be used for tree banding, in emergencies. They are best placed over bands of cotton batting, as described above, and fastened to the trunk by means of heavy twine tied tightly around the upper and lower edges.

STICKY PREPARATIONS FOR BANDING.[6]

The market offers proprietary preparations for banding which are frequently preferred because ready for use. Where materials, facilities, and time are available, however, these preparations may be made at home. Homemade preparations offer advantages in that adulterant or harmful substances are sure to be excluded, the cost will be less, and substances may be used up that might otherwise go to waste. Following are some of the substances and mixture that may be employed for this purpose:

ROSIN-CASTOR OIL MIXTURE.[6]

Place 5 pounds of rosin and 3 pints of castor oil in a pot and heat slowly until the rosin is melted. Add more oil if the resultant is too thick.

AXLE GREASE, FISH OIL, AND ROSIN.[6]

These substances are used in Europe for the preparation of a tree-banding mixture which is reported effective. The mixture is made as follows:

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

[6] See also Department Bulletin 899, "Gipsy Moth Tree-Banding Material: How to Make, Use, and Apply It," which may be obtained from the Superintendent of Documents, Washington, D. C., for 15 cents (postage stamps not accepted).

The rosin-castor oil mixture and the mixture of axle grease, fish oil, and rosin have been tested by the Bureau of Entomology in New England for banding purposes but are unsatisfactory in that region.

Heat the axle grease in a cooking vessel of at least a gallon capacity until all the water in it is evaporated. Without removing this from the fire, stir in the fish oil, followed by the powdered rosin, a little at a time. When the latter is dissolved, remove from the fire, and the mixture is ready for use next day.

PRINTER'S INK.

Refuse printer's ink, sold as "tree ink," may be used for tree-banding purposes, but it should be mixed with a heavy oil to prevent it from drying too rapidly.

SPRAYING OUTFITS FOR SMALL OPERATIONS.[7]

HAND ATOMIZERS.

For spraying a few plants or very small trees, hand atomizers (fig. 7) may be used. These are made of brass, copper, heavy tin, or other material, and usually have a capacity of about 1 quart.

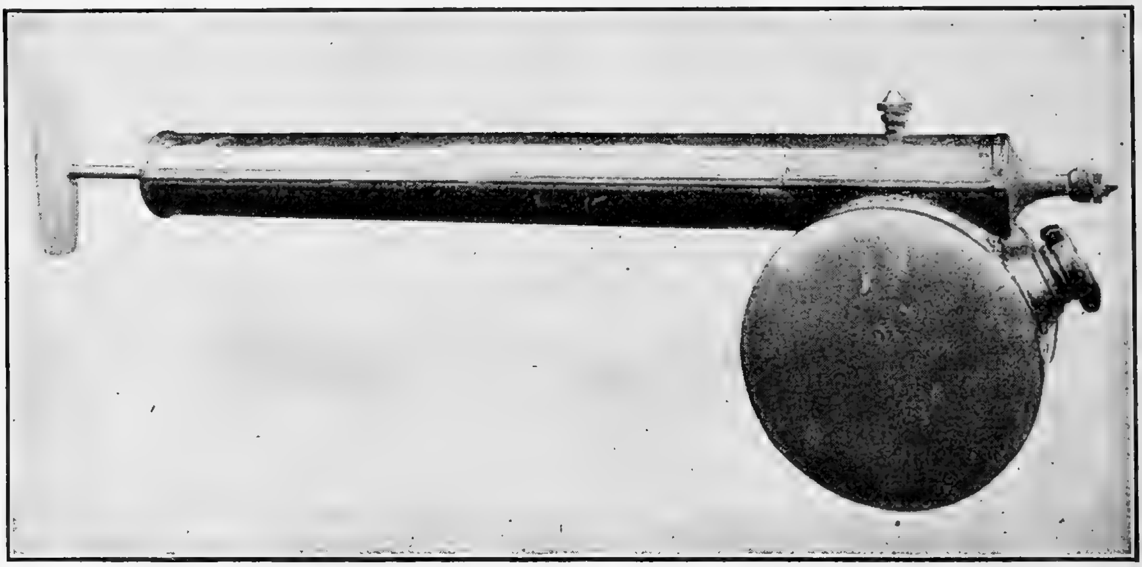

FIG. 7.—Hand atomizer, useful for spraying small plants or low-growing trees. (Quaintance and Siegler.)

SMALL COMPRESSED-AIR PUMPS.

Compressed-air pumps (fig. 8) are now most frequently used in small-scale spraying, and are preferred to the bucket or knapsack pumps by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 to 4 gallons. They are carried by means of a shoulder strap. In the better types agitation is provided, usually by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank, and the opening closed by the tight-fitting cap, the air is pumped until the liquid is under pressure. The tank is usually emptied by three to four pumpings of a dozen strokes each.

[7] Adapted from Farmers' Bulletin 908.

BARREL PUMPS.

The barrel hand-pump outfit (fig. 9) has a capacity of about 50 gallons, and may be used to advantage on a limited number of trees. With a good barrel pump considerable spraying may be done in a satisfactory manner. The working parts of the pump should be of bronze, brass, or other noncorrosive material, and the valves and plungers should be readily accessible and easily repaired. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure a good pressure and uniform discharge of the spray material the pump should be provided with an adequate air chamber, to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side of the barrel, and the whole outfit placed on skids or on a wagon. On hilly land it is preferable to have the barrel in a horizontal position.

Fig. 8.—Compressed-air sprayer for small spraying operations; no pumping is required while spraying. (Quaintance and Siegler.)

DOUBLE-ACTION HAND PUMPS.

The double-action hand pumps (fig. 10) usually are employed in connection with spray tanks of greater capacity than a barrel, as the 150 or 200 gallon half-round tank used in place of the wagon bed. The pump, which may be either vertical or horizontal, is fastened to a small platform, and placed on top of the tank or on a platform at the hind end of the wagon. A suction hose extends into the spray tank. A barrel or 100-gallon hogshead may be used, however, and placed at one end of the wagon bed or platform, thus leaving plenty of room for the pump and operator. When properly used these double-acting, double-cylinder pumps furnish adequate pressure for two leads of hose, and for single or double nozzles. They furnish an outfit intermediate in cost and capacity between the barrel pump and the gasoline or other power sprayer.

A common defect is lack of adequate facilites for agitation, although tanks are available in which this deficiency is corrected to some extent.

SPRAYING OUTFITS FOR LARGE OPERATIONS.[8]

Spraying outfits in larger towns and cities are generally best operated by gasoline engines. In an emergency even the fire engines may be utilized for this purpose in some communities.

GASOLINE-POWER SPRAYERS.

Spray pumps, operated by gasoline engines, are by far the most useful type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for hillside spraying, vineyard spraying, shade-tree spraying, etc.

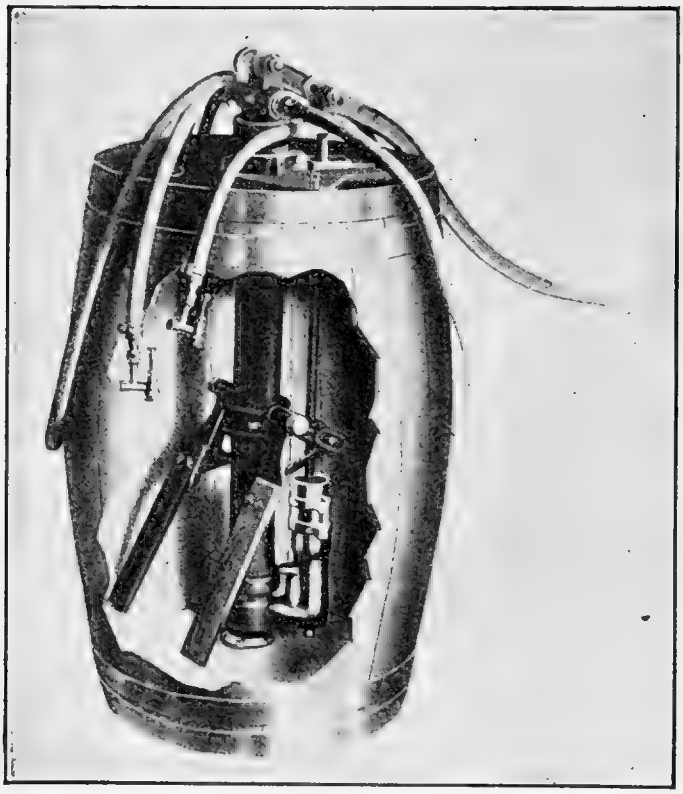

FIG. 9.—Barrel pump, suitable for spraying a few medium-sized trees. (Quaintance and Siegler.)

The smallest power sprayers are nothing more than ordinary barrel pumps equipped with a small engine of 1 to 1½ horsepower. These small mechanical outfits are higher in price than the hand pump, but are usually worth the additional first cost. They may be operated at a comparatively small cost and will give a steadier spray and at a higher pressure than will the pumps operated by hand. With the small power outfit one lead of hose is generally used, but two leads may be employed if the pump has sufficient capacity.

Large power sprayers (see title-page) are made with pumps of from two to four cylinders, having a capacity of 5 to 50 or more gallons per minute under a pressure of 150 to 300 pounds. These sprayers are operated by gasoline engines of from 2 to 12 horsepower. For the four-cylinder pumps of large capacity, auto-type 4-cylinder engines of 10 to 12 horsepower are sometimes used.

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[8] Adapted from Farmers' Bulletin 908.

In the extensive spraying operations in New England for the gipsy and brown-tail moths motor-truck sprayers[9] (fig. 11) have been used to great advantage.

The makes of spray machines now on the market vary a good deal in durability and efficiency. The tree warden, before selecting an outfit, should consider carefully the several designs and choose an outfit that will best meet his requirements.

SPRAYING ACCESSORIES.[10]

The spraying outfit is not complete or efficient unless properly equipped with useful accessories. Spraying devices that will save

FIG. 10.—Double-action hand pump for spraying home grounds or in the small community. (Quaintance and Siegler.)

time or aid the tree warden in doing more thorough work should be provided. The equipment need not necessarily be elaborate or expensive, but should be sufficiently complete and modern so that there will be no handicap when the time to spray is at hand. Spraying, to be most effective, must be done at critical periods, and delays caused by insufficient or inferior equipment may mean a heavy loss.

SPRAY NOZZLES.

Manufacturers of spraying machinery and accessories have placed on the market a large number of nozzles to which they have given

[9] Department Bulletin 480, "Solid-Stream Spraying Against the Gipsy Moth and Brown-Tail Moth in New England," contains full information on the subject and may be purchased from the Superintendent of Documents, Washington, D. C., for 15 cents (postage stamps not accepted).

[10] Adapted from Farmers' Bulletin 908.

various trade names. Although these nozzles differ somewhat in size and style, the principle of construction is not distinctive for each.

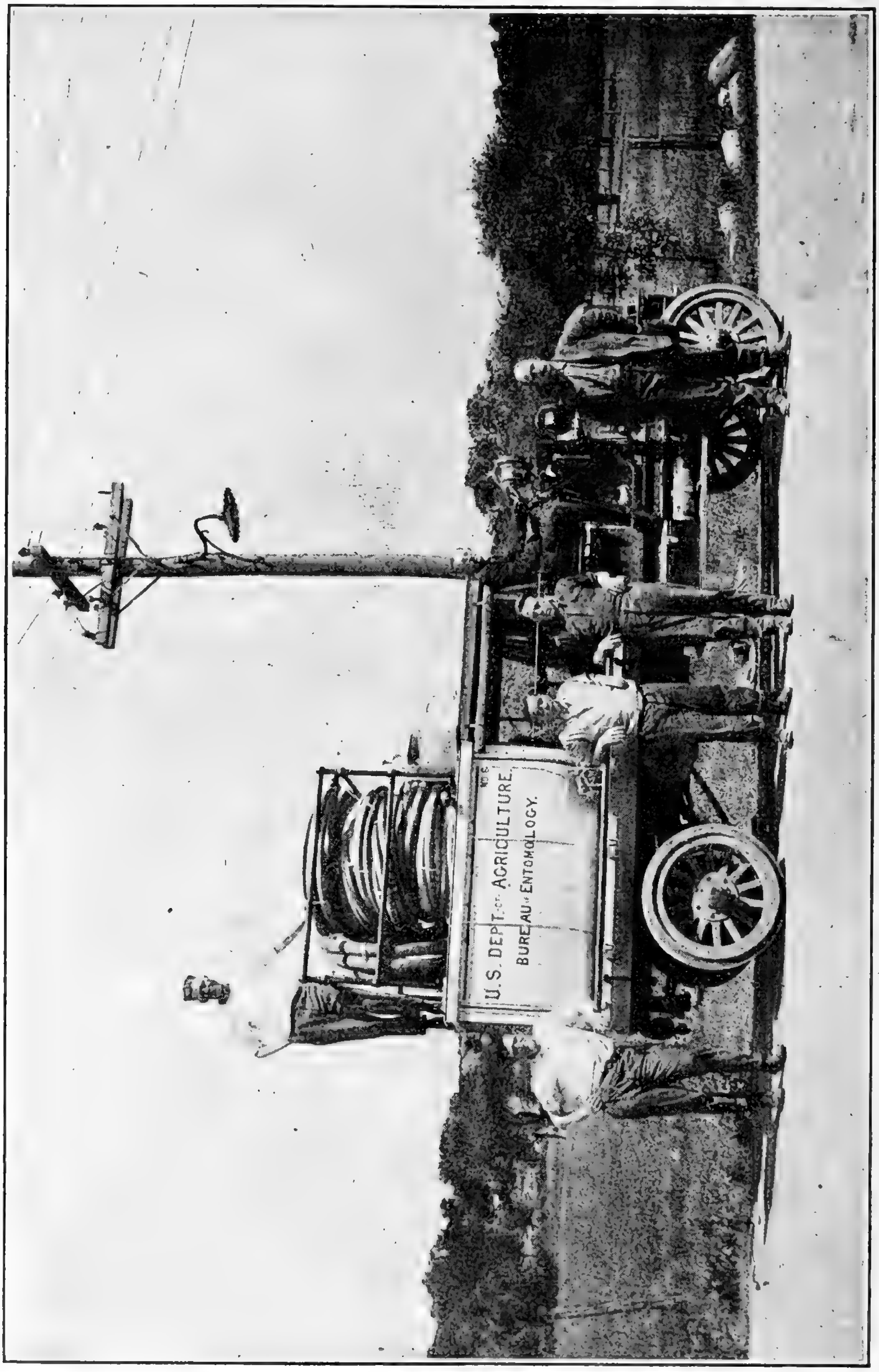

FIG. 11.—Motor-truck sprayer of the Bureau of Entomology with crew and equipment. (Worthley.)

The nozzle type most suitable for shade-tree spraying is that known as the whirlpool disk type (fig. 12). It is as well adapted for use with small spraying outfits as with larger ones. These nozzles are usually provided with three interchangeable disks or plates, each having a different sized opening to give a fine, medium, or coarse spray. The spray material passes through a tangential opening into the eddy chamber, where it obtains its whirling motion and escapes through the opening in the disk. The disk nozzles are relatively small and compact and, owing to the absence of any appendages, do not catch in the branches of trees as happens with other designs. The coarse spray disks deliver a fairly large quantity of spray material, and can not be used satisfactorily with pumps of small pressure capacity. With the smaller spraying outfits the disks having small apertures should be used.

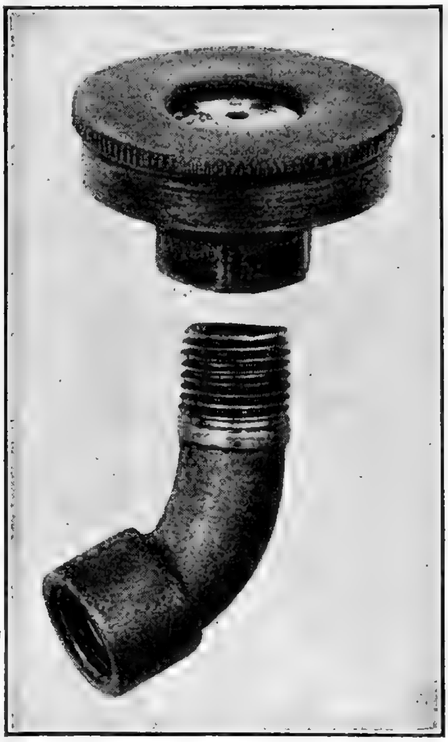

FIG. 12.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook. (Quaintance and Siegler.)

NOZZLE Y.

For rapid spraying, with outfits having sufficient capacity and pressure, two nozzles per rod may be used. These can be attached to the spray rod by means of a **Y**.

SPRAY RODS.

Spray or extension rods (fig. 13) are employed in order to reach the upper and inner parts of the trees. These generally consist of an aluminum, brass, or iron rod contained within a bamboo pole and are usually made in lengths of from 6 to 14 feet. Some fruit growers use an ordinary gas pipe, but the lighter weight spray rods are much more desirable.

ANGLE SHUT-OFF.

An angle shut-off, connecting the spray hose with the base of the spray rod, is a convenient device for cutting off the spray material whenever desired, as in passing from one tree to another. The angle construction permits the hose to hang in its natural position, and thereby saves the hose from wearing at the coupling. Without an angle shut-off, spray material is frequently wasted because of the inconvenience of closing the stopcock.

THE WORTHLEY NOZZLE, FOR SOLID-STREAM SPRAYING.

In the spraying of shade trees, which, when full grown, are usually quite tall and large generally, the time and labor previously required in climbing in order to reach the top have constituted the heaviest item of expense in insect control. The introduction of solid-stream spraying has largely eliminated this expense, and the Worthley nozzle (fig. 14) is a material help in the same direction. It is in effect a combination of extension rod and nozzle. With this nozzle the tops of trees 85 feet high and higher can be reached from the ground quite effectively. To break the force of the stream, so that small trees and the lower foliage of large trees may be properly sprayed, a strip of brass, slightly curved, about 10 inches long and $1\frac{1}{4}$ inches wide, known as a spreader (fig. 14, B), is attached to a brass ferrule about a foot in length, so that it can be moved up and down the tube of the nozzle. When this brass strip is slid beyond the tip the solution forcibly coming in contact with it is broken up into a fan-shaped stream, thus giving a good mist spray.

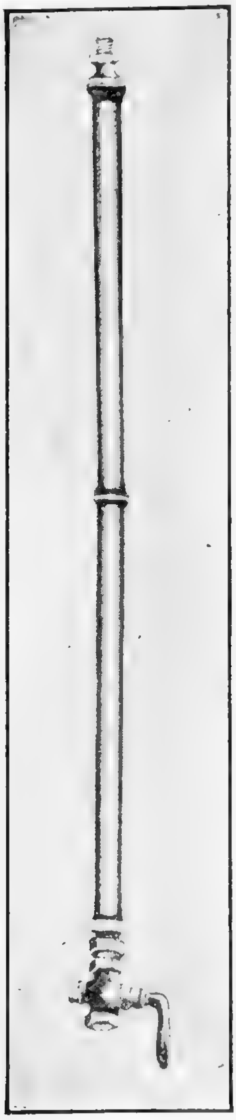

FIG. 13.—Bamboo spray rod. (Quaintance and Siegler.)

SPRAY HOSE.

Only the best grade of high-pressure hose, usually about three-eighths to one-half inch inside diameter, should be used for spraying operations. The length of the hose for spraying from the ground will vary according to conditions, but should be adequate for the work to be done. In large tree spraying, from 50 to 150 feet, with an average of about 100 feet of hose is desirable, and this will be long enough to permit the spray men to work around the tree without hindrance. Special conditions may require greater lengths of hose.

HOSE COUPLINGS AND CLAMPS.

It is poor economy to use light-weight hose couplings and clamps, since rough usage will soon cause them to break or blow out. Heavy couplings and clamps are obtainable, and these will give better satisfaction.

TANK FILLERS.

During spraying operations it is highly important to refill the spray tank quickly, since delays in filling waste the time of the team and spray men. Unless the community is provided with a convenient water system, a tank filler is practically indispensable. This device, which usually operates on the jet system, will promptly fill the tank from any source of water, such as a cistern, pond, etc.

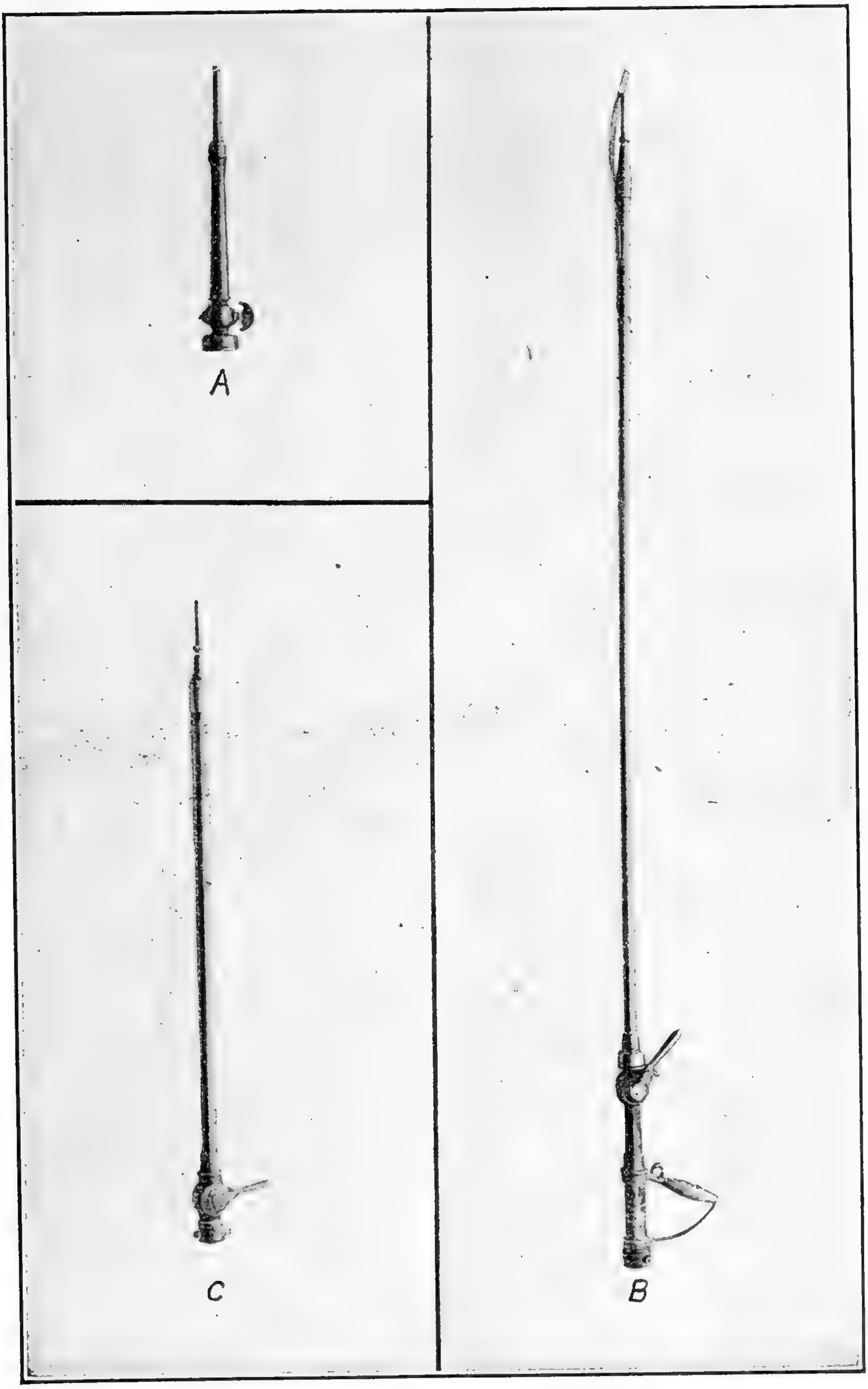

Fig. 14.—Nozzles for solid-stream sprayer. A, Old type nozzle; B, latest type, known as the Worthley nozzle, with spreader; C, smaller size, same type as B. (Worthley.)

Rotary pumps (fig. 15) connected with the spray engine are employed for the same purpose and are more satisfactory where the water contains considerable sediment. Rotary pumps are frequently used in districts where the water is drawn from the irrigation ditches.

PRESSURE REGULATOR.

This is a useful attachment for the regulation of the pressure. By its proper adjustment a uniform spray is obtained at the pressure desired.

MISCELLANEOUS SPRAYING SUPPLIES.

The following accessories should be provided:

Scales.—A good pair of scales should be used for weighing out the spray materials. Guess-work is poor economy.

FIG. 15.—Gasoline-power spraying outfit with carpenter's horse type of tower and rotary pump tank filler. (Quaintance and Siegler.)

Galvanized buckets.—These are useful for measuring liquid spray materials, especially when gallons and smaller quantities are marked on them by means of graduating dents.

Strainer.—Before admitting spray material into the spray tank, it should first pass through a screen (fig. 16) to remove all of the coarse particles. The opening in the spray tank for filling purposes is usually provided with a removable brass screen.

Extra parts.—Extra parts of the equipment most subject to wear or breakage should always be on hand. Failure to observe this precaution will frequently result in delays at critical spraying periods.

Tools.—Tools specially made for the different parts of the spraying outfit are usually supplied by the manufacturer. Other standard tools, however, such as wrenches, screw drivers, hammers, etc., should be carried in the tool box in case of need.

Help.—In solid-stream power spraying at least 5 men are required: One mechanic and driver (or chauffeur if the outfit is mounted on a power truck), three men at the hose, and one at the nozzle. If more than 150 feet of hose are used, more men will be needed.

It is perhaps not out of place to state here that, in view of the fact that spraying is practically futile unless it is intelligently done, it is not only desirable to have the help in this work intelligent and measurably well informed, but also to have the rewards of their labor sufficiently attractive to hold them to a certain degree of permanence, thereby insuring effectiveness and efficiency. In the long run such a policy will prove the cheapest and most satisfactory.

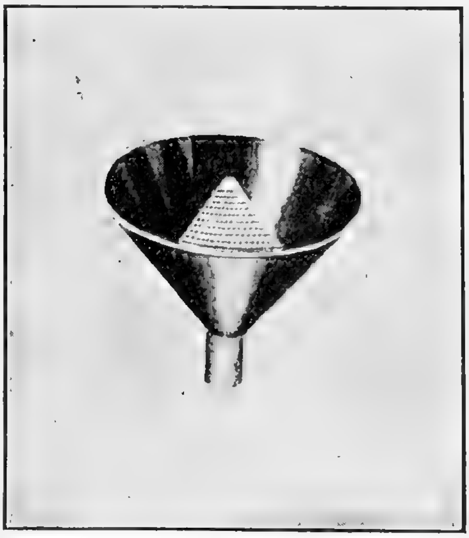

Fig. 16.—Strainer for use in removing sediment in sprays when these are being poured into the spray tank. (Quaintance and Siegler.)

SPRAY DILUTION TABLE FOR READY REFERENCE.[11]

Table I shows the amount of spray material required for a number of different quantities of spray. The rate at which the materials have been computed will be found in the first column. The figures at the top of the table represent the total number of gallons of diluted spray desired, and the figures in the vertical columns give the amount of spray material required. Thus, if 150 gallons of arsenate of lead, paste, at the rate of 2 pounds to 50 gallons, is to be used, it will be noted in the table that 6 pounds is required. Again, if 100 gallons of kerosene emulsion, 10 per cent strength, is wanted and the stock solution contains 66 per cent of kerosene, it will be found by referring to the table that 15 gallons of the stock emulsion should be used.

[11] Adapted from Farmers' Bulletin 908.

TABLE I.—*Spray dilution table for ready reference. (A) For trees in foliage; (B) for dormant trees.*

	Total gallons of diluted spray material.									
	200	150	100	50	25	20	15	10	5	1
(A) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR TREES IN FOLIAGE.										
Stomach poisons.										
Arsenate of lead, paste, 2 lbs. to 50 gals	8 lbs	6 lbs	4 lbs	2 lbs	1 lb	12.8 oz	9.6 oz	6.4 oz	3.2 oz	0.64 oz. or 1 teaspoonful.
Arsenate of lead, powder, 1 lb. to 50 gals	4 lbs	3 lbs	2 lbs	1 lb	8 oz	6.4 oz	4.8 oz	3.2 oz	1.6 oz	0.32 oz. or 3 teaspoonfuls.
Arsenate of lime, paste, 2 lbs. to 50 gals	8 lbs	6 lbs	4 lbs	2 lbs	1 lb	12.8 oz	9.6 oz	6.4 oz	3.2 oz	0.64 oz. or 1.5 teaspoonfuls.
Arsenate of lime, powder, ¾ lb. to 50 gals	3 lbs	2.25 lbs	1.5 lbs	12 oz	6 oz	4.8 oz	3.6 oz	2.4 oz	1.2 oz	0.24 oz. or 2 teaspoonfuls.
Paris green, 6 oz. to 50 gals	1.5 lbs	1.12 lbs	12 oz	6 oz	3 oz	2.4 oz	1.8 oz	1.2 oz	0.6 oz	0.12 oz. or 0.5 teaspoonful.
Contact sprays.										
Nicotine sulphate (40%), 1 to 800=½ pt. to 50 gals.	1 qt	1.5 pts	1 pt	8 fl. oz	4 fl. oz	3.2 fl. oz	2.4 fl. oz	1.6 fl. oz	0.8 fl. oz	1 teaspoonful.
Nicotine sulphate (40%), 1 to 1,066=⅜ pt. to 50 gals.	1.5 pts	1.12 pts	12 fl. oz	6 fl. oz	3 fl. oz	2.4 fl. oz	1.8 fl. oz	1.2 fl. oz	0.6 fl. oz	0.75 teaspoonful.
Kerosene emulsion (66%), 10% strength	30 gals	22.5 gals	15 gals	7.5 gals	3.75 gals	3 gals	2.25 gals	1.5 gals	3 qts	1.2 pints.
Fish-oil soap, 1 lb. to 4 gals				12.5 lbs	6.25 lbs	5 lbs	3.75 lbs	2.5 lbs	1.25 lbs	4 oz.
(B) SPRAY MATERIAL AND USUAL RATE OF DILUTION FOR DORMANT TREES.										
Contact sprays.										
Lime-sulphur concentrate (33° B.), 1 gal. to 8 gals.	25 gals	18.75 gals	12.5 gals	6.25 gals	3.12 gals	2.5 gals	1.87 gals	1.25 gals	2.5 qts	1 pint.
Lime-sulphur concentrate (33° B.), 1 gal. to 9.5 gals.	21 gals	15.75 gals	10.5 gals	5.25 gals	2.62 gals	2.1 gals	1.57 gals	1.05 gals	2 qts	0.84 pint.
Kerosene emulsion (66%), 25% strength	76 gals	57 gals	38 gals	19 gals	9.5 gals	7.6 gals	5.7 gals	3.8 gals	1.9 gals	3 pints.
Kerosene emulsion (66%), 20% strength	60 gals	45 gals	30 gals	15 gals	7.5 gals	6 gals	4.5 gals	3 gals	1.5 gals	2.4 pints.
Fish-oil soap, 2 lbs. to 1 gal	400 lbs	300 lbs	200 lbs	100 lbs	50 lbs	40 lbs	30 lbs	20 lbs	10 lbs	2 lbs.

Abbreviations: oz.=ounce; lb.=pound; fl. oz.=fluid ounce; pt.=pint; qt.=quart; gal.=gallon. Weights: 16 ounces=1 pound. Measures: 7 teaspoonfuls=1 fluid ounce; 16 fluid ounces=1 pint; 32 fluid ounces=1 quart; 4 quarts=1 gallon.

LEAF-CHEWING INSECTS.

GENERAL.

The life of the deciduous tree attacked by leaf-chewing insects is directly endangered by them only when they keep the tree in a state of complete defoliation for several years in succession. Fortunately this condition can apparently be brought about only by recent insect pest immigrants before our native predacious and parasitic insects develop an appetite for them. This was true not so many years ago of the elm leaf-beetle, for instance, which is only an occasional and local pest at present owing to the effective work of predacious bugs that feed on its eggs. Nevertheless, aside from disfiguring the tree for the season, defoliation tends to reduce its vitality more or less, and this often leads to its attack by other insects, principally bark and wood borers, which are much harder to combat and the injury of which not infrequently results in fatalities among trees. For these reasons, as well as the fact that it is the most easily done, it is advisable, wherever practical considerations permit, to check defoliation as soon as observed. As not every hole in the foliage necessarily indicates the presence of a defoliator this point is best first definitely ascertained before the labor and expense of spraying are undertaken. Municipalities, however, should always be prepared for such emergencies by having on hand the necessary machinery and supplies for a prompt, thorough, and quick job.

BAGWORM.[12]

Recognition of work.—Although arborvitæ and other evergreens are the favorite food of the bagworm, broad-leafed trees and shrubs are not infrequently discovered to have their foliage eaten and bearing rough looking, more or less spindle shaped bags up to 2 inches long (fig. 17). On closer examination a head and six legs are found protruding from the opening at the upper end of the bag. Badly defoliated trees during the dormant season are bespangled with such bags, although at that time most of these contain eggs instead of caterpillars.

Habits and seasonal history.—The bagworms attain full growth in the District of Columbia toward the end of August, whereupon they transform to pupæ. About three weeks later these change into adult moths, of which the females are wingless and do not leave the bag. The males alone emerge from the bags and fly in search of females, with which they mate. Immediately thereafter the female begins laying her eggs, with which she nearly fills her old chrysalis skin in the bag, wriggles out of it, and dies. The eggs thus laid pass the

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[12] *Thyridopteryx ephemeraeformis* Haworth.

winter in the bag and late the following spring hatch into caterpillars, which make their way to the nearest leaf and immediately begin to feed and construct bags for themselves. The bags are made from bits of the foliage on which they feed and silk spun by them. In the latitude of Washington, D. C., it takes the bagworm a full year to complete its life cycle.

Control.—Several forms of parasitic insects prey on the bagworm, keeping its numbers within harmless bounds during most years. From time to time, however, this check fails to operate, and then artificial measures of control must be resorted to.

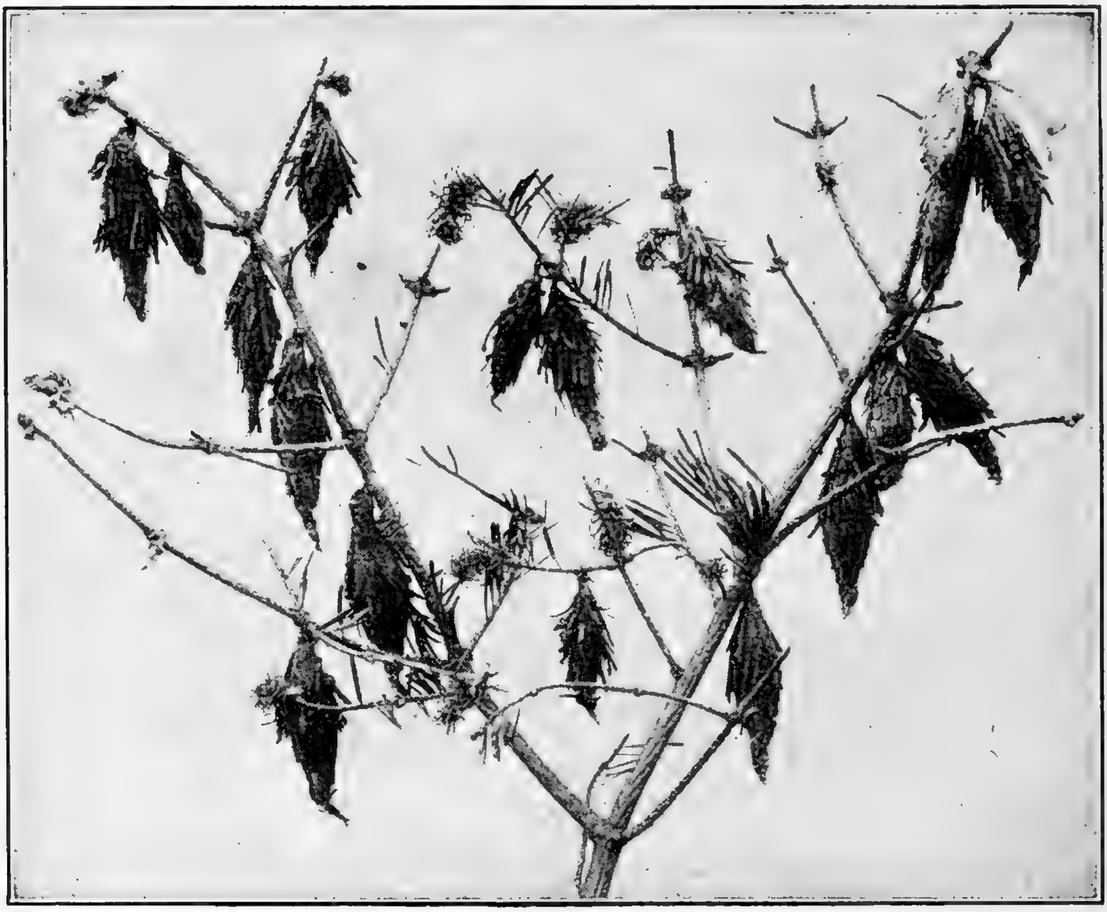

FIG. 17.—Twig of conifer completely defoliated by bagworms, showing bags in various stages of development. (Photo by Paine.)

It is clear from the seasonal history of the insect that if, wherever practicable, the bags be picked off the trees during the winter and burned, so many eggs will have been destroyed that the damage the following season will be limited to the caterpillars from the eggs in the few overlooked bags. A better practice than burning the bags, however, would be to confine them in a bag made of sheer or coarse material and suspended from the ceiling of an outhouse, thus allowing the issue and escape of parasites they may contain, confining the bagworms until they die, and protecting the mass from destruction by mice, decay, etc. Where hand picking is impracticable, and especially on evergreen trees, the most efficient remedy is to spray infested trees with lead arsenate (p. 11) while the worms are feeding and, preferably, soon after they are hatched from the eggs in the late spring. For strength of spray and method of applying it see pages 20–30.

The effectiveness of the campaign against this pest will be in direct proportion to the extent to which the immediate neighborhood participates in it.

A full account of the bagworm is given in Farmers' Bulletin 701 of this Department which will be sent on request as long as the supply lasts.

CATALPA SPHINX.[13]

Recognition of work.—Catalpa trees, the only kind attacked by this insect, are often found having their leaves rapidly devoured by caterpillars which, when full grown, are conspicuously yellow and black striped, 3 inches long, with a short horn near the hind end of the body (fig. 18, *c*, *e*, *f*, *h*). Caterpillar droppings beneath a catalpa tree are another indication of their presence. In some seasons the leaves are completely stripped off entire trees or even groves by this insect.

Habits and seasonal history.—Around Washington, D. C., the insect completes two generations annually, three or four in the extreme South. On attaining full growth the caterpillars of the fall generation crawl down the trunk of the tree and into the ground where they pupate and spend the winter in that stage (fig. 18, *j*). Late the following spring the large grayish brown moths (fig. 18, *k*), known as catalpa sphinx or catalpa hawk moths, issue from these, mate, and lay their eggs (fig. 18, *a*) in batches up to about a thousand on the underside of leaves, and sometimes in smaller batches on stems and branches. The young caterpillars hatching from these feed in groups for some time before scattering (fig. 18, *b*, *b*,). They molt before reaching full growth and pupating, and vary considerably in the markings, as shown in the illustration (fig. 18, *e*, *f*).

Control.—Normally, natural agencies, such as small wasplike and flylike parasitic insects and insectivorous birds, keep this insect in check, so that it is not seen in a given locality for from one to several years. In some parts of the South the catalpa is grown specially for the purpose of attracting the sphinx moth, for its caterpillars are highly esteemed there as bait for fishing. Occasionally, however, natural agencies fail to exercise satisfactory control and then the artificial killing of the caterpillars with poison spray, like lead arsenate, becomes necessary. The method of application of the spray is given on pages 20–30.

Farmers' Bulletin 705 contains a full account of this insect and will be sent on request as long as the supply lasts.

[13] *Ceratomia catalpae* Bdv.

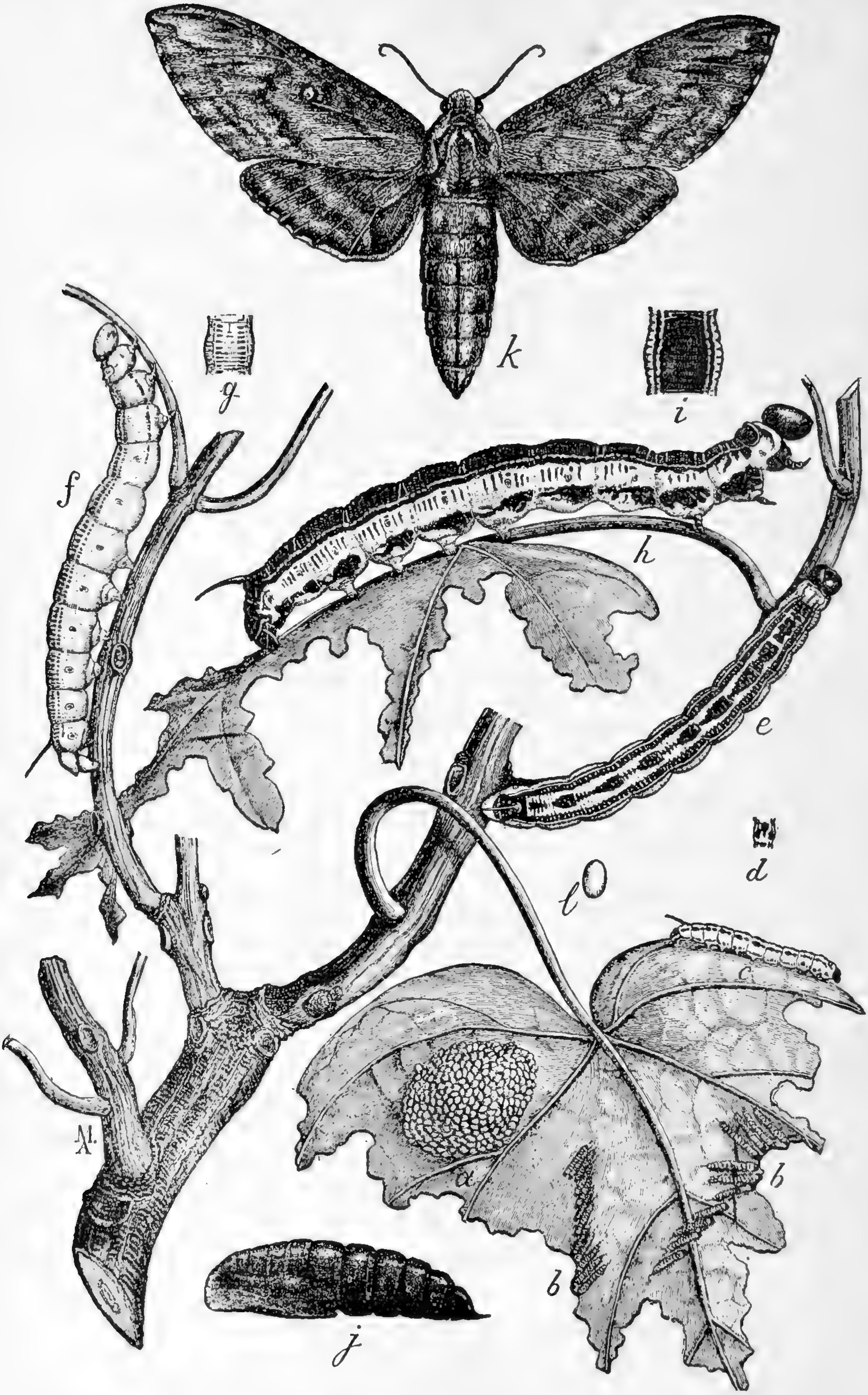

FIG. 18.—Catalpa sphinx: *a*, Egg mass; *b*, *b*, newly hatched larvæ; *c*, larva one-third grown; *d*, dorsal view of joint of *f*; *h*, full-grown dark larva; *i*, dorsal view of joint of same; *j*, pupa; *k*, moth; *l*, egg, enlarged. All natural size, except *l*. Marx del. (Howard and Chittenden.)

FOREST TENT CATERPILLAR.[14]

Manner and amount of damage it does.—Although the sugar maple is its favorite food in the North and oak in the South, the forest tent caterpillar will feed on almost any deciduous tree. Like most native insects it is very abundant and causes serious injury only during

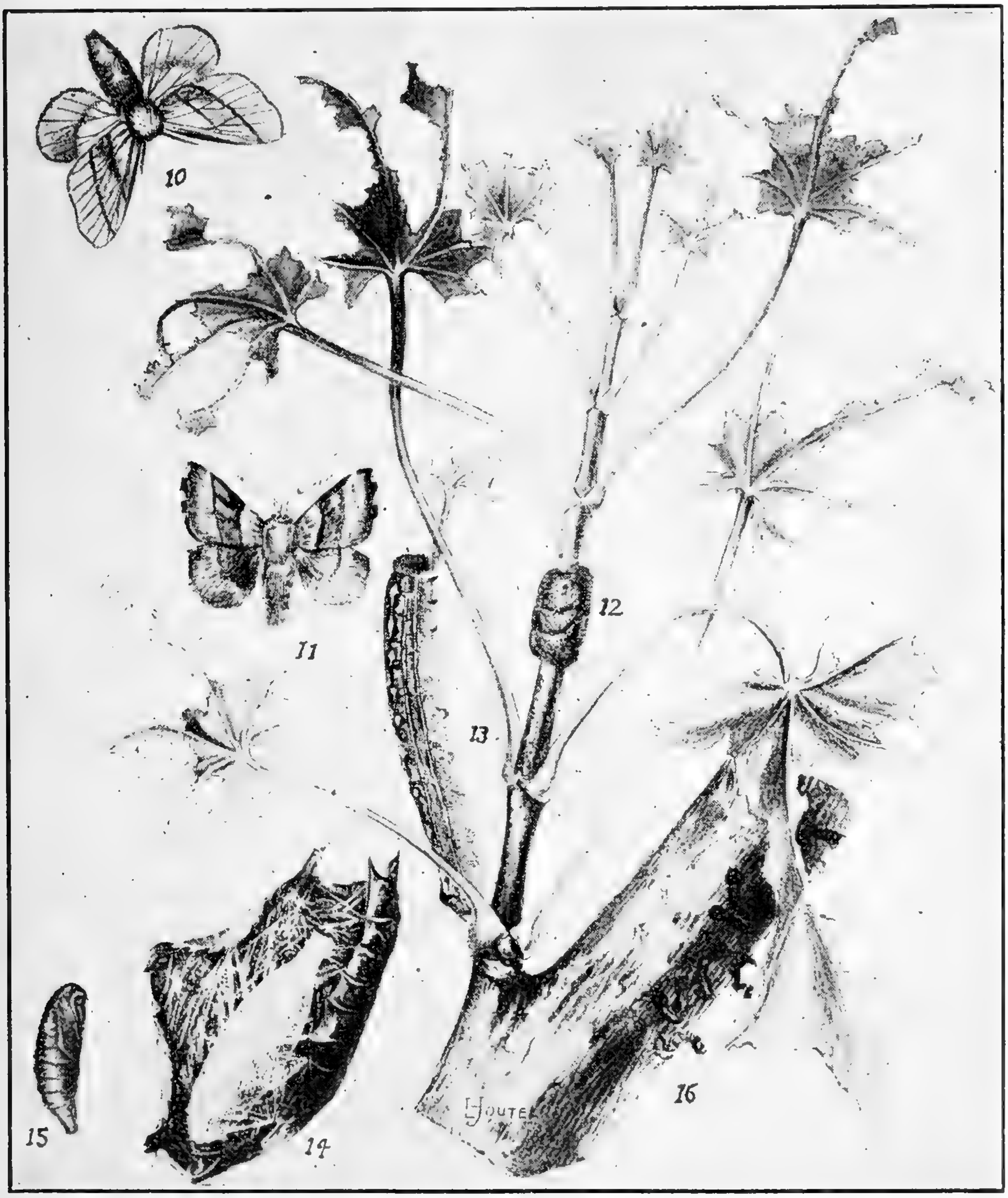

FIG. 19.—Forest tent caterpillar: *10*, Female moth with wings expanded; *11*, male moth with wings expanded; *12*, egg belt encircling twig; *13*, side view of full grown caterpillar; *14*, cocoon in leaf; *15*, pupa; *16*, cast skins of caterpillars. (Felt.)

spells of two or three consecutive years. During these years, however, it is capable of completely stripping the foliage of deciduous trees over hundreds of square miles. The stopping of trains, due to tracks made slippery by crushed masses of caterpillars which had

[14] *Malacosoma disstria* Hübn.

wandered in search of suitable feeding or transformation grounds, has been frequently reported.

How to recognize its presence.—In early summer leaves of hardwood trees or shrubs may show signs of having been eaten by caterpillars with blue head and silvery, diamond-shaped spots down the middle of the back (fig. 19, *13*). When not feeding, these caterpillars cluster on the trunks and large limbs. In a wind they drop to the ground or hang from the tree by silken threads.

Seasonal history and habits.—On approaching full growth, about early June, many of the caterpillars abandon the tree and settle in sheltered places for pupation (fig. 19, *14*). Stones, fences, and wood piles serve their purpose. They remain in this state (fig. 19, *15*) about two weeks and early in July the pupæ turn into moths (fig. 19, *10*, *11*). A little later the females lay their eggs in bands of about 150 around slender twigs (fig. 19, *12*). By fall the young caterpillars are fully developed within the eggs, pass the winter thus, and emerge the following spring about the time leaves begin to unfold.

Remedial measures.—Between the spells of abundance this insect is kept in check by natural agencies, chiefly parasitic and predacious insects and birds as well as unfavorable weather conditions.

Destruction of egg masses, caterpillar clusters, and pupæ in season, either by hand picking and burning or by daubing with creosote or spraying with kerosene emulsion or any of the standard miscible oils on the market, will aid materially in checking the pest. Finally, in the care of choice trees and where the necessary apparatus is available early spring spraying with lead arsenate (p. 11) of the trees known to be infested, if thoroughly done, will effectively check injury for the season.

SPRING CANKERWORM [15] AND FALL CANKERWORM.[16]

Character and extent of injury.—Caterpillars, which because of the peculiar loop they make of their bodies are variously known as "measuring worms," "spanworms," or "loopers" (fig. 20), are frequently found devouring the leaves of forest and shade trees of the eastern United States. Of the numerous species of loopers the cankerworms are among the few species that attack both fruit and shade or forest trees and occasionally become so numerous as completely to defoliate trees on large areas. While as a rule healthy trees replace their foliage, repeated defoliation frequently leads to attack, especially on oaks, by bark and wood boring insects, which habitually thrive on weakened trees and ultimately cause their death. The fall cankerworm is the species usually injurious on shade trees, the spring cankerworm being principally an orchard insect.

[15] *Paleacrita vernata* Peck.

[16] *Alsophila pometaria* Harr.

Appearance and seasonal history.—The cankerworm is the caterpillar stage of a moth and comes from an egg laid by the female moth, which is always wingless. The eggs of the fall moth are from 50 to 150 in number, flowerpot shaped, and laid in regular rows and compact patches which are generally exposed in rings around twigs near the ends of branches. Those of the spring moth are egg shaped and are laid in irregular batches beneath bark scales. At the time the first leaves expand in the spring these eggs hatch into caterpillars, which attain full growth in about four weeks (about June) and by a silken thread descend to the ground, there pupating a few inches below the surface. From these pupæ the moths of the fall species usually emerge and lay eggs late in the fall or during warm days in winter. The males are winged, the females wingless. Soon after emerging the latter crawl up near-by trees and bushes to deposit their eggs.

FIG. 20.—Full grown caterpillars of the spring cankerworm. (Quaintance.)

Natural control.—Cankerworms are subject to attack by a variety of insect enemies. Climbing ground beetles (fig. 1, p. 6) devour many caterpillars bodily. Small parasitic wasps and flies lay their eggs in and on the caterpillars and in the eggs of the moth, and the ensuing grubs kill even greater numbers of them. Together these insects usually succeed in keeping the cankerworms in check, but if these fail, the cankerworms become seriously injurious.

Artificial control.—It is impractical to attempt to combat these insects on trees in the forest, but shade trees can be protected as follows: (1) Advantage may be taken of the winglessness of the female by keeping the tree banded (p. 17–20) with some sticky substance or cotton bands to prevent her from ascending the trees to deposit her eggs. Such bands are most effective where applied toward the end of September and maintained in the spring until the end of May. These bands also prevent the worms that come from the undergrowth from ascending the trees. (2) Where banding has been neglected and evidence of heavy infestation is indicated by numerous perforations in the opening leaves, the foliage can be saved by prompt spraying with lead arsenate (p. 11).

ELM LEAF-BEETLE.[17]

How injurious.—The elm leaf-beetle (fig. 21, *b*) feeds on all species of elm, but the common English elm is its favorite. Wherever it is established and abundant it may, under favorable conditions, keep the elms in a constant state of partial or complete defoliation and eventually lead to their death. Hundreds of elm trees of all ages are known to have died as a result of continuous defoliation by it and subsequent attack by bark-boring insects.

Evidence of infestation.—From the time the buds burst in the spring until the leaves are fairly grown the leaves show irregular holes made by the beetles. Later in the season more of the injured leaves are skeletonized from below (fig. 21, *a*) by yellowish black to blackish yellow larvæ (fig. 21, *d*, *e*, *f*) up to half an inch in length, which may also be observed crawling along the trunk. Clusters of 5 to 20 or more orange-yellow, elongate-oval, tapering eggs standing on end (fig. 21, *c*) in two or three irregular rows occur on the underside of leaves, and naked orange-colored pupæ (fig. 21, *g*) in crevices and under scales on the bark and on the ground at the base of trees.

Seasonal history and habits.—The winter is passed in the adult or beetle condition in any suitable shelter. When the buds begin to swell in the spring the beetles issue from their winter quarters, mate, and feed upon the leaflets. When the leaves are fairly well grown the females begin their egg laying. In about a week the eggs hatch into larvæ, which begin to feed at once. Larvæ reach full growth in 15 to 20 days and transform to pupæ, which, 6 to 10 days later, change to beetles. In Washington two generations are produced annually, the eggs of the second generation appearing in July.

Control.—Whenever there is evidence that the insect is present in large numbers, spray the trees with lead arsenate (p. 11) just after the buds have burst and again two weeks later. Aim to spray the underside of the leaves. Rains soon after spraying may necessitate third and fourth applications of the poison to keep the trees fresh and green. Destroying the pupæ at the base of trees by digging up and exposing to weathering or by pouring hot water or thick soapsuds over them will assist in keeping the beetle down.

Simultaneous community action, by individuals cooperatively or by the local government, is indispensable in the work of combating this insect, because unless all trees in a community are treated at the same time the results will be unsatisfactory. Cooperative action is advisable because elm trees are usually large and require costly spraying apparatus. Treatment of individual private trees by the community outfit should be arranged for, in order that no trees may be left untreated.

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[17] *Galerucella luteola* Müll.

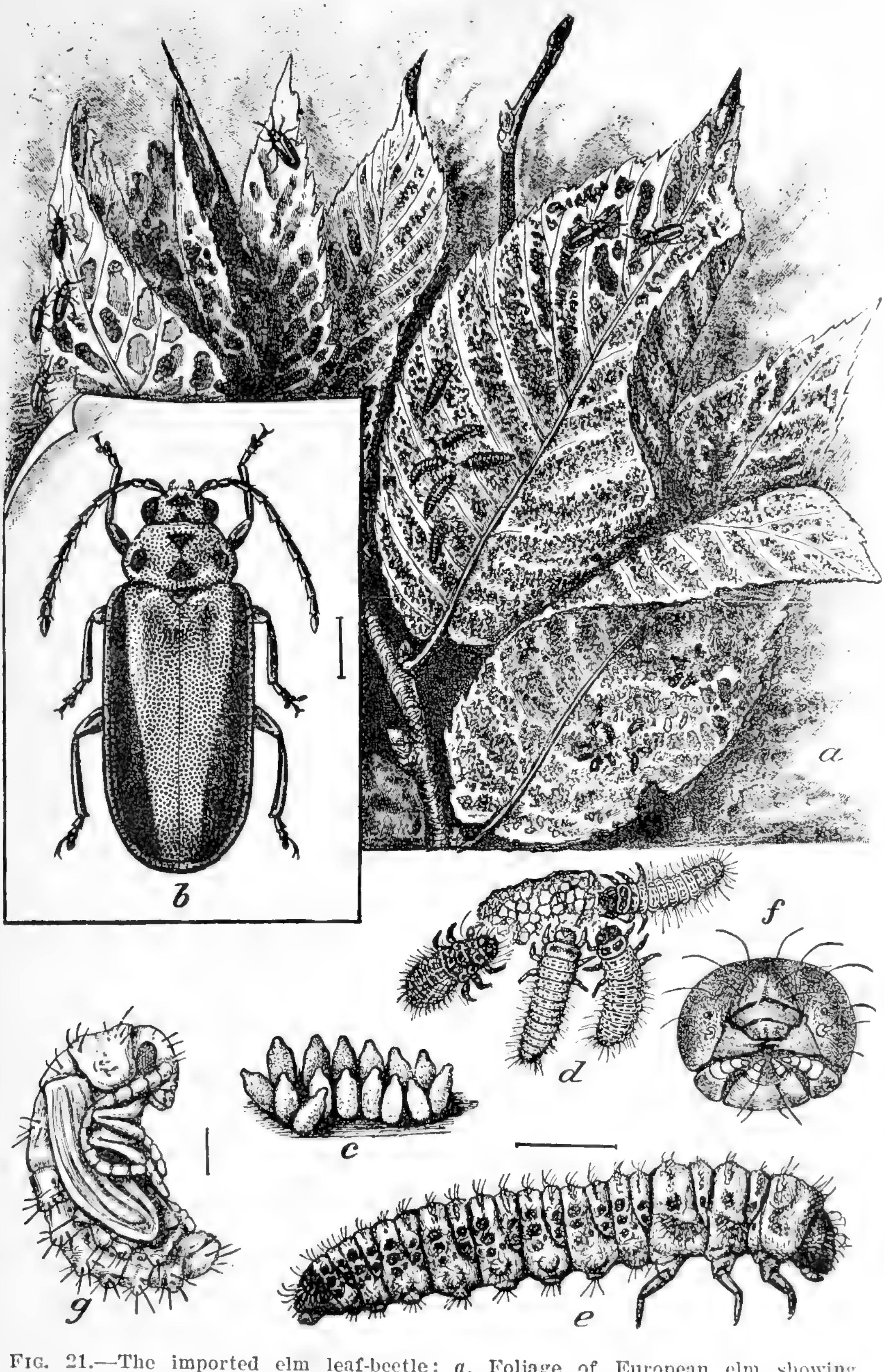

FIG. 21.—The imported elm leaf-beetle: *a*, Foliage of European elm showing method of work of beetle and larva; *b*, adult beetle; *c*, egg mass; *d*, young larvæ; *e*, full-grown larva; *f*, mouth parts of full-grown larva; *g*, pupa; *a*, Natural size; *b*, *c*, *d*, *e*, *g*, greatly enlarged; *f*, still more enlarged. (Howard.)

FALL WEBWORM.[18]

Recognition of work.—In the latter part of summer, trees are often found bearing on the limbs conspicuous webs (fig. 22) inclosing skeletonized, usually brown leaves and numerous hairy caterpillars. These are the tents of the fall webworm. The unsightly nests mar the appearance of the trees and, in years of abundance, defoliation of whole rows of trees may be caused by these worms.

Habits and seasonal history.—In Washington, D. C., the fall webworm completes two life cycles annually; less to the north and more

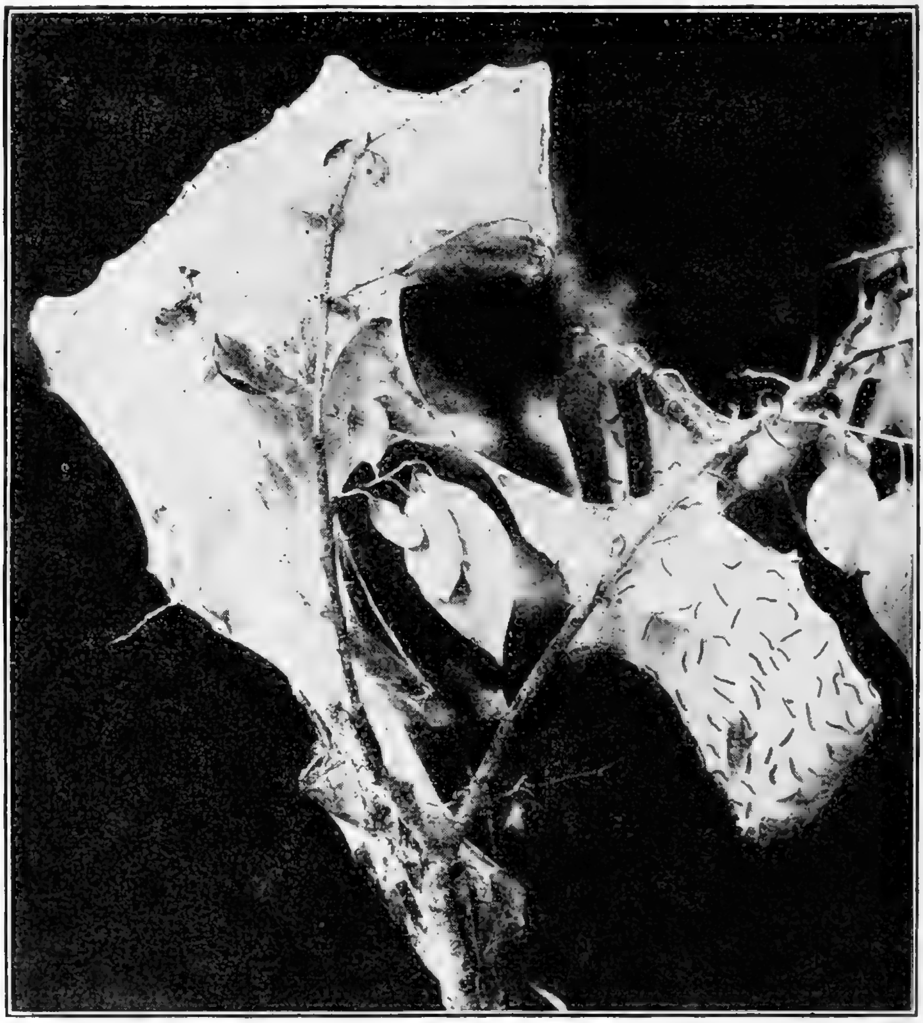

FIG. 22.—The fall webworm: Web and caterpillars. (Gill.)

to the south. It passes the winter in the pupa state in sheer silk cocoons (fig. 23) in such places as among sticks and rubbish at the surface of the ground, in cracks and crevices of tree boxes and fences, under doorsteps, and on basement walls. In May the pupæ change to moths (fig. 23) which lay their eggs in flat batches of 400 to 500 on the underside of leaves. The young worms, hatching from the eggs, feed in colonies, webbing first one leaf, then several together, and eventually covering sometimes all of a good-sized limb. These

[18] *Hyphantria cunea* Drury.

worms attain full growth in July, leave the web, and crawl down the trunk of the tree to pupate. Late in August the year's second crop of their tents is in evidence.

Control.—Natural agencies, and particularly parasitic and predacious insects, usually keep the fall webworm in check. When they become excessively abundant they are invariably attacked by a variety of insect enemies and by a veritable epidemic of diseases which destroy great numbers of the caterpillars, so that they are usually numerous not more than two years in succession.

The most practical remedies against the fall webworm are the destruction of the cocoons, burning the tents, and spraying the infested trees with lead arsenate (p. 11). The methods to be employed are the same as those recommended for the tussock moth.

FIG. 23.—Fall webworm: Moths and cocoons. Natural size. (Howard.)

WHITE-MARKED TUSSOCK MOTH.[19]

How injurious.—The white-marked tussock moth is one of our worst shade-tree pests. Under favorable conditions it is capable of increasing to enormous numbers, and its caterpillars may completely defoliate the shade and park trees of a community. Excepting conifers, it attacks almost every variety of tree, and especially poplar, soft maple, elm, alder, birch, and willow. It is most destructive in cities. The caterpillars are given to migration, and the cocoons made by them may be located in almost any place that offers some measure of shelter. It is not abundant every year, being in the meantime kept in check by natural agencies, principally parasitic insects.

Signs of infestation.—From September until the following spring, conspicuous, glistening white, frothy-looking egg masses (fig. 24, *h*) may be observed, mostly low down on the trunk of the tree or on the

[19] *Hemerocampa leucostigma* S. & A.

main limbs. In the spring and summer, leaves partly or entirely eaten by the caterpillars are in evidence. These caterpillars when full grown are more than an inch in length, with red head, three long black plumes at the extremities of the body, and four yellow, brush-like tufts with two red spots behind them on the back (fig. 24, *a*). Cocoons and egg masses (fig. 24, *i*, *k*) occur on the bark of the trunk,

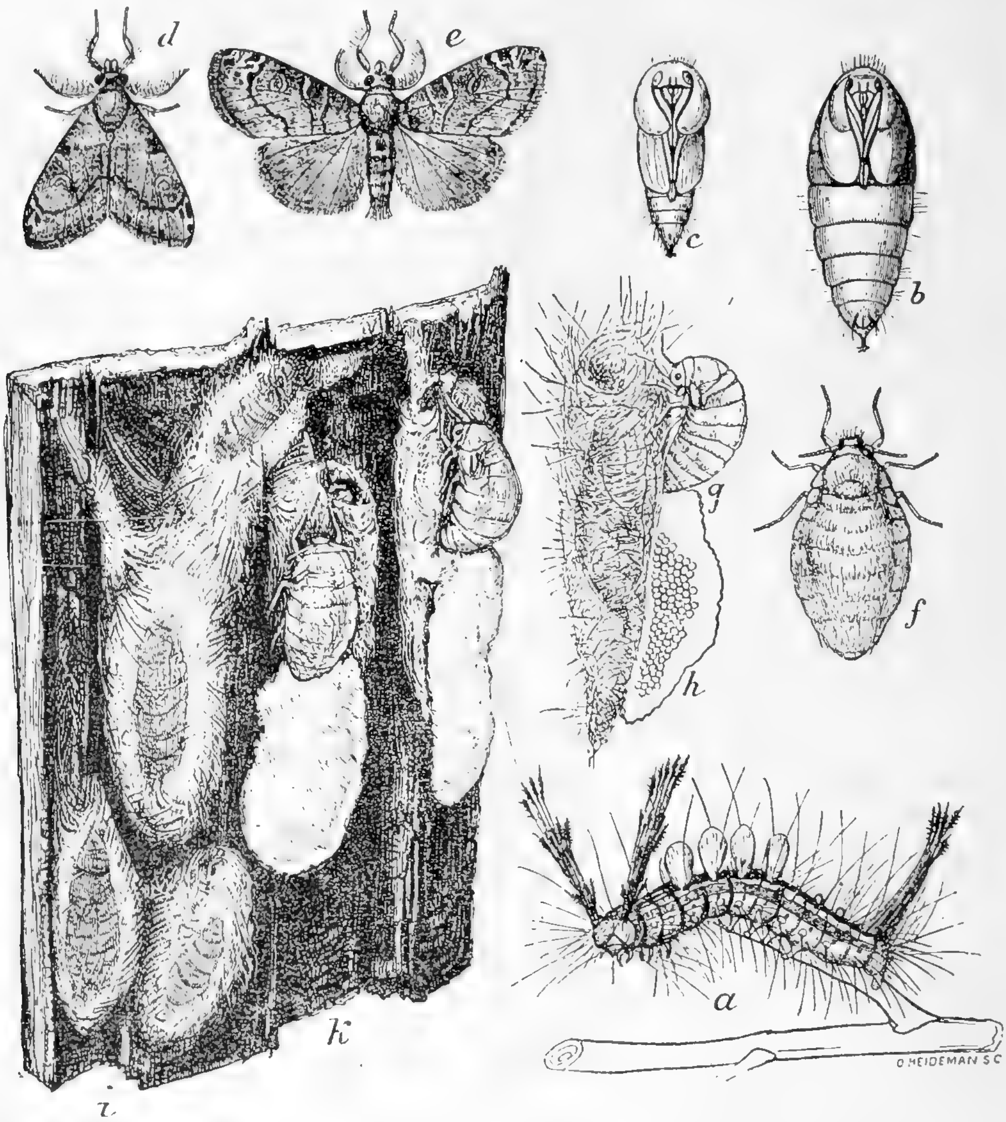

FIG. 24.—White-marked tussock moth: *a*, Larva; *b*, female pupa; *c*, male pupa; *d*, *e*, male moth; *f*, female moth; *g*, same ovipositing; *h*, egg mass; *i*, male cocoons; *k*, female cocoons, with moths carrying eggs. All slightly enlarged (Howard.)

branches, and occasional leaves in localities where more than one generation is produced annually.

Seasonal history and habits.—From the overwintered eggs the caterpillars hatch in April and May and immediately begin to skeletonize the leaves, later eating holes through them, and finally devouring all but the main veins. Often they may be observed swinging from the tree on a silken thread, and, when caught by wind or passing objects, are transported to other trees. They remain as caterpillars from a month to five weeks, shedding the skin five times in the course of their growth. When nearly full grown they are great travelers, especially from defoliated trees. When full grown the caterpillars spin delicate grayish cocoons of silk, mixed with hairs from their bodies, and within these cocoons they transform to pupæ (fig. 24, *b*, *c*) and, about two weeks later, these change into moths (fig. 24, *d*, *e*, *f*) of which the females are wingless. Mating and egg laying take place soon afterwards. Three generations of the insect are produced annually in Washington, D. C.; two or only one north of that city.

Remedies.—Destroy the eggs in the winter either by hand picking or scraping them off and burning, or by spraying or dabbing with creosote oil, mixed with turpentine to keep it liquid in winter. As soon as injury by the caterpillars is noticed, spray infested foliage with lead arsenate (p. 11). Hand picking or any simple device will do for treatment of the eggs. For spraying purposes a spray pump is necessary, and the size of the equipment will vary with the amount of work to be done. A barrel pump mounted on a horse-drawn cart with one or two 50 to 100 foot leads of garden hose and a 10-foot bamboo rod with a spray nozzle at the end will do for a small town. Cities will find advantage in horse or motor-drawn power spray pumps. The catalogues of reliable spray-pump manufacturers, giving detailed information, are procurable in most seed, pump, or hardware stores and should be consulted.

Essentials of successful control.—Thoroughness, concerted community action, and cooperation are essential for success. Leave as few surviving eggs or caterpillars as possible. Treatment of a tree here and there, now and then, protects no trees, not even those treated. All or most trees must be treated the same season, whether this be done by citizens individually or as a community organization. The trees attacked are usually large. Where spraying must be resorted to, the requisite apparatus is too expensive for the average individual, and can be bought (or hired) and operated only cooperatively, either through local governments or other civic organizations.

LOCUST LEAF-MINER.[20]

Evidence of work and seriousness.—About the time the locust leaves become full grown they are often observed to turn brown, as if fire scorched. Entire trees and groves of locust may assume this appearance. But aside from marring their appearance the injury to the trees is generally less real than apparent. No later than the following spring the trees are sure to put out a fresh, healthy set of leaves, as if nothing had happened.

[20] *Chalepis dorsalis* Thunb.

Cause of injury.—The locust leaves turn brown mainly because the green tissue within them is being hollowed out—"mined," we call it—by the flattened grubs (fig. 25, *b*) of this beetle; while the blister-like effect on them is produced by the surface feeding pits made by their parents. The parents of these grubs are about one-fourth inch long; they are flattened, orange-red beetles (fig. 25, *a*) with an area along the middle of the back, the head, appendages, and underside black, and the wing covers deeply pitted. This is the stage in which the winter is passed. In the spring, about May, in the District of Columbia, they appear on the leaves, feed, and begin laying eggs in batches of from 3 to 5. From these the grubs hatch and immediately penetrate to the inside of the leaf which they hollow out. On attaining full growth these grubs change to pupæ (fig. 25, *c*) which, in turn, change to adults that come out. These also feed on the leaves and thus help to complete their destruction. There is apparently but one generation produced annually in the latitude of the District of Columbia.

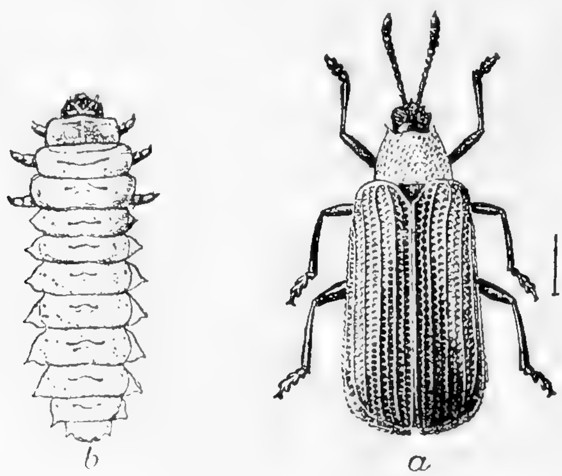

FIG. 25.—Locust leaf-miner: *a*, Beetle; *b*, larva; *c*, pupa. Five times natural size. (Chittenden.)

Remedy.—It is only specially prized trees that are worth treating, and on these an application of lead arsenate (p. 11) as soon as the leaves appear early in the season will kill the grubs as they issue from the eggs and before they penetrate the leaf epidermis, and thus the injury will be stopped.

GREEN-STRIPED MAPLE WORM.[21]

How injurious.—Some years the green-striped maple worm is a troublesome insect on maple trees, especially silver and swamp maples. In the absence of these, however, it has been found to feed on and defoliate other trees. It is capable of completely denuding the foliage twice or even three times during the same season, not only of entire trees but of entire rows and groves of them. Aside from disfiguring the trees for the time being, the defoliation also weakens them.

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[21] *Anisota rubicunda* Fab.

The insect and its habits.—When full grown this maple worm is a smooth caterpillar (fig. 26, *d*, *e*) about 2 inches long, pale yellowish green in color, striped lengthwise with dark green, and having a pair of long black horns just back of the head and a number of black pegs along the sides and at its hind end. These caterpillars enter the ground, there changing to pupæ (fig. 26), *f*), from which the moths issue in about two weeks. The moth is a woolly-bodied, pink-shaded,

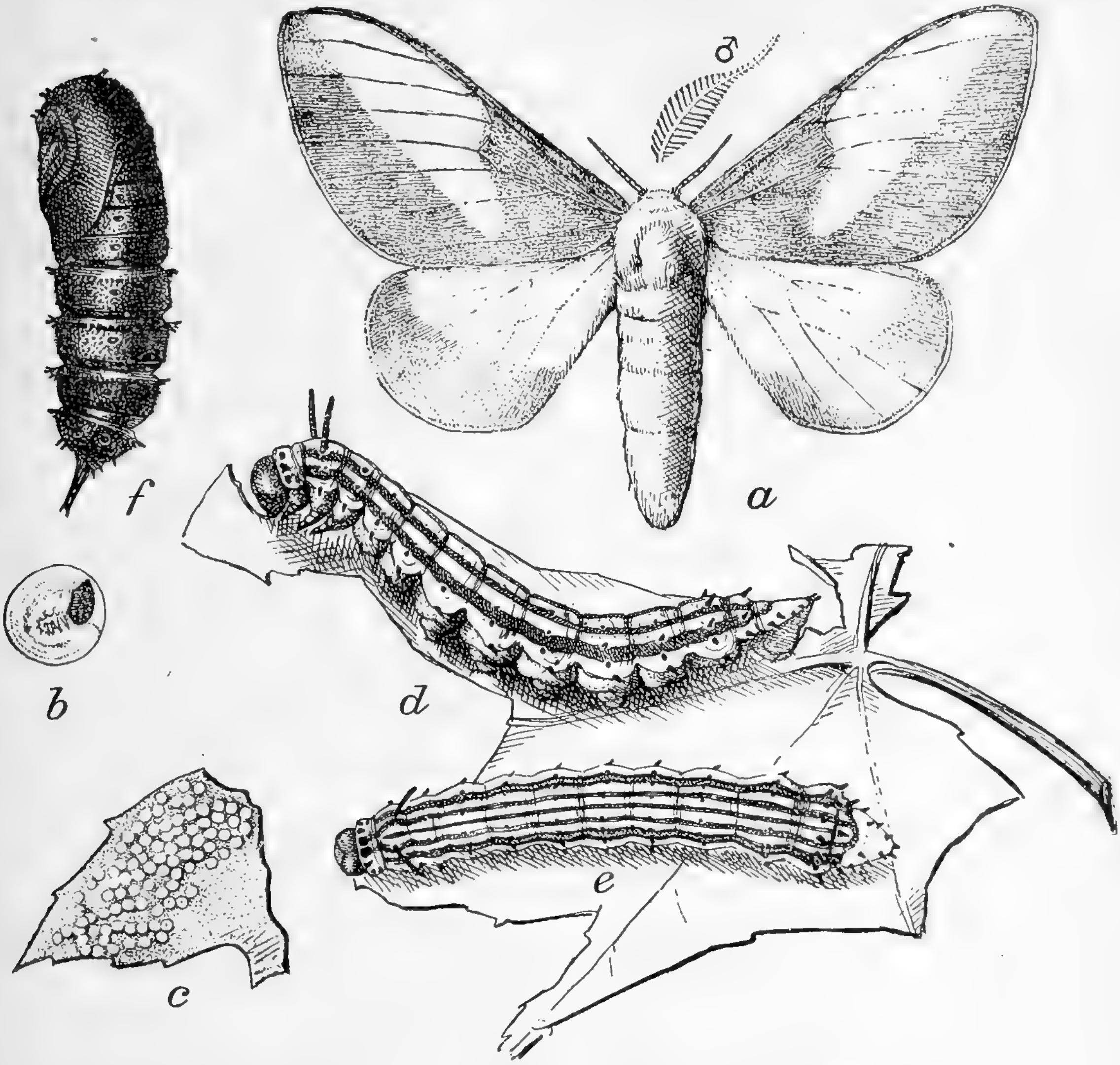

FIG. 26.—The green-striped maple worm in all its forms: *a*, Female moth and antenna of male moth; *b*, egg showing embryo within; *c*, portion of egg mass; *d*, full-grown larva from side; *e*, same from back; *f*, pupa. Enlarged. (Howard and Chittenden.)

pale yellow insect with a wing spread of about 2 inches (fig. 26, *a*). After mating the female lays on the underside of leaves about 150 eggs (fig. 26, *b*, *c*), from which the caterpillars hatch in about 10 days. The insect overwinters in the pupa state in the ground and the first generation of moths issues from them in May or June, depending on the locality, which also determines whether two or three crops of the caterpillars are produced annually. The green-striped maple worm is a native of North America, and this accounts for the periodicity of its abundance. In the intervals between outbreaks it is kept in check by its natural enemies, including birds and parasitic insects. It is more abundant in the Middle West than in the East, although it is more or less generally distributed east of the 100th meridian.

Remedies.—On specially prized smaller plants some relief from this pest may be obtained by hand picking and destroying the caterpillars. Sizable trees should be sprayed with lead arsenate (p. 11) as soon as the caterpillars appear, to protect them from defoliation. In case of maple groves or suitably located individual trees it has been found possible to protect them from a repetition of defoliation by digging around them a trench about a foot deep, with the outer wall sloping under, and destroying the caterpillars and pupæ that collect in them.

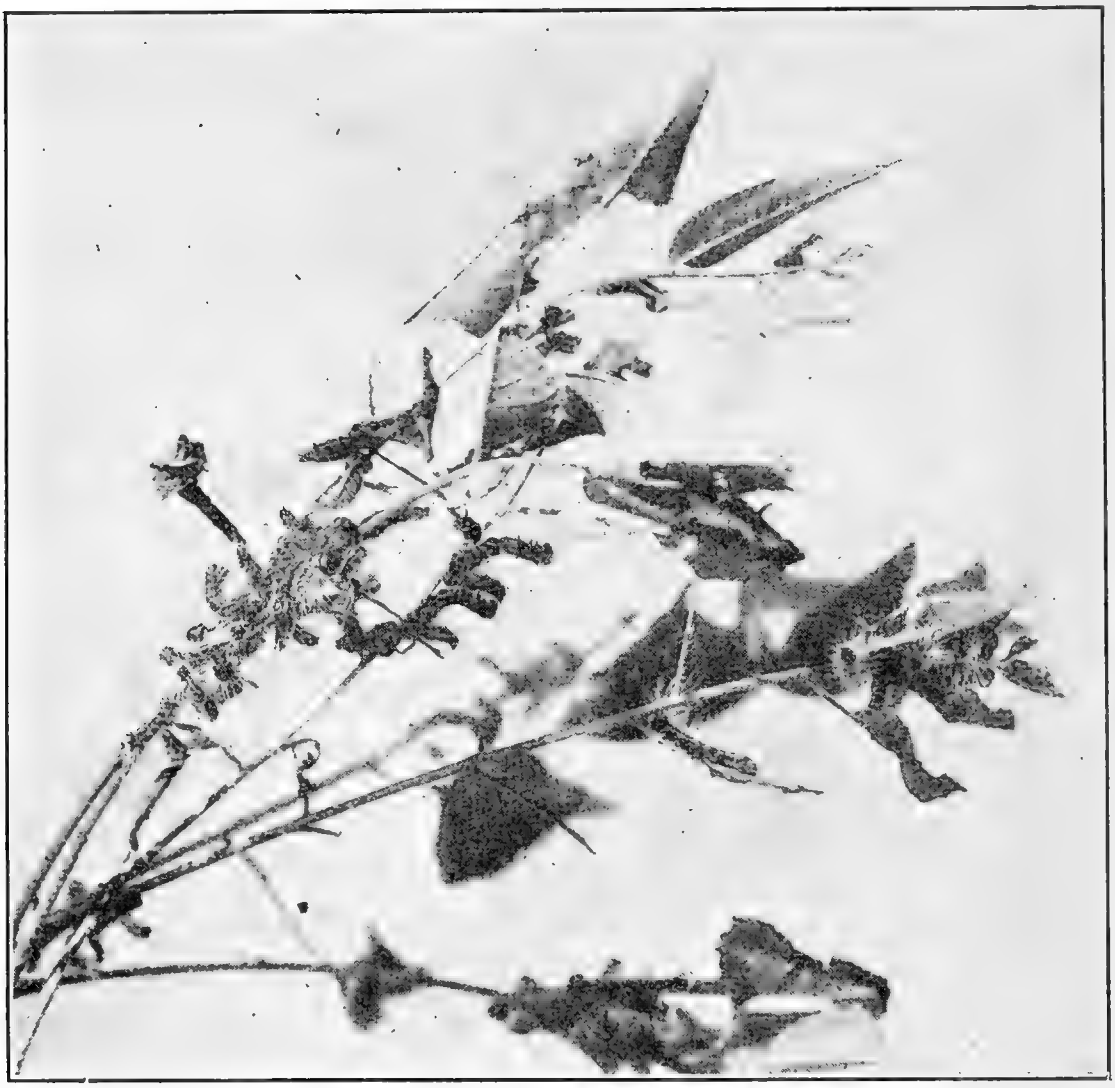

FIG. 27.—Cluster of full grown walnut caterpillars, showing peculiar poses, long hairs, and clustering habit. (Photograph by Cramer, Washington, D. C., Sept. 27, 1919.)

WALNUT CATERPILLAR.[22]

How injurious.—When there are enough of them, these caterpillars (fig. 27) strip walnut trees bare of leaves. Other trees also, especially butternut and hickory, are likely to suffer the same fate.

[22] *Datana integerrima* G. & R.

Successive defoliation in many instances kills the trees. The walnut caterpillar is more abundant and therefore more destructive some years than others.

How recognized.—When this insect is present pieces of leaves begin to disappear in late summer and early fall, eaten by the gregariously feeding caterpillars, which when full grown are black, covered with dirty gray hairs, and nearly 2 inches in length. When disturbed caterpillars rear at head and tail ends (fig. 27) in an unusual manner. On the trunk and larger branches of infested trees large clusters of caterpillars or their cast skins may be observed.

The insect and its habits.—On maturity the caterpillars crawl down the trunk of the tree an inch or two into the ground and there transform into chrysalids. In this shape they overwinter, remaining in the ground until the following July, when the moths issue from them and lay their whitish eggs in clusters of 75 to 100 on the underside of the leaves selected as food for the caterpillars that hatch from them. The habit of feeding and molting gregariously is a characteristic of this insect.

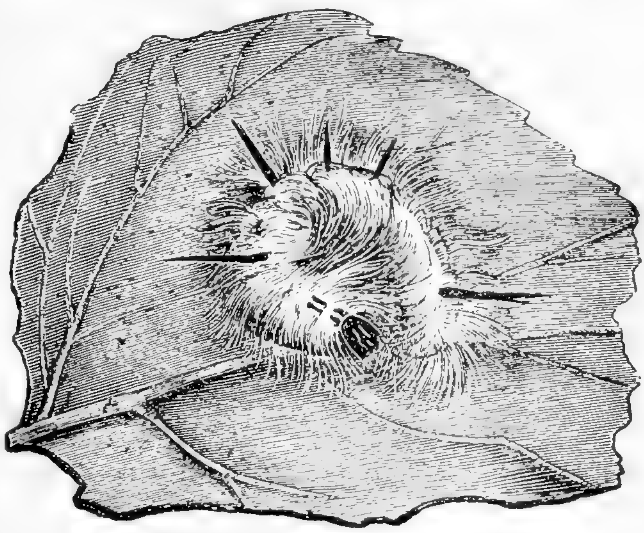

FIG. 28.—Caterpillar of cottonwood dagger moth. (Riley.)

Remedies.—Collect and destroy the clustered caterpillars feeding on twigs or molting on the trunk and branches. Failing this, and if the facilities are at hand, spray infested trees with lead arsenate (p. 11).

COTTONWOOD DAGGER MOTH.[23]

How injurious.—In prairie regions the caterpillar of the cottonwood dagger moth is a serious enemy of cottonwood and willow trees, which it often strips of foliage. As these trees are important in these regions for purposes of timber and shelter, this defoliation is a serious matter.

The insect and its habits.—The caterpillar (fig. 28) is densely covered with long, soft, drooping, yellow hairs, bears five rather long, stiff tufts of black hairs along the back, and when at rest it lies curled up on the underside of a leaf. When full grown it retires to some cranny where a silken cocoon, intermixed with its hairs, is spun and within it the change to chrysalis takes place.

[23] *Apatela populi* Riley.

In this form it overwinters and the following spring the pale gray moth emerges from it. The moths are night flyers and lay their eggs on the host plant, one in a place. Two cycles are completed in the course of the year in the latitude of Nebraska.

Remedy.—Spray infested trees with lead arsenate (p. 11).

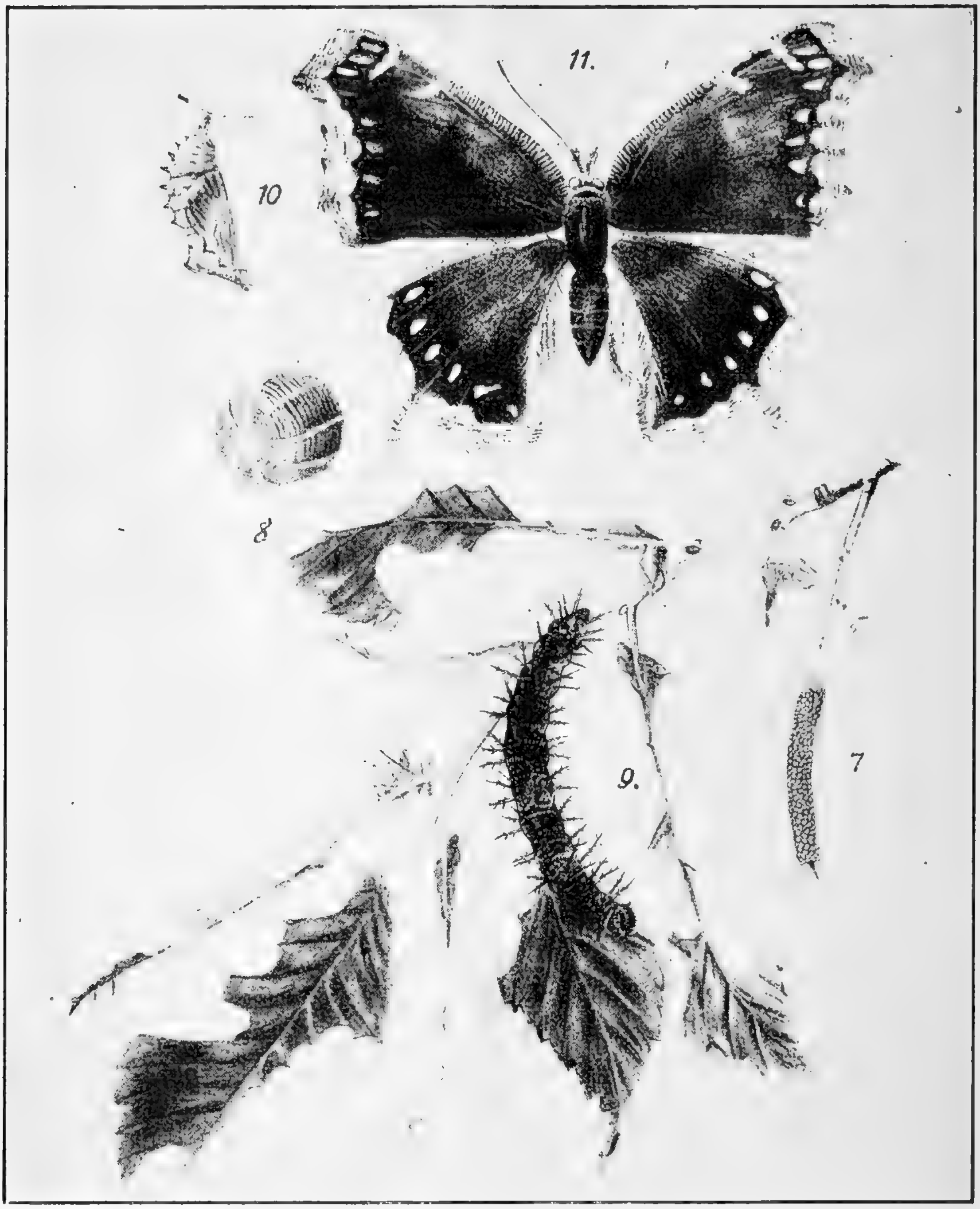

FIG. 29.—Spiny elm caterpillar: 7, Cluster of eggs on leaf stem; 8, one egg, much enlarged; 9, caterpillar feeding; 10, chrysalis hanging from leaf stem; 11, butterfly with spread wings. Egg cluster and caterpillar on elm twig showing characteristic appearance after feeding by the caterpillars. (Felt.)

SPINY ELM CATERPILLAR.[24]

How injurious.—The spiny elm caterpillar feeds on elm, willow, poplar, and hackberry leaves. The amount of injury depends on the

[24] *Euvanessa antiopa* L.

number of caterpillars present, but when abundant these are known to defoliate entire branches and trees. In our prairie regions, where trees are so scarce and precious, the injury to willows and poplars is most serious.

Appearance and habits.—If parts of leaves are missing or entire branches or trees are bare and stocked with black, red-marked, spiny caterpillars (fig. 29, *9*), about 2 inches long, feeding in groups, it is safe to conclude that this insect is the one responsible for the damage. On maturing the caterpillars change to strange looking sea-shell shaped chrysalids (fig. 29, *10*) which may be found suspended from a limb and fastened to it by the small end. After a few weeks the beautiful butterfly, known as the "mourning cloak" (fig. 29, *11*), the first butterfly to appear in the open in early spring, issues and, after mating, lays a batch of from 300 to 400 eggs (fig. 29, *7*, *8*) in a ring about the twig of the food plant. From one to three generations are

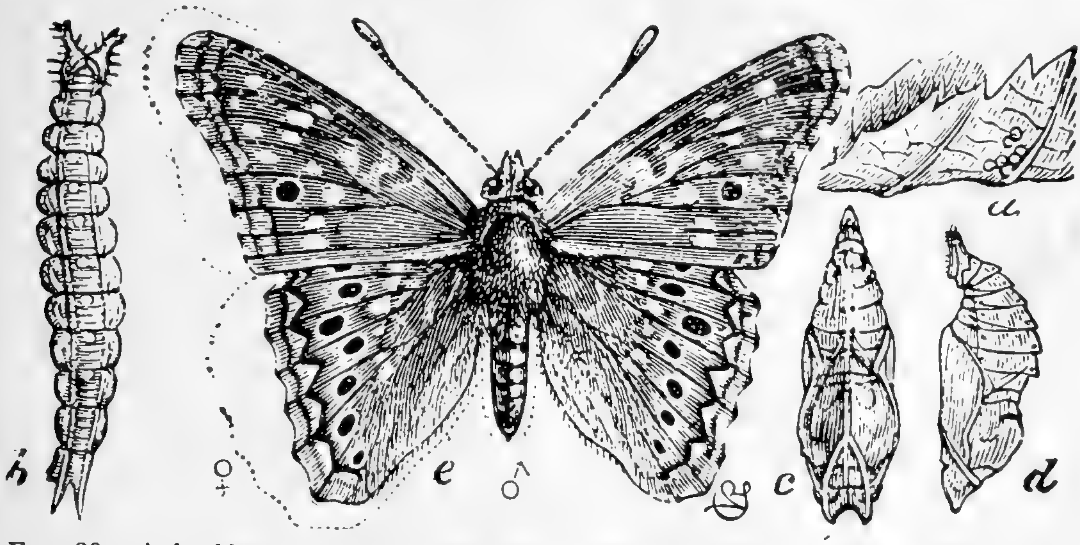

FIG. 30.—A hackberry butterfly, *Chlorippe celtis: a*, Eggs; *b*, larva, dorsal view; *c*, *d*, chrysalis, dorsal and lateral views; *c*, imago, male, dotted line showing form of female. (Riley.)

produced annually. The insect overwinters in the adult stage, the butterflies hiding under rocks and bark scales for protection.

Remedies.—Spray with lead arsenate (p. 11) as soon as signs of injury are observed. In some cases the twigs with clustered caterpillars may be cut off and the caterpillars destroyed by crushing, burning, or dipping in kerosene.

HACKBERRY BUTTERFLIES.[25]

How injurious.—The caterpillars of these butterflies feed on hackberry leaves wherever these trees grow and often greatly mar their appearance. As the hackberry is extensively grown as a shade tree

[25] *Chlorippe celtis* Bdv. and *C. clyton* Bdv.

in the Middle West, the injury of these insects assumes lively importance.

Appearance and habits.—Attention is drawn to the insect by hackberry leaves which show signs of being eaten away, and green caterpillars with pale spots and lines along the back and projections on head and rear (fig. 30, *b*) are found on the underside of leaves. The caterpillars change to chrysalids (fig. 30, *c*, *d*) in folded leaves and later to russet-gray, brown-spotted buterflies (fig. 30, *e*), which, after mating, lay their eggs singly (in one case, fig. 30, *a*) or in batches of 300 to 500. Two generations are produced annually, the second-stage caterpillars of the last generation falling to the ground with the leaves they are on and passing the winter there.

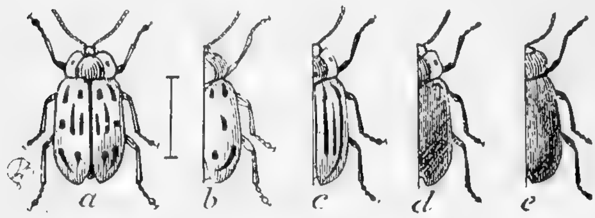

Fig. 31.—Streaked cottonwood leaf-beetle (*Melasoma scripta*), showing variation in markings. (Riley.)

Remedies.—The leaves may be raked up and burned in the fall or the infested trees sprayed with lead arsenate (p. 11) while the caterpillars are feeding.

COTTONWOOD, POPLAR, AND WILLOW LEAF-BEETLES.[26]

How injurious.—Poplar, cottonwood, and willow leaf-beetles are particularly injurious because their adults as well as young or larvæ derive their nourishment from eating the leaves of these trees, and, as they produce from three to five generations annually, they are capable of keeping the trees in a constant state of defoliation. They are most prevalent in the Northern States, are occasionally seriously injurious, especially to basket willow in the East, and are an almost constant drain on the health of these trees in the Middle West, where tree life is so scarce and precious that injury to it is intolerable.

How recognized.—Infestation is indicated by leaves of these trees bitten part way through in places and entirely through in others early in the season, and entirely consumed later by spotted, soft-bodied, short, stoutish grubs and spotted or striped, half-inch long, hard-shelled beetles (fig. 31), mostly on the underside of leaves where also batches of yellow or reddish eggs standing on end and pupæ are to be found. The young when disturbed emit a milky fluid.

Habits.—The overwintering beetles appear in the spring as soon as growth starts on these trees and promptly begin eating this growth. After feeding awhile they lay clusters of eggs from which the soft-

[26] *Melasoma scripta* Fab., *M. lapponica* L., *M. tremulae* Fab., and others.

bodied grubs hatch and begin eating away the underside of the leaf. When after several molts they are full grown, they partly cast the last skin and pupate in it fastened to the leaf. "Hangers" they are called in some sections of the country, where the beetles issuing from them are known as "hard shells." During the growing season the generations overlap, owing to more rapid development of some and slower growth of others, so that all stages, from egg to adult, may be found at the same time.

Remedy.—Spray with lead arsenate (p. 11), especially as soon as growth starts. Direct the spray against the underside of the leaves and for smooth leaves add soap (p. 14) so that the spray will stick to the leaves.

LARGE ELM AND WILLOW SAWFLY.[27]

How injurious.—More commonly in the Middle West, and locally in the East, the large elm and willow sawfly has been observed completely defoliating willow and elm trees and groves, and occasionally poplar and other trees. As stated in connection with other defoliating insects occurring in the Middle West, such outbreaks are pathetic in view of the solicitude with which trees are regarded there and the disappointment entailed when they are found undergoing despoliation.

How recognized.—Occasionally the tops of these trees look as if overrun by fire from the girdling of the bark of the twigs by the adult sawfly (fig. 32, *b*). More often, however, their leaves are found blistered by eggs or larvæ in pockets (fig. 32, *a*) or eaten by cylindrical, coiled, yellowish-white worms (fig. 32, *e*, *e*) with a black line down the middle of the back.

Habits.—The caterpillar-like insects that eat the leaves attain full growth about July or August and descend to the base of the tree where they spin a tough, coarse, silken cocoon (fig. 32, *f*) among the débris or just below the surface of the ground and overwinter there. The following spring they change to pupæ (fig. 32, *g*, *h*) and the adults, rather large, flylike insects, with four clear wings (fig. 32, *i*), appear about May, mate, and the females make slits in the fleshy part of the leaves and thrust their eggs (fig. 32, *c*) into these pockets and from these the young worms (fig. 32, *d*) come out to feed soon after hatching.

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[27] *Cimbex americana* Leach.

Remedies.—Winter burning the rubbish and breaking up the ground at the base of infested trees should destroy many of the insects. Where practicable, hand picking of worms or infested leaves early in the spring is a great help. Finally, lead arsenate (p. 11) is always a reliable stand-by against these insects.

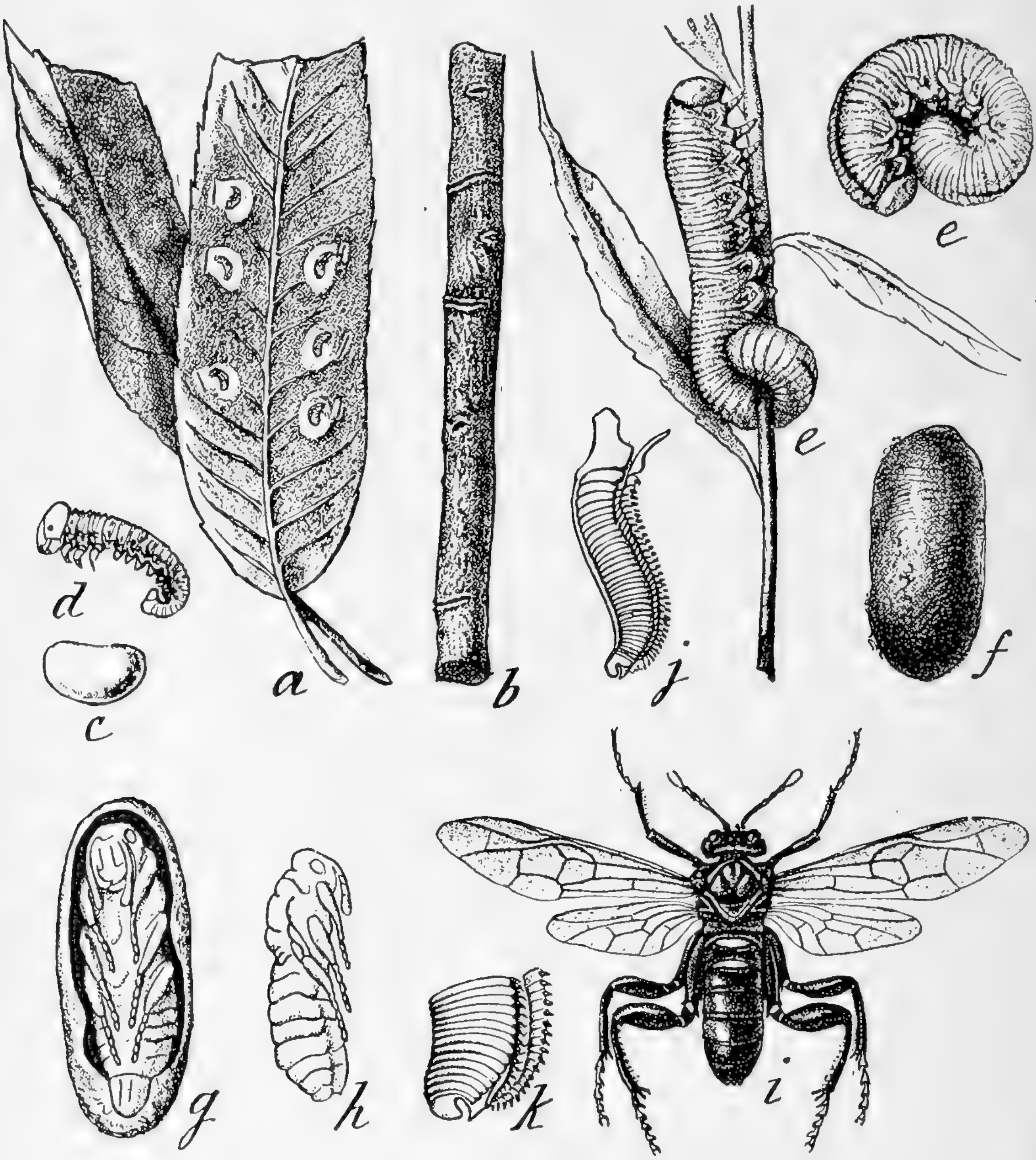

FIG. 32.—Large elm and willow sawfly: *a*, Willow leaves showing location of eggs; *b*, twig showing incisions made by adult; *c*, egg; *d*, newly-hatched larva; *e*, *e*, mature larvæ; *f*, cocoon; *g*, open cocoon showing pupa; *h*, pupa, side view; *i*, mature sawfly; *j*, *k*, saw of female; *c*, *d*, *j*, *k*, much enlarged, the rest less enlarged. (Riley.)

BARK, WOOD, AND TWIG BORING INSECTS.

GENERAL.

Boring insects secure their nourishment either by extracting it from chips of bark and wood that they bite off and swallow as they burrow or by feeding on the sap, depending on whether they feed in the dead wood or in the sapwood. Their injury to shade trees is along two directions: (1) When their burrows do not kill the tree or limb, they admit, on the body of the boring insect or in the moisture that penetrates their excavations, diseases which rot and ultimately disable or kill it; (2) when their burrows in that life-giving layer located between the bark and wood extend around the limb or tree, the circulation of sap between roots and leaves is arrested and death ensues quickly. In the case of timber the burrows also reduce in grade the lumber cut from it or make it entirely worthless. Moreover, the work of these insects is hidden from view, so that too often it is discovered when it is too late to save the tree. For these several reasons the presence of borers in trees is particularly dangerous and must be guarded against most carefully.

Because they feed and live most of their lives out of sight they are beyond reach of the usual poison or contact insecticides. The use of certain preparations, like poisoned miscible oil or kerosene emulsion or carbon disulphid, as will be pointed out under the respective insects, is practicable in a few instances. In the majority of cases, however, the healthy trees can be saved only by opportune sacrificing of those that are badly infested, or, in some cases, by stimulating the growth and well-being of those just invaded by these insects. Protection of shade trees from boring insects rests, therefore, almost wholly on preventive measures. Trees well nourished, protected from all manner of injury, and otherwise well cared for are more nearly immune to attack by boring insects than those not so cared for. In a neighborhood, community, grove, or park where a majority of the individuals of a given borer are destroyed the remaining trees will successfully resist attack and be saved thereby.

SUGAR-MAPLE BORER.[28]

How injurious.—In some sections of the country, especially along roadsides in New York State, the sugar-maple borer is regarded as the most serious enemy of this tree. It attacks trees in full vigor, killing large limbs and entire trees. The serious damage is done by the grubs, especially when their burrows meet so as to girdle the tree or limb.

Signs of borer presence.—When the borer is present the trees show dead limbs here and there; ridges and dead spots appear on the bark (fig. 33, *1*, *1a*), or naked scars on the branches and trunk, especially near the base of the larger limbs, sometimes with oval holes three-eighths to five-eighths inch in diameter, and "sawdust" (fig. 33, *6*) at

[28] *Plagionotus speciosus* Say.

the base of the tree or in bark crevices; the foliage on a large limb suddenly wilts, dries up, and dies with sap and small masses of frass flowing from some point. Any one or a combination of several of these signs indicates the work of this borer.

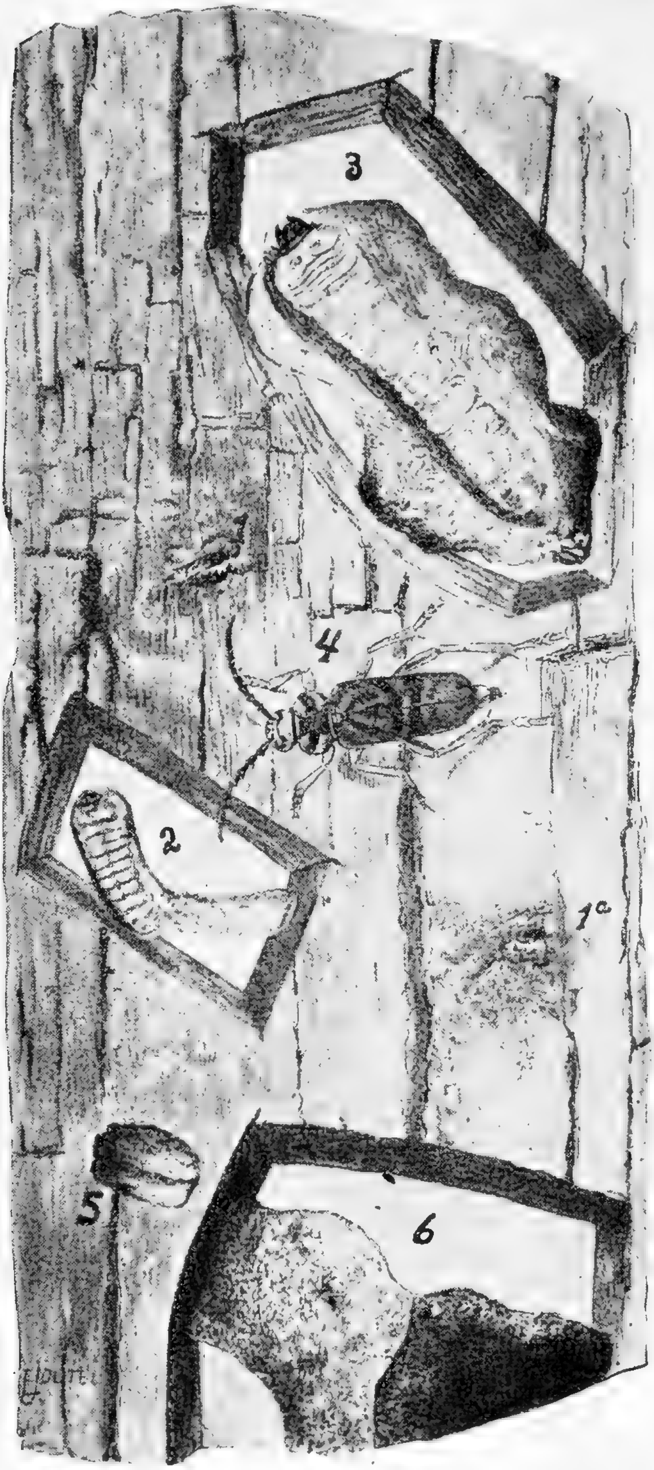

FIG. 33.—Sugar-maple borer and work: *1*, Place where egg was laid; *1a*, another more than normally discolored and showing borings thrown out by borer; *2*, grub in September from egg laid the same season; *3*, grub nearly full grown; *4*, beetle; *5*, hole through which beetle escaped; *6*, borings packed in burrow. (Felt.)

Description, seasonal history, and habits of the insect.—The borer is a whitish grub (fig. 33, *2*) about one-half inch long with brownish mouth parts, located at the end of the burrow in the sapwood, or about 2 inches long and of similar shape and color in a larger burrow somewhat deeper in the wood (fig. 33, *3*). The parent insect is a beetle about 1 inch long, stout, shorthorned, black, brilliantly marked with yellow (fig. 33, *4*). It comes out between June and August through oval holes in the bark (fig. 33, *5*).

Remedies.—Dying trees or limbs should be cut down and burned before June, so as to kill the grubs in them before they have transformed into adults and emerged. Specially prized trees should be examined in the fall and spring for signs of the insect, and the borers killed either by cutting them out (in which case cut surfaces should be covered with creosote-tar mixture or good white-lead paint (see p. 14–15), or by forcing a flexible wire to the end of the burrow, or by injecting carbon disulphid (p. 14) into the holes and promptly plugging them with clay, putty, or similar substance. Where facilities are at hand the trunk and larger branches of the trees may be sprayed in the late summer with poisoned kerosene emulsion (p. 12–13) or miscible oil (p. 12), which will reach and kill the borers that have just penetrated the bark. Care should be taken to avoid spraying the foliage, as this is injured by these solutions.

ELM BORER.[29]

Signs of attack.—Elm trees only are subject to injury by this borer. The leaves of tops or ends of branches of infested trees turn brown and fall in summer, after which tops and branches here and there die, as shown by their failure to leaf out in the spring, and in two or three years the entire tree is killed. Thorough search of the trunk and larger branches of dying trees discloses patches of dead, readily peeling bark with burrowing roundheaded grubs beneath it (fig. 34, *1*). This is the form of the insect that does the injury, and when the limb or tree is girdled by the burrows (fig. 34, *3*) its doom is sealed.

How destructive.—Trees growing in unfavorable environment, particularly in cities, are most subject to attack by this borer, and then apparently only when the trees have been previously weakened by some other agency. Hence it becomes epidemic only occasionally, but on such occasions it is apt to wipe out the trees on entire blocks of some communities.

Distribution.—The elm borer probably occurs generally throughout the northeastern United States.

Description and seasonal history.—The parent insect is a gray, long-horned beetle (fig. 34, *4*), about one-half inch long and marked with red lines and black spots. Its flying period is between May and August. At that time the eggs are laid singly or in groups on the bark, where they hatch into tiny, footless grubs which promptly tunnel through it to the cambium layer. Here they excavate continuously wider cavities to accommodate them as they grow. These tunnels, when they reach around the tree or limb, girdle and kill. The full-grown grub (fig. 34, *1a*) is white, a little over an inch in length, thickest in front, but the head is only about half as wide as the segment immediately behind it. It is not definitely known how long the insect remains in the grub stage, but on reaching full growth it cuts out a cell beneath the bark and pupates in it, looking very much like a mummified beetle (fig. 34, *2*). In the spring, about May, these pupæ change to adult beetles which cut round holes in the bark and come out.

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[29] *Saperda tridentata* Oliv.

Prevention of attack.—Once a tree is badly attacked nothing can save it and the axe is the best remedy. If this is applied during the winter or early spring, before the beetles begin to emerge, to all trees or infested branches of a community, and the wood is promptly burned, many of the beetles will be destroyed and the rest of the

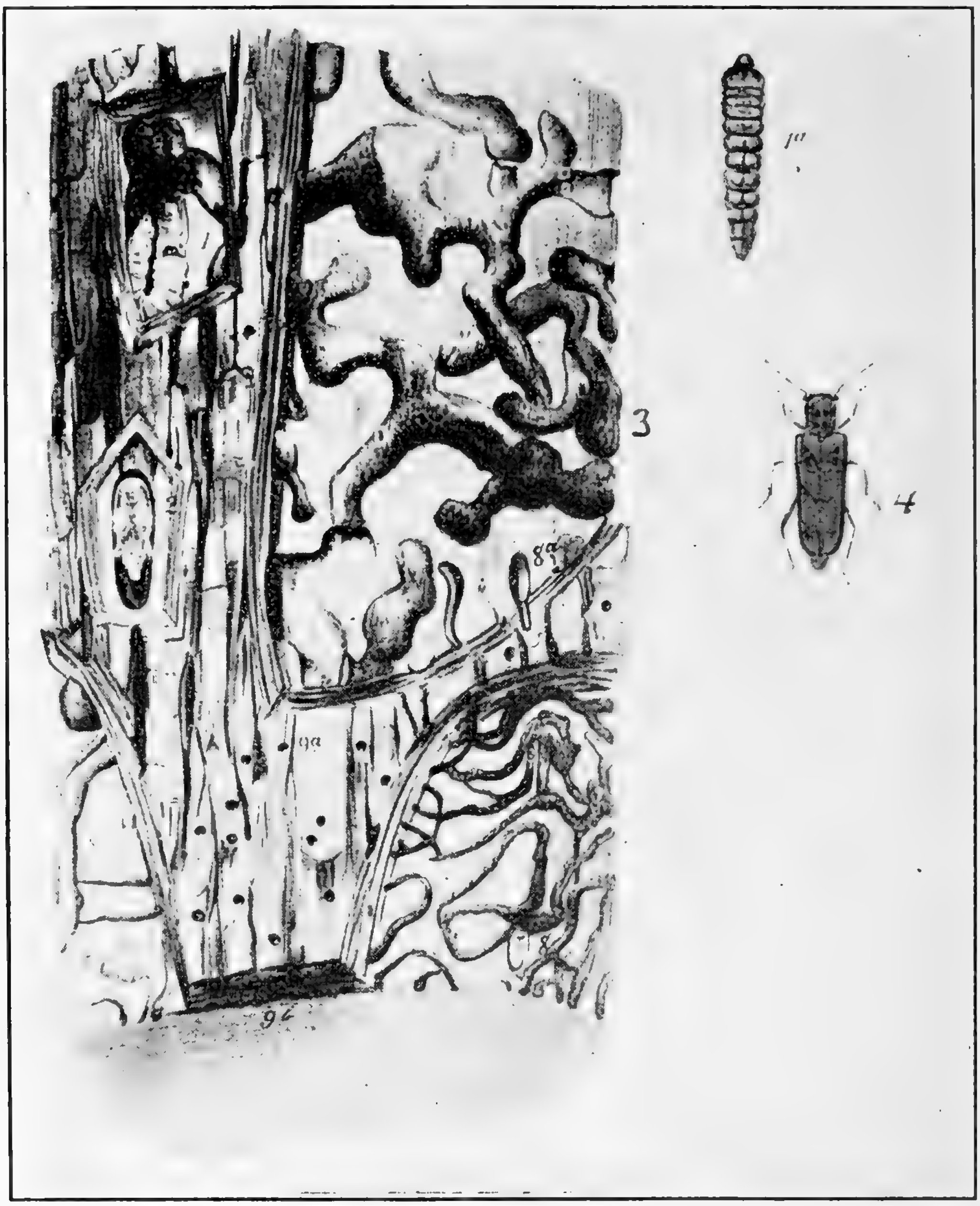

FIG. 34.—Elm borer and work: *1*, Grub within its burrow; *1a*, grub extended; *2*, pupa within its cell just under the bark; *3*, burrows of the grub exposed by removal of the bark; *4*, adult beetle. (Felt.)

trees saved. As indicated under "How destructive," removal or prevention of the agencies causing the primary weakening of the trees will go far toward preventing the beetles from inflicting the final fatal blow. This preventive work can best be called scientific arboriculture, and involves proper nourishment of the tree and its protection from injury.

LINDEN BORER.[30]

How injurious.—This insect apparently attacks only linden, but on this it is common and occasionally quite injurious. It is more or less generally distributed over the eastern United States.

How recognized.—Toward the end of summer tips are found killed and the green bark of growing shoots, leaf stems, and larger veins on the underside of leaves are eaten. This is the work of the beetles and is quite noticeable when the insect is abundant. Burrows made by a slender grub occur under the bark and deep in the wood (fig. 35, *11, 16*) of the trunk nearer the ground, in exposed roots, and in lower limbs.

Habits of the insect.—The beetles (fig. 35, *15*), which are long-horned with six black spots on the middle of the back, issuing out of holes (fig. 35, *12*) in the bark, begin to appear in May, and after

FIG. 35.—Linden borer and work: *11*, Burrows in cross section; *12*, circular exit hole of the beetle; *13*, wound made by borer; *14*, frass thrown out by larva; *15*, beetle; *16*, grub in the gallery under the bark which was cut away. (Felt.)

feeding awhile the females make with their jaws slight incisions in the bark and lay two or three eggs in each. One female lays about 90 eggs. The grubs (fig. 35, *16*) that hatch from these make the burrows mentioned above and, after an undetermined length of time, change to pupæ and then to beetles which leave the tree through holes in the bark throughout the summer.

Remedies.—On valuable trees the injury may be checked by digging out the borers. Probing with wire, injections of carbon disulphid (p. 14), and spraying with poisoned miscible-oil solution (p. 13) in the late summer are other serviceable means of killing this borer. Heavily infested and badly damaged trees are best cut and burned during the winter.

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[30] *Saperda vestita* Say.

ASPEN BORER.[31]

Character of damage.—The aspen borer is generally quite destructive to poplar trees and particularly so to aspen and cottonwood throughout the United States, especially in the Middle and Western States. Malformation of the trees, death of limbs and often the entire plant, and riddling of the main trunk with large holes which cause the tree to break off in the wind, are the usual results of the attack.

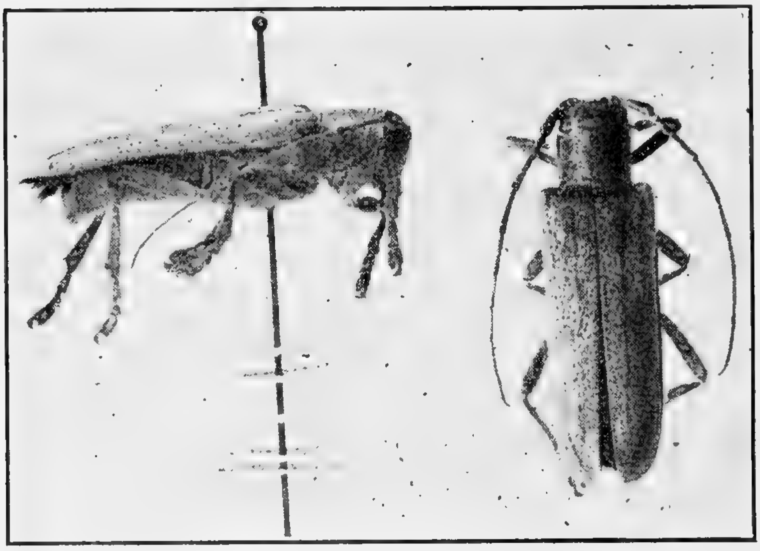
FIG. 36.—Aspen borer: Side and top views of beetle. Enlarged. (Hofer.)

External evidence of infestation.—In June and July irregular scars occur on the main trunk, especially around the crotch of branches, from which sap exudes and fibrous boring dust is thrust out. Later or older evidence of infestation is the enlargement of holes, extrusion of more or larger bits of frass, and often the death of limbs. The adults (fig. 36) are rarely seen because they feed on the young twigs and lay their eggs at night.

Description and habits.—The boring stage or larva (fig. 37) of the poplar borer is a yellowish, cylindrical grub which can be distinguished from all other insects boring in poplar by the presence of numerous fine, short, hard points on a plate immediately back of the head. It hatches from an egg laid in a scar on the bark by a grayish cylindrical beetle (fig. 36) with numerous brown spots over the body. The eggs are laid during the period from May to July, the young larvæ mining during the first year beneath the bark, and during the succeeding two years deep in the wood.


FIG. 37.—Aspen borer: Grub, much enlarged. (Hofer.)

Remedies.—For shade trees and small plantations or groves spraying of infested trunks during the late summer months with poisoned

[31] *Saperda calcarata* Say.

kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12–13) is recommended for killing the very young larvæ in the outer bark. On valuable trees some measure of relief may also be obtained by painting the eggs with creosote or carbolineum or by digging out and killing the young borers in early fall as they begin to tunnel their way into the wood. Heavily infested and badly damaged trees should be removed and burned or exposed to drying during the winter.

For a full account of the aspen borer see Farmers' Bulletin 1154 which will be sent on request.

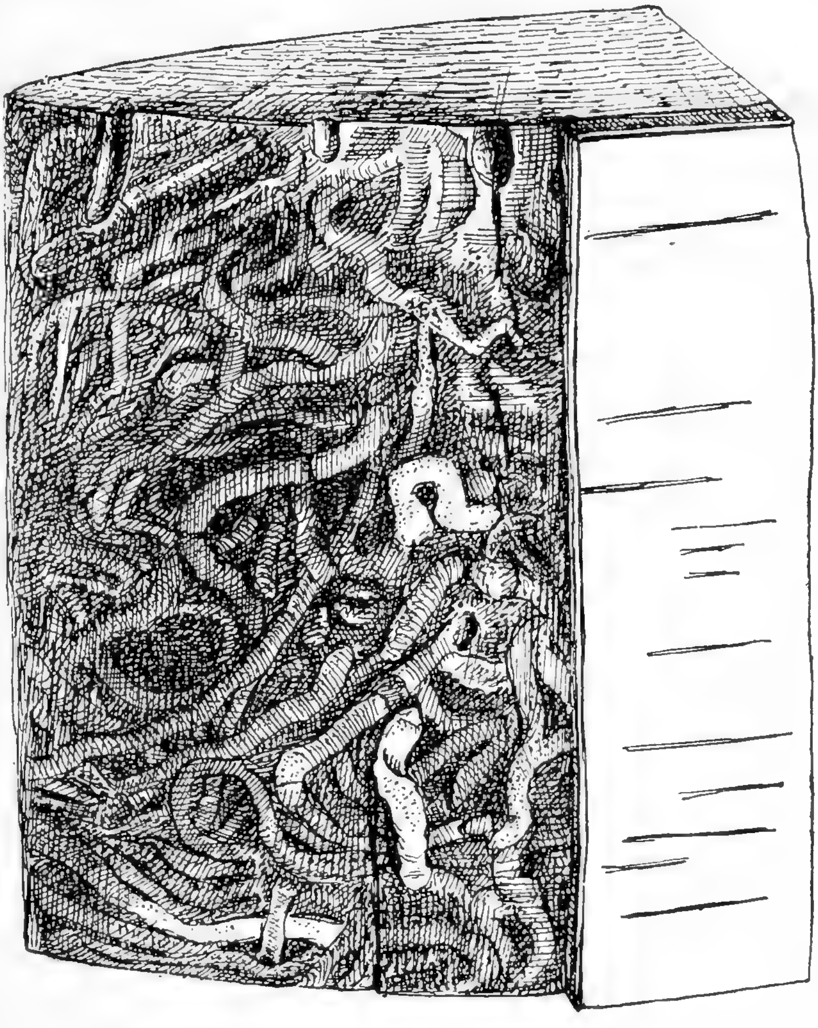

FIG. 38.—Work of bronze birch borer on trunk of white birch; bark removed to show larval galleries. Somewhat reduced. (Chittenden.)

BRONZE BIRCH BORER.[32]

Character and extent of injury. — During the past 20 years or so the birch trees of many city and private parks have died. As the top branches die first, the vitality of the trees gradually deteriorates and finally, one or two years later, the entire tree succumbs. This condition is usually due to the work of the bronze birch borer.

Evidence of infestation.—The following are signs that the trees are infested: (1) Characteristic reddish or rusty brown spots or discoloration on the white bark of the trunk and larger branches, which, on being cut through, usually disclose peculiar winding burrows (fig. 38) in the bark of the wood; (2) ridges (fig. 39) in the bark on the branches which often develop over the burrows of the insect; (3) dying tops.

[32] *Agrilus anxius* Gory.

Seasonal history and habits.—The borer itself (fig. 40, *c*), i. e., the stage of the insect mainly responsible for the damage, is a slender, flattened, footless, creamy white grub, about three-fourths inch long when full grown, which transforms to a small, slender, olive-bronze, winged beetle (fig. 40, *a*) nearly one-half inch in length. This beetle emerges from the trees in May or early June, depending on the location and season, and the female deposits her eggs in crevices on rough surfaces of the bark, several together. These eggs hatch into tiny grubs which burrow their way through the bark, underneath which they tunnel a zigzag course in the bark and sapwood until they are full grown. In the autumn they excavate a chamber in the wood or outer bark and here spend the winter. About April or May the following spring they transform to pupæ, and these into the adults which gnaw their way out, leaving peculiar oval holes in the bark. Their life cycle is thus completed within a year. The beetle attacks birch, poplar, and aspen trees wherever they grow in the United States, being particularly destructive to imported birch in parks and lawns in the Northern States and attacking from slender branches to trunks of trees over 25 years old.

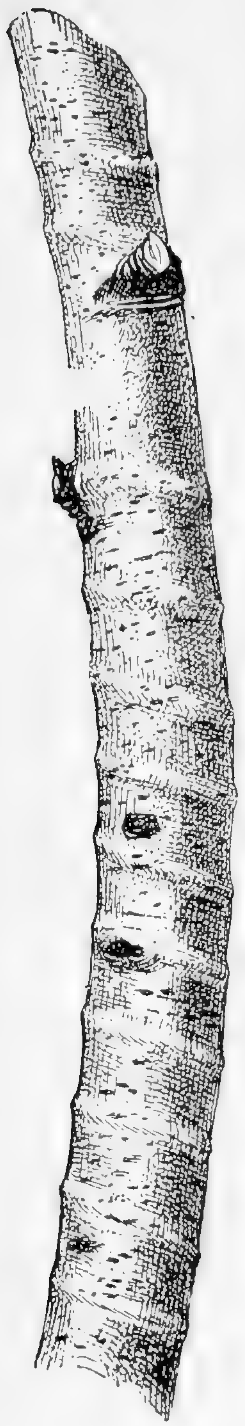

FIG. 39.—Work of bronze birch borer on limb of white birch. Somewhat reduced. (Chittenden.)

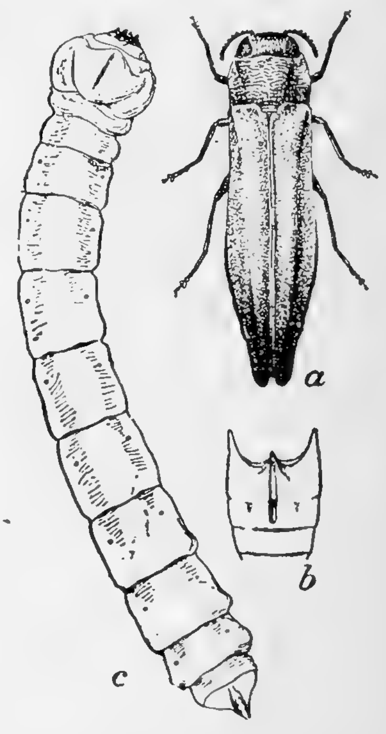

FIG. 40.—Bronze birch borer: *a*, Female beetle; *b*, first abdominal segments of male from below; *c*, larva from above. All enlarged about 3½ times; line at side of beetle shows natural length. (Chittenden.)

Prevention of damage, and control.—Badly damaged trees are not only past saving but are a menace to the trees of the neighborhood still free from attack; therefore trees showing dead tops and other evidences of infestation should be cut down and burned during autumn or winter and *not later than May 1.* A tree cut here and there will not check the ravages of borers. This is a neighborhood or community problem, and to insure that the work is thoroughly done and in good season it must be enforced either by community ordinance or by aroused public sentiment and understanding.

THE PARANDRA BORER.[33]

How injurious.—Although primarily breeding in utility timber, like telephone and telegraph poles, and other structural wood in contact with the ground or in moist situations, this insect is frequently found in the eastern half of the country seriously injuring all kinds of mature shade trees. This injury is at the base, and in windstorms trunks and branches thus weakened break off easily. This insect probably accounts for a greater percentage of destroyed bases of shade trees than any other.

Character of work and habits of the insect.—The adult, a rather large brown beetle, flies during the month following the blossoming of the chestnut, laying large numbers of eggs deep in the heartwood wherever this is exposed. In this wood the grubs live as such for three or four years before changing to pupæ. They feed gregariously, completely honeycombing the wood and packing the mines with granular frass. The oval pupal cell is constructed in the wood, plugged behind with a wad of fibrous frass. Pupation takes place about a month before the adults emerge.

A small wound near the base or in the larger branches of living trees offers a place of entrance for the young grubs which, penetrating the heartwood, continue to feed until nothing remains but a shell of sapwood. Under certain conditions the adults do not emerge but mate and lay eggs in the same cavity in which they are working. Often the wound where they gained entrance heals over and shows no sign of their presence.

Remedies.—As it is very difficult or frequently impossible to locate points on the tree where this insect is working, remedial measures must be directed toward prevention of the injury. All scars, fresh wounds, or injuries exposing the wood should be painted (p. 14–15) or so treated that no decay can start and that they quickly heal. Old cavities should be thoroughly cleaned and filled with concrete, care being taken that all wood showing any trace of grub-made mines is removed.

TWO-LINED CHESTNUT AND OAK BORER.[34]

How injurious.—The sudden death of sickly and healthy chestnut and oak trees is most often traceable to injury by the two-lined chestnut and oak borer, as this is their most serious insect enemy. As high as 75 per cent of these trees have been killed off by it in some

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[33] *Parandra brunnea* Fab. [34] *Agrilus bilineatus* Weber.

areas. In sickly trees the insect is very generally found associated with the shoe-string root fungus, or previous defoliation, and it unquestionably hastens the death of such trees. When weak trees are scarce and the beetles are numerous they may attack perfectly healthy trees and kill them.

Habits and appearance.—The beetles are on the wing in early summer, when they mate and lay eggs, preferably in deep cracks on the bark of the main trunk and branches. Each egg hatches into a flat, bigheaded, milky or yellowish white grub (fig. 41, *c*) which burrows through the bark and, by the time it is full-grown, by fall, it has excavated a burrow up to 3 feet long obliquely and across the grain in the inner bark and outer wood. It spends the winter in a chamber in the outer bark. Late the following spring it changes here to a pupa (fig. 41, *d*) and about two weeks later transforms to the adult, which is a dull or brownish black beetle (fig. 41, *a*) one-fourth to two-thirds inch long with two yellowish lines along the back, which burrows its way out of the tree and begins life in the open as described above. A number of such burrows (fig. 42), side by side around the trunk, girdle the tree and sever the vessels which carry food and moisture between roots and top, and the tree dies in consequence.

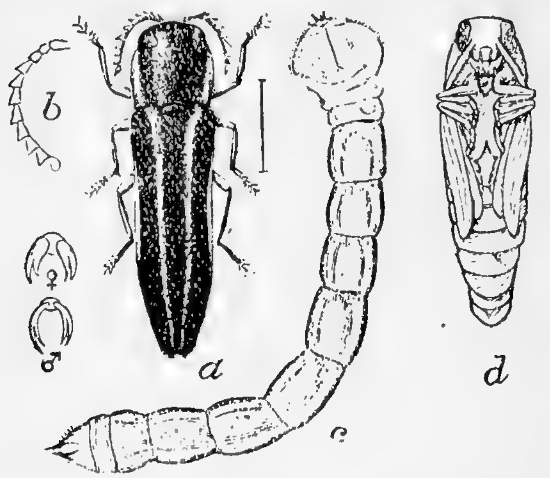

FIG. 41.—Two-lined chestnut and oak borer: *a*, Adult beetle; *b*, antenna of same; ♀, claws of posterior tarsi of female; ♂, same of male; *c*, larva; *d*, pupa. *a*, *b*, *c*, and *d*, Enlarged; *b*, ♂, and ♀, more enlarged. (Chittenden.)

Remedy (applicable only to specially prized, individual, slightly infested trees).—Spray the trunks during fall with poisoned kerosene emulsion (p. 12–13).

Prevention.—In the grove or forest prevention is the only practical means of control. This consists of the following measures calculated to eliminate the beetle's favorite breeding quarters (bark on freshly felled or dying trees and cordwood): Remove and promptly burn, during the fall, winter, or early spring, the bark (the wood may be utilized for any suitable or desired purpose) of all heavily infested, injured, weak, dying, and dead chestnut and oak trees and limbs over as wide an area about the trees to be protected as possible. Thoroughly done, this will kill the grubs in these trees, eliminate the borer's favorite breeding places, and reduce the numbers of the beetles to such an extent that those remaining will be incapable of effecting serious injury. In most cases extension of the area of control operations can be achieved only through cooperative or joint action of adjoining owners, and this must be secured for successful results.

Beetle brood trees left in the area will tend to nullify haphazard control work.

LOCUST BORER.[35]

Character and extent of injury.—The locust borer is the most destructive insect of black or yellow locust in some localities. Perfectly healthy trees are attacked. The wounds it makes in the bark and sapwood stunt their growth. If the attack is severe or continuous for a number of years, the trees, particularly young saplings and branches of larger trees, are killed and their wood is made worthless by the wormholes.

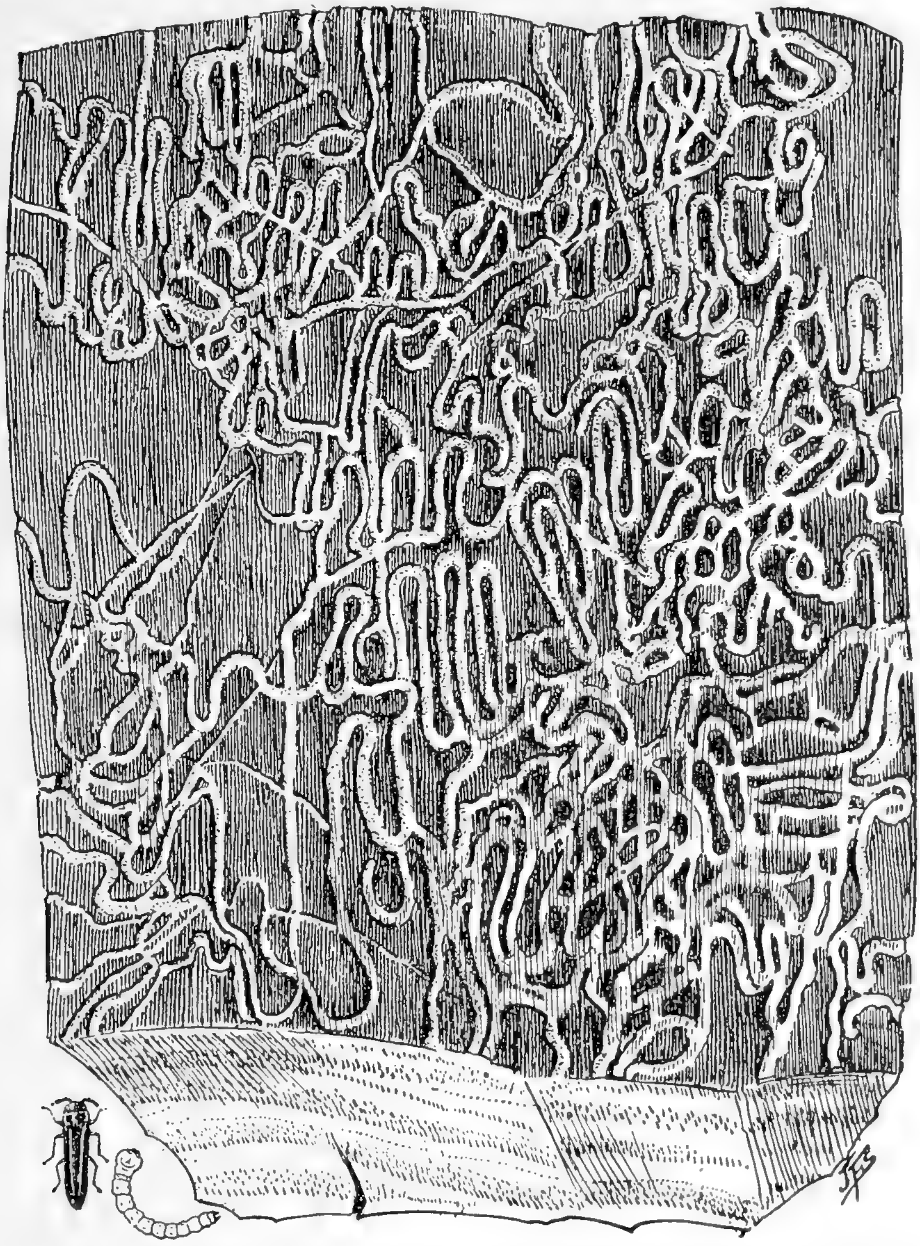

FIG. 42.—Work of two-lined chestnut and oak borer. Section of wood from main trunk of a dead chestnut, showing the larval mines on the outer surface after removal of bark. Beetle and grub at left lower corner. (Burke.)

[35] *Cyllene robiniae* Forst.

Evidence of infestation.—In April and May brownish boring dust and wet spots are to be seen on the bark of the trunks and branches, and as the season advances wet spots and yellowish boring dust mixed with liquids are present in increasing quantity. Leaf buds fail to open, the foliage is dwarfed or faded and sickly, and branches and small trees break down. The frequent occurrence of the adults in the period from August to October, particularly on goldenrod flowers, indicates the presence of the insect in injurious numbers.

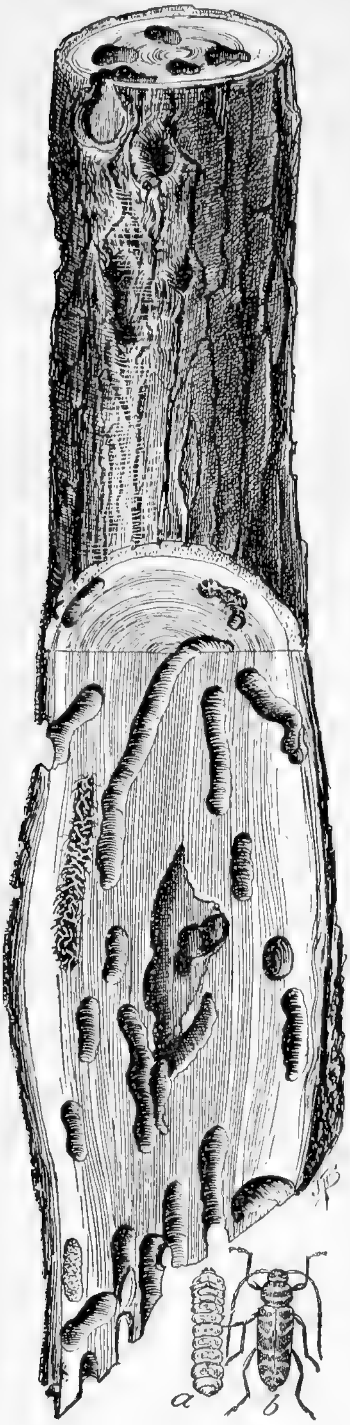

FIG. 43.—Section of trunk of locust tree, dying from injury by the locust borer. Shows burrows of borer in bark and wood; also the larva at *a*, and the beetle at *b*. (Webb.)

Description and habits.—The locust borer is a whitish, elongate, roundheaded grub (fig. 43, *a*). It hatches from an egg laid by a black, longhorned beetle (fig. 43, *b*) with yellow, zigzag stripes. The eggs are laid in crevices of the bark during the period from August to October and the young borers that hatch from them excavate individual cells in the outer layers of the inner, living bark, where they overwinter. In the spring they bore into the wood, where they change to pupæ during July and August and to beetles during August and September, whereupon the beetles bore exit holes and come out to mate and resume the life cycle. This beetle is a lover of and works in the sunlight, therefore shaded trunks and branches are not subject to its attack—a fact which, if borne in mind in connection with the care of locust plantations, will result in the saving of trees. (See Bulletin 787, United States Department of Agriculture.)

Remedy.—For shade trees and small plantations or groves, spray infested trees in the spring, when these trees begin to show green, with poisoned kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12, 13). This will kill the young borers in the bark.

Control.—Cut locust trees for posts, etc., during the dormant season, and peel and promptly burn the bark and branches to destroy the borers in the bark. In May and June (not later than the falling of the locust flowers) cut and burn all badly infested trees.

Prevention.—In localities where it is still absent, guard against introduction of the borer in posts or other products having the bark on. Regularly each year locate and destroy entirely or remove the bark from infested trees. Secure cooperation of neighbors in the work, so far as possible. Finally, allow all the undergrowth possible and keep growing trees untrimmed so that they will be well shaded when the beetles fly. The beetles, being sun loving, will not lay eggs on shaded trees.

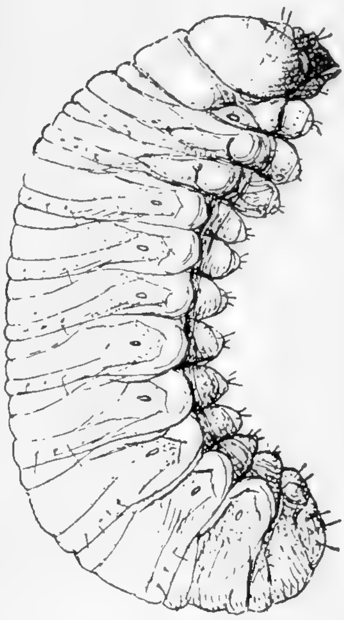

Fig. 44.—Grub of the mottled willow and poplar borer. Enlarged. (Chittenden.)

MOTTLED WILLOW AND POPLAR BORER.[36]

Fig. 45.—Poplar branch showing work of larva and punctures made by beetle of mottled willow and poplar borer (near bottom at right); also beetles. Natural size. (Chittenden.)

How injurious.—This is a most serious enemy of willow and poplar trees, the limbs and trunks of which it tunnels until they die or break in the wind. It found its way into this country a number of years ago and has since established itself in practically all the Northern States.

How recognized.—Dead or dying limbs, swellings, and dead patches of bark often cracked open on limbs or trunk, fading foliage, and "sawdust" and oozing sap at points of attack are signs of infestation. Fresh punctures made by the beetles while feeding on the younger shoots are also in evidence. Injured twigs, when split open, disclose burrows, mostly along the middle, and within each is a fleshy, white, footless grub (fig. 44) about one-half inch long when full grown.

Habit and appearance.—The grub is usually full grown about June or July, pupates, and turns to the adult, which is a rather stocky, dark colored snout-beetle (fig. 45) about three-eighths inch long, with spots and rear third of the wing covers pinkish white. For a week or two after emerging the beetles feed on the young bark and then the females begin to gouge out cavities in the bark of 2 to 4 year old growth and

[36] *Cryptorhynchus lapathi* L.

lay their eggs in them. The grubs hatching from these penetrate the bark and spend the winter directly under it. The following spring they resume feeding and keep it up until full grown, whereupon they bore into the wood, through it to the pith, and make a 3 to 4 inch gallery along that, filling it with wood fiber and pupating at one end of it. Thus the life cycle, although completed within a twelvemonth, extends from one calendar year into the next.

Remedies.—Cut out and burn all infested wood before May or June, thus preventing the grubs from reaching maturity and propagating. It appears possible also to control the insect by thoroughly coating the bark in July with lead arsenate (p. 11) or by painting trees with kerosene emulsion (p. 12, 13) in April or thereabouts.

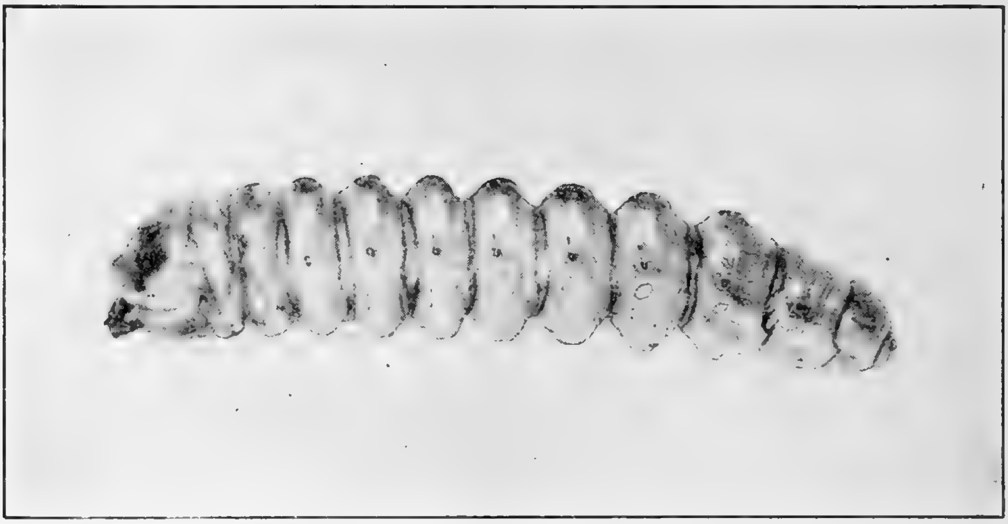

FIG. 46.—The cottonwood borer: Larva, side view. Enlarged. (Milliken.)

COTTONWOOD BORER.[37]

Destructiveness.—In the Middle West the cottonwood borer is very destructive to poplar or cottonwood and willow trees in all stages of growth. The mines of the borer, made at the base of the stem, often girdle the tree, causing its death or so reducing the strength of the wood that it is broken off by the wind.

Evidence of infestation.—Broken-off trees, sickly tops, and collections of shredded boring dust on the surface of the ground beneath the trees indicate the presence of the borers. On removal of the bark at the surface of the ground borer mines are disclosed.

Description and habits.—The cottonwood borer is a yellowish, elongate, cylindrical grub (fig. 46). It hatches from an egg laid by a large, black and white mottled, longhorned beetle (fig. 47). The eggs are laid during July and August in small punctures made in the bark at or just below the surface of the ground, and the borers

[37] *Plectrodera scalator* Fab.

hatching from them excavate individual mines, first beneath the bark and later deep into the wood, throwing out shredded borings as they work along. Two years of feeding in the tree pass before the borer matures and transforms to a beetle.

FIG. 47.—The cottonwood borer: Male beetle. More than twice natural size. (Milliken.)

Remedies.—In the case of shade and otherwise valuable trees the borer may be profitably killed either by being dug out while young or by injection of carbon disulphid (p. 14) into the hole showing fresh sap and boring dust, this hole being then promptly plugged with putty, clay, or similar substance. It seems as though the young borers might also be killed by spraying the infested trunk with poisoned kerosene emulsion (p. 12, 13) or miscible oil (p. 12, 13).

Prevention.—A wire screen, up to half an inch mesh, wrapped around the base of the tree so that it reaches about a foot above ground and several inches into the ground, which fits snugly at the top and is an inch or two away from the bark the rest of the way, will prevent the beetles from laying their eggs in it.

LEOPARD MOTH.[38]

Recognition of work.—The death or dying of limbs on otherwise healthy shade trees in cities along the Atlantic seaboard from eastern Massachusetts to southern New Jersey and in the Hudson River Val-

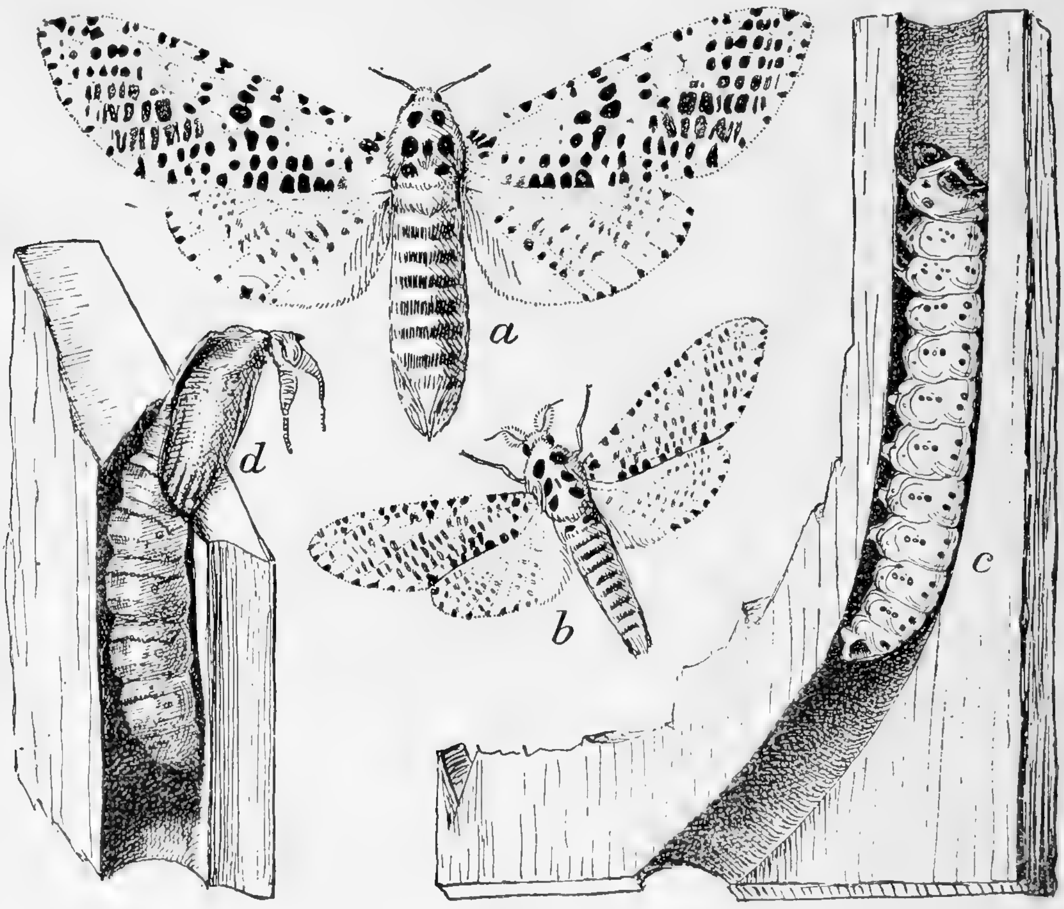

FIG. 48.—The leopard moth: *a*, Adult female; *b*, adult male; *c*, larva; *d*, empty pupal case. Enlarged. (Howard and Chittenden.)

ley is in many cases traceable to the destructive work of the caterpillars of the leopard moth. In cases of severe attack, especially on young trees, growth is checked and, when the trunk is girdled, death follows. In the region of its occurrence the leopard moth has proved to be a most serious menace to shade trees.

Habitats and seasonal history.—The leopard moth was introduced from Europe about 40 years ago, but fortunately its spread has been very slow. The caterpillar of this moth is a wood-boring insect, and feeds on the living wood in branches and trunks of deciduous trees. Evergreens are not attacked. From the time it hatches out of the egg, about two years pass before the caterpillar (fig. 48, *c*) stops

[38] *Zeuzera pyrina* Fab.

growing and changes to a chrysalis within its burrow (fig. 48, *d*). When it becomes mature, which happens during the period between May and September, the pupa or chrysalis forces its way partly out of the burrow (fig. 48, *d*), its skin splits open, and the leopardlike, spotted white moth (fig. 48, *a*, *b*) come out of it. Immediately after mating the female begins egg laying. As many as 800 eggs were observed to have been laid by a single female. The eggs are laid singly and in groups of three or more in crevices of the rough bark, from which they hatch about 10 days later and the issuing larvæ begin to burrow their tunnels toward the heart of the wood, thus completing the two-year life cycle.

Methods of control.—No easy method of wholesale destruction of this insect is known at present. Badly infested trees and limbs should be cut and *burned promptly* lest the borers migrate from them to the healthy wood. Many young and highly prized trees, showing only a few burrows, have been saved from death and even further injury by killing the borers in them with carbon disulphid injected into the burrows (p. 14). A flexible wire in many cases can be employed to advantage for killing borers in their burrows by probing. Clean culture, prompt attention, and simultaneous community work are necessary for effective control. Farmers' Bulletin 708 contains full information on this insect.

CARPENTER WORM.[39]

How destructive.—Although it rarely kills trees, the large burrows up to one-half inch wide made by the carpenter worm in the very heart of trees produce serious deformities which render the trees unsightly. Oak, chestnut, maple, locust, and cottonwood are among the trees most likely to suffer from it.

Indication of presence.—Infestation is shown by the wilting of smaller twigs, strings of frass dangling from holes in the bark, the large gallery (fig. 49, *9*), and, when present, the inhabiting worm, which is a large, vivid, reddish-white caterpillar (fig. 49, *7*) up to nearly 3 inches in length, greenish beneath, with scattered, long, fine hairs on the body and with head shining black.

Seasonal history and habits.—It takes this insect about three years to complete its life round, which accounts for the presence of caterpillars in badly infested wood at all seasons of the year. In an oval cell made by the caterpillar at the outer end of the gallery just before completing growth, transformation to the chrysalis (fig. 49, *6*) takes place in May or June. After about two weeks' life as such the chrysalis wriggles partly out of the hole in the tree (fig. 49, *5*) and

[39] *Prionoxystus robiniae* Peck.

the adult moth (fig. 49, *4*) emerges from it. Soon after mating the female begins laying her eggs (fig. 49, *4a*), from 300 to 400 in number, a few in a place and preferably near wounds or scars. The hatching of the eggs and penetration of the resulting caterpillars (fig. 49, *8*) to the heartwood complete the life cycle to the point from which its description was begun.

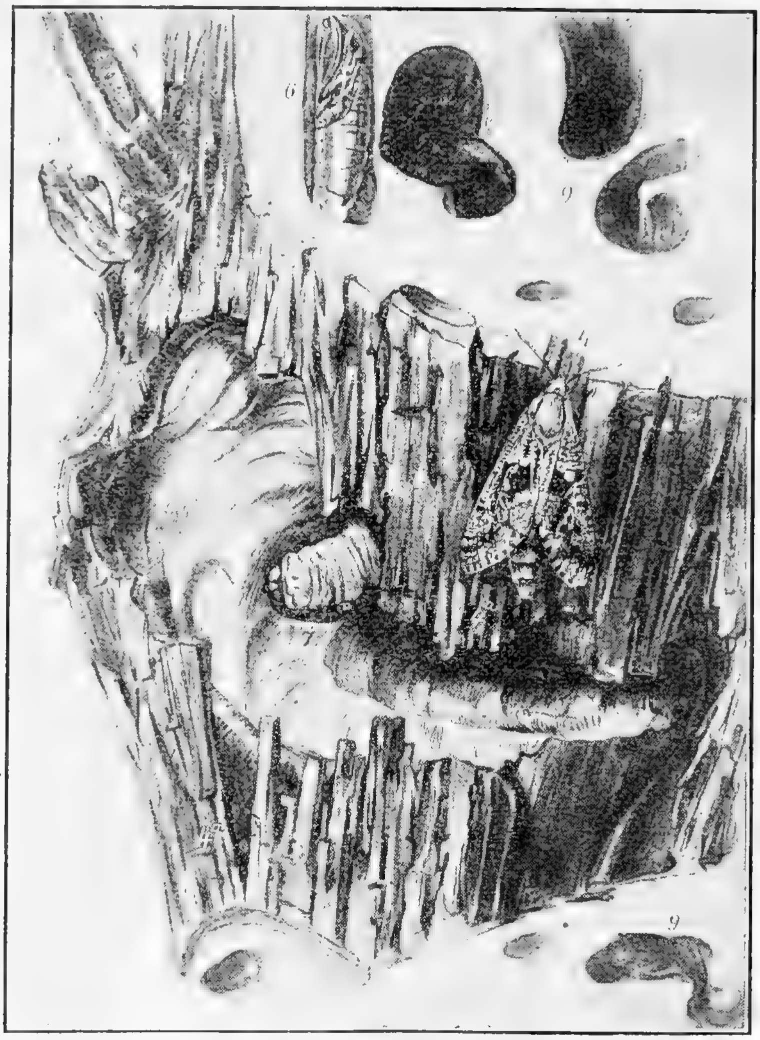

FIG. 49.—Carpenter worm and work: *4*, Female at rest on the bark; *4a*, dark colored eggs deposited loosely in the crevices; *5*, empty pupal case partly sticking out of the burrow; *6*, pupa within its cell; *7*, full grown caterpillar with its head protruding from the burrow; *8*, young caterpillar at work in a small twig; *9*, irregular burrows of full grown caterpillars. (Felt.)

Prevention.—Avoid wounding trees; dress wounds with tar or paint them (p. 14–15) after they are made.

Remedies.—Cut off during the winter and promptly burn all infested wood. Inject carbon disulphid (p. 14) into the wounds and promptly plug them with putty, grafting wax, or similar substance.

MAPLE AND OAK TWIG-PRUNER.[40]

Extent of injury.—While not a menace to the life of trees, the work of the maple and oak twig-pruner, which is often very abundant, tends to destroy the shape and thereby to mar the appearance of trees, besides littering with débris the ground beneath them.

Recognition of work.—During the summer and fall the ground beneath trees is found more or less strewn with small twigs, showing a clean cut at the larger end (fig. 50) with a burrow in the center plugged with wood shavings. Quantities of such twigs may also be hanging from the tree. Freshly fallen twigs, when split in two, disclose the hollowed-out interior and usually at some point within the

[40] *Elaphidion villosum* Fab.

burrow the whitish grub (fig. 50, *a*) with brown jaws that did the damage.

Seasonal history and habits.—The grub above referred to passes the winter in the fallen twig and changes to a pupa early next spring, unless this change has taken place late in the fall, which happens not infrequently. A little later in the spring the pupæ change to adult beetles (fig. 50, *b*), which begin emergence from the wood about June and remain abroad all summer, laying their eggs in July in the smaller twigs of, preferably, oak, but also of maple and other trees. The eggs hatch into grubs, which tunnel and sever the twig.

Remedy.—As the fallen branches usually contain the destructive insect in one form or another, gathering and burning them before emergence is the most logical and the simplest means of controlling the pest.

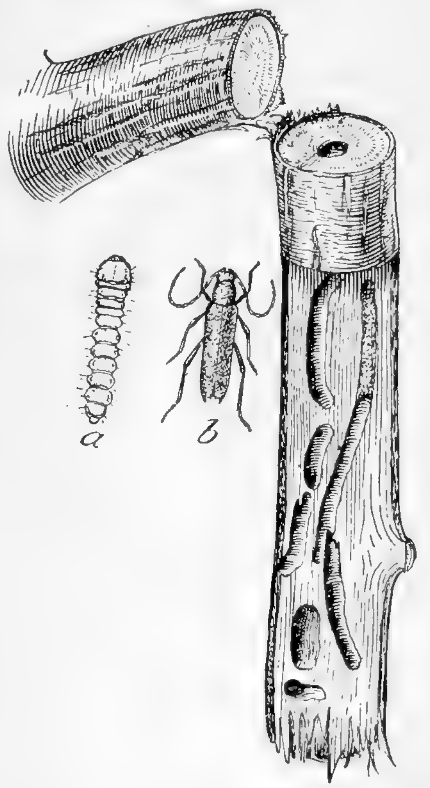

FIG. 50.—The maple and oak twig-pruner: *a*, Larva; *b*, adult; pruned twig and larval mines at right. (Webb.)

TWIG GIRDLERS.[41]

How injurious.—Trees are often found with numerous twigs lying on the ground beneath them or still hanging, dead. The larger ends of such twigs show evidence of having been cut off, and at some place in the burrow running the length of them the architect of the burrow may be found. Among shade and grove trees, hickory, persimmon, elm, poplar, sour gum, basswood, honey locust, dogwood in the East and South, and huisache, mesquite, and acacias in the Southwest, are subject to this injury. This is the work of beetles known as twig-girdlers, and may become so prevalent as to deform trees badly. Young hickory trees are frequently cut off near the ground. The hickory twig-girdler[42] in the East, the pecan twig-girdler[43] in the South, and the huisache girdler[44] in the Southwest, are the insects involved.

Character of work and habits of the insects.—In late summer or early fall these beetles appear and often feed on the thin bark before laying the eggs. The adult female girdles branches of the host tree by cutting a circular incision through the bark and deep into the wood. The twigs so girdled vary from $\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. In these twigs the eggs are deposited in a small scar gnawed through

[41] *Oncideres* spp.
[42] *Oncideres cingulata* Say.
[43] *O. texana* Horn.
[44] *O. putator* Thom.

the bark. These branches soon die and most of them fall to the ground. Until the middle of the following summer the larvae feed in the wood, loosely filling the mine with frass, though much of it may be expelled. The pupal cell is firmly walled with fibrous frass. One year is required to complete the development, though in more northern localities many of the larvae feed through the second year before pupating. A high mortality occurs in the larva stage, due to too many borers in the same twig or excessive drying of the branches.

Remedy.—Gather and burn twigs as fast as they fall.

Fig. 51.—Injury by the hickory barkbeetle to the twigs, buds, and base of leaves. (Hopkins.)

HICKORY BARKBEETLE.[45]

How destructive.—For years the number of dead and dying hickory trees throughout this country has been increasing. In many instances the death of these trees has been traced to the work of the hickory barkbeetle. This beetle, then, constitutes a serious enemy of our hickory trees, which, unless prompt steps are taken, are in danger of being seriously depleted.

[45] *Scolytus quadrispinosus* Say,

Evidence of infestation.—The presence and work of the hickory barkbeetle are indicated in several ways: (1) Bases of twigs, buds, and fallen hickory leaves in the spring show signs of having been eaten by insects (fig. 51); (2) clear-cut, round holes occur in the bark; (3) in August and September the foliage of hickory is faded and dying; (4) the inner bark of hickory trees and the wood surface beneath it are engraved with peculiar centipede-shaped designs (fig. 52), consisting of a broader, central, straight, upright gallery with narrower burrows radiating like centipede legs from either side of it.

History of seasonal activity.—About the time the pollen is falling from the tassels of healthy hickories the beetles mate and each pair starts the excavation of an upright gallery. In niches along the sides of these, eggs are laid which hatch into the grubs that tunnel out the "centipede legs." Until the larvæ are about half grown they feed in the inner layers of bark; later they tunnel into the middle and outer layers of it and pass the winter there. In the following spring they change to pupæ and then to adults, which emerge soon thereafter, thus completing the life cycle in one year. Retarded development of some individuals and accelerated development of others often complicate the situation so that most often all stages of the insect may be found in the same tree at the same time. Each barkbeetle brood gallery cuts that much of the sap flow between root and top, and when these galleries connect up completely around the trunk the tree is girdled and doomed to inevitable death.

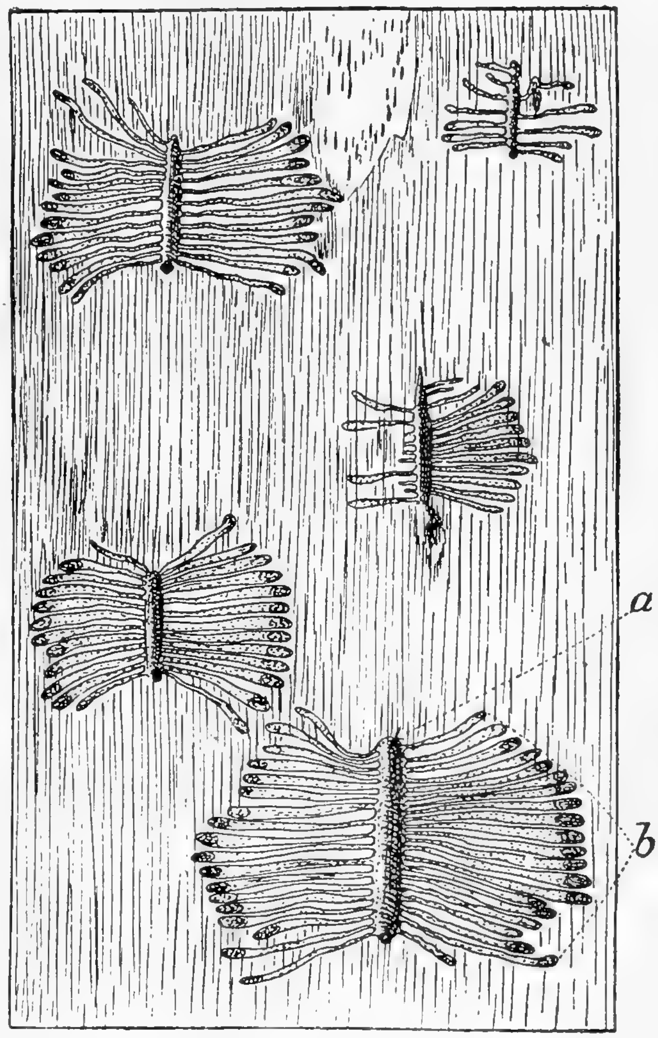

FIG. 52.—Work of the hickory barkbeetle on surface of wood beneath bark. *a*, Primary or egg gallery; *b*, larval mines. (Hopkins.)

Natural checks.—Like all native insects, the hickory barkbeetle is subject to attack in the mature and immature stages by a variety of parasitic and predatory insect and other enemies. By means of the sap flow a vigorous hickory tree is also capable of stubbornly resisting attack. The attack can not be successful, therefore, unless the vitality of the tree is low at the time of attack or unless the beetles are sufficiently numerous to overwhelm a healthy tree. An abundance of sickly, dying, or felled hickory trees in the near vicinity provides favorable conditions for the production of an excess of beetles.

Control.—The evident means of checking the ravages of this pest is to keep the beetles down below a number sufficient to attack vigorous trees successfully. This can be accomplished (1) by putting into practice the very important principle of forestry of prompt, systematic removal from the area and disposal of all hickory trees which show signs of decline, and (2) by cutting and utilizing, for firewood or otherwise, the badly infested trees in the area.

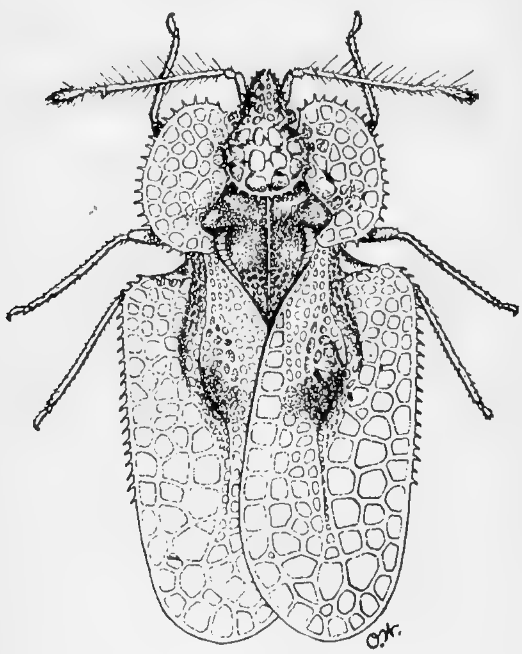

FIG. 53.—Sycamore lace-bug: Adult, greatly enlarged. (Wade.)

SAP-SUCKING INSECTS.

GENERAL.

The feeding of sap-sucking insects on deciduous shade trees is not manifested by visible holes in leaf or bark, but usually by discolored or wilting foliage and generally by the sickly and often black, dirty appearance of the trees. As these insects do not feed on plant tissue but on plant sap, which they secure from the inner tissues by thrusting their beaks through the outer layers, they can not be destroyed by poisoning the foliage of the trees on which they live but must be hit directly by substances which kill on coming in contact with their bodies and which, therefore, are known as contact insecticides.

SYCAMORE LACE-BUG.[46]

How injurious.—By no means can the sycamore lace-bug be called a tree-killing insect, but great numbers of it not only discolor the foliage of the sycamore, its only host tree, but also cause premature falling of the leaves, thus rendering the tree unsightly and littering the ground beneath it. It may be found on sycamore, especially *Platanus occidentalis*, wherever it grows in the United States.

How recognized.—The sycamore leaves are off color in irregular spots or entirely and the underside is inhabited by colonies of queer, rather slow-moving bugs with prettily marked, lace-like horizontal wings (fig. 53), or their offspring with larger or smaller wing pads.

[46] *Corythuca ciliata* Say.

Habits.—The winter is passed in the adult stage hidden in crevices on the bark of the host tree. As growth starts in the spring the over-wintered individuals move over to the foliage and, after feeding for a week or two and mating, the females lay groups of eggs on the underside of the leaf. These hatch in about two weeks into tiny bugs, which differ from the adults only in lacking wings, and promptly begin feeding. They cast their skin or molt as they grow, doing so five times before maturity is reached. Two or more generations a year are produced, depending on the length and condition of the season, and varying therefore with the latitude and climate of the locality.

Remedy.—When the lace-bug is excessively abundant and other conditions permit, it has been found possible to achieve satisfactory control by spraying the insects with soap solution (p. 14).

BOXELDER PLANT-BUG.[47]

How injurious.—Although it feeds on plants only, and primarily on boxelder, this bug (fig. 54, *e*) is known mainly as a fall house pest owing to the fact that, if the infested tree is near enough, masses of the bugs in search of winter quarters are apt to invade dwellings and become a general nuisance there, besides alarming the unwitting householders. It first came to notice some 40 years ago in the far West, but has since spread pretty generally over the States west of the Mississippi River, and has recently been reported in States east of that river.

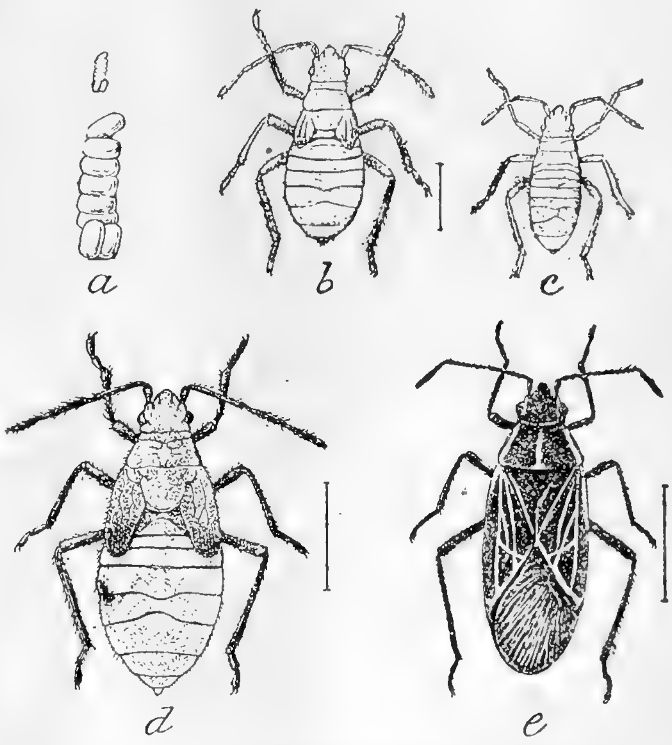

FIG. 54.—The boxelder plant-bug: *a*, Eggs enlarged, natural size above; *b*, *c*, *d*, different stages of immature bugs; *e*, adult. All enlarged; natural sizes indicated by hair lines. (*a–d*, Marlatt; *e*, Howard.)

How recognized.—In late summer large numbers of bright red, wingless or red bordered, darker winged bugs may be seen sucking the sap from the leaves and tender growth of boxelder or, in the fall, masses of them wandering up and down the trunk of the tree and crawling up brick walls and into houses, cellars, and all sorts of cracks and crevices in search of hibernation quarters.

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[47] *Leptocoris trivittatus* Say.

Habits.—The adults emerge from hibernation about the time box-elder buds open and lay their eggs (fig. 54, *a*), usually in crevices of the bark of this favorite host tree. The hatching young migrate to the foliage in great hordes, traveling up and down the trunk. After several molts (fig. 54, *b*, *c*, *d*) maturity is reached and by fall great streams of the bugs start on the march for winter shelter.

Remedies.—Spray trees as soon as the insects appear with soap solution (p. 14) or kerosene emulsion (p. 12–13). In the fall great masses of them can be destroyed by pouring hot water or kerosene on them or by sweeping them into a vessel containing kerosene.

SCALE INSECTS IN GENERAL.

Appearance and habits.—Scale insects are so called because of the scale that covers or constitutes the back of most of them. This covering may be horny, leathery, waxy, cottony, or mealy, and just as various in size, shape, and color. There are many species of scale insects; and, according to the consistency of their covering, they are roughly divided into *armored scales*, *soft* (leathery) *scales*, *cottony scales*, *mealybugs*, etc. Except for a few days after hatching, when they are naked, these insects are nearly always covered by the scale characteristic of the species to which they belong. The number of generations annually, date of hatching, and other life-history habits vary with the species, season, and location. They are all plant feeders, some confining themselves to a single species of plant, while others occur on a great variety of plants. They occur on roots, main stems, branches, and twigs; some of them occur also on the leaves and fruit in summer. They feed on sap, which, by means of their slender, flexible, needlelike beaks, they suck up from within the plant tissues. They are, therefore, classified as sucking insects. Some of them produce more or less honeydew, which attracts ants, bees, wasps, etc., which eat it but do not harm the plants. Certain fungi growing on honeydew frequently give the affected plants a sooty appearance.

Natural control.—Like other insects, most scale insects are usually kept in check by a variety of natural agencies, especially parasitic and predacious insects. Under such conditions they do no permanent serious harm and require no remedial treatment. Quite often, however, some species become so numerous as to be very injurious, and make early treatment imperative if the life of the affected plant is to be saved or its value kept unimpaired.

Remedies.—Winter spraying with a contact insecticide (p. 11–14), done when the buds are dormant, is preferable for scale insects because (1) there is then no delicate foliage to injure and none to conceal the insects or to use up the spray; (2) dead and superfluous portions of the plant may and should then be removed, still further reducing the area to be sprayed and exposing the insects; (3) plants are then dormant and can withstand stronger sprays without injury. Summer spraying, when imperative, is most effectively done when the young are at the height of hatching, i. e., crawling about in numbers.

OYSTER-SHELL SCALE.[48]

How injurious.—The oyster-shell scale lives and feeds on a great variety of shade trees, especially poplar, maple, birch, beech, and willow, besides hardy shrubs and certain fruit trees, all over this country, and though it occasionally kills an entire grown tree, it generally retards and stunts the infested growth and frequently causes the death of twigs and branches.

How recognized.—The bark of an infested branch is found more or less densely crusted with brown or grayish, rather long, somewhat bent scales (fig. 55), wider at one end than the other, and sloughing off more or less readily.

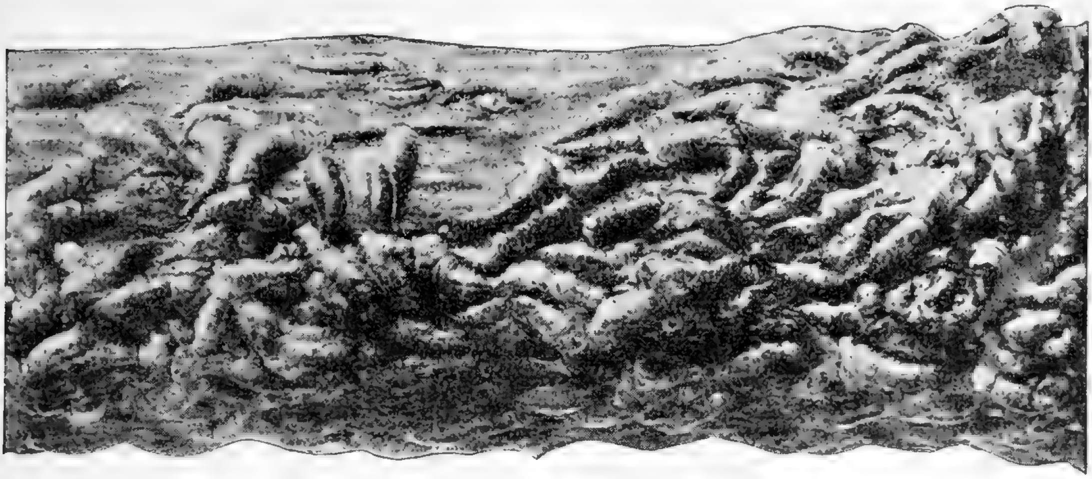

Fig. 55.—Oyster-shell scale on poplar. Much enlarged. (Quaintance and Sasscer.)

Habits and seasonal history.—Shortly after the apple blossoms fall the eggs of the oyster-shell scale, which overwinter beneath the female scale, hatch into minute, licelike insects which crawl about for three or four days, and after inserting the threadlike beak, which serves as an anchor as well as a food conduit, into the host, settle permanently on the bark. Thereafter the female never leaves the scale started by it when young, but ultimately lays its eggs and dies there.

Control.—Here and there an infestation by these scale-bugs is checked by minute, wasplike, parasitic insects that kill them. In most cases, however, spraying with lime-sulphur (p. 11–12) or a miscible oil (p. 12) must be resorted to for a prompt, effective remedy. The necessary preliminary work in preparation for spraying is indicated on pages 15–16.

SAN JOSE SCALE.[49]

How injurious.—For a series of years at the close of the last century the San Jose scale was the most dreaded insect pest of the

[48] *Lepidosaphes ulmi* L.

[49] *Aspidiotus perniciosus* Comst.

horticulturist, for not only was it found exceedingly destructive, but few woody plants seemed immune to it. Since then time and intensive study have developed both insect enemies and remedial measures which have effectively curbed its inroads. Nevertheless it is still a serious pest at times here and there, limbs and whole trees being killed by it.

How recognized.—Ailing trees show the smooth bark roughened and covered with scurf (fig. 56, *a–c*) beneath which pouchlike, yellow insects (fig. 56, *e*) may be observed. The live wood under such bark is tinged with bright red and circles of the same color surround these insects on green growth, leaves, and, in the case of orchard trees, the fruit.

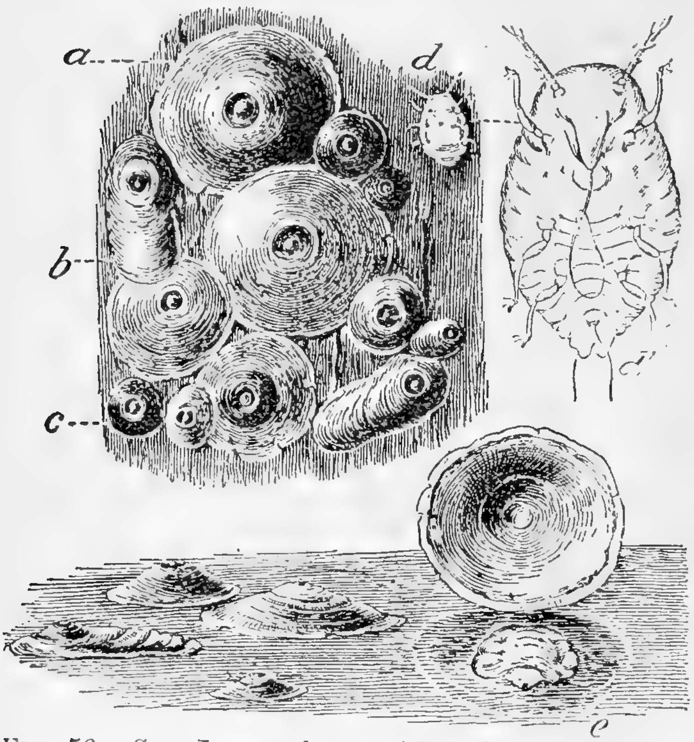

FIG. 56.—San Jose scale: *a*, Adult female scale: *b*, male scale; *c*, young scales; *d*, larva just hatched; *d'*, same highly magnified; *e*, scale removed showing body of female beneath. All much enlarged. (Quaintance.)

Habits.—Attached to the bark this scale insect hibernates in immature stages, resuming feeding and growth with the advent of spring. Maturity is reached and young (fig. 56, *d*, *d'*) are hatching in Washington about the middle of June. After crawling about for a day or two the tiny yellow louse settles down to feed and build the scale. From three to five generations are produced annually, varying with the latitude and climatic conditions.

Remedies.—The San Jose scale readily yields to treatment with miscible oils (p. 12) or with lime-sulphur (p. 11, 12) where their application is practicable. Even fish-oil soap solutions (p. 14) or kerosene emulsion (p. 12–13) give satisfactory results. In heavy infestations two treatments should initiate the work, one in the fall as soon as the leaves fall and the other in the spring just before the buds swell.

GLOOMY SCALE.[50]

How injurious.—The gloomy scale is a special enemy of soft-maple trees, which it often cripples or kills, though other maples may be infested by it. It is especially abundant in the South where it is eliminating the soft maple as a shade tree.

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[50] *Chrysomphalus tenebricosus* Comst.

How recognized.—In appearance it is not unlike the San Jose scale (fig. 56) and the effect produced by it is much the same, except that the red color is absent from the area it infests and the scale is larger and coarser. Also white rings, places from which the scales have peeled off, are a characteristic appearance on old infested surfaces.

Habits.—In its habits this scale is very much like the San Jose scale, except that apparently only one generation is produced in Washington, D. C., and proportionately more farther south. It is a prolific breeder, however, and can incrust trees with its scales in a comparatively short time.

Remedy.—Winter applications of miscible-oil solution (p. 12) will keep it in check.

OBSCURE SCALE.[51]

How injurious.—Oak is the favorite and only host of the obscure scale, and young trees and branches may suffer severely from it or even be killed. This is particularly true of the southern half of the country.

How recognized.—This insect looks much like the San Jose scale. In addition, large whitish rings or circles, which are spots from which the scales have been rubbed off, are an evidence of infestation with this scale. The reddish discoloration characteristic of the San Jose scale is absent and the scale is even coarser than the gloomy scale.

Habits.—Very much like the preceding.

Remedy.—Winter applications of miscible-oil solution (p. 12).

PUBESCENT OAK KERMES.[52]

How injurious.—The pubescent oak Kermes can by no means be considered a tree-killing insect, although twigs here and there may be killed by it. The growth of badly infested trees, however, is severely checked, the tender growth particularly. This scale insect occurs on oaks only; white oak (*Quercus alba*) suffers most from it in the vicinity of Washington, D. C.; burr oak in Ohio and Indiana; and red, chestnut, and chinquapin oaks are other species on which it has been collected.

How recognized.—During the growing season leaves and green, soft wood are found crumpled up, and motionless, hairy, plump bodies resembling the background in color are attached to them. When mature, the insects become much more rounded and chestnut brown in color. Occasionally small, feltlike, white sacks may be found on the wood of branches. These are the male cocoons. To-

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[51] *Chrysomphalus obscurus* Comst.

[52] *Kermes pubescens* Bogue.

ward the end of the season leaves begin to die and clumps of them remain attached to the tree through most of the winter. During the winter masses of tiny, reddish, licelike insects may be found in cracks of the branches and twigs.

Habits.—The overwintering young desert their winter quarters about the time buds on the white oak begin to open and migrate to the new growth, where they settle and, inserting their beaks, begin to feed, usually on the midribs of leaves and the soft wood. Wherever one of them settles growth ceases, while the surrounding tissue, of the leaf blade, for instance, continues growing, thus producing the sagging effect. At maturity the body of the female becomes filled with eggs, which, in Washington, D. C., hatch early in July, the "lice" coming from them infesting further the year's growth. Two generations are produced during the year, the offspring of the second hatching late in the fall and migrating to the bark for hibernation.

Remedy.—Experiments made by the writer on several groups of large oak trees have shown that a water solution of miscible oil, 1–15, thoroughly applied at the time the buds begin to swell on the white oak in the spring, kills 85 to 90 per cent of the young insects without hurting the tree in any way. In the given case a high-power sprayer with a solid-stream nozzle was used. The cost of the spraying material averaged about 50 cents a tree. The labor in this particular instance was abundant and free so that no estimate of the cost could well be made. An average of 15 minutes was consumed by the crew to a tree, including transportation over the grounds and time required to fill the tank. For further details on this subject see pages 12 and 22 to 30.

TULIP-TREE SOFT SCALE.[53]

How injurious.—Branches of tulip trees may be so crowded with the tulip-tree soft scale that they sicken and die, greatly disfiguring the tree.

How recognized.—Sickly, blackened branches are found thickly beset on the underside with vivid gray to brown, prominently raised scales about one-fourth inch long and a little narrower. Toward fall the young may be observed crawling about and settling on the bark.

Habits.—The young pass the winter on the bark where, the following spring and summer, they feed and grow, producing young again toward fall, thus making only one generation a year in the latitude of Washington, D. C.

Remedy.—Miscible-oil solution (p. 12) has been found to be an effective remedy for this insect.

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[53] *Toumeyella liriodendri* Gmel.

MAGNOLIA SOFT SCALE.[54]

The magnolia soft scale, as its name indicates, occurs primarily on magnolias, although occasionally on tulip trees. Its appearance, effects, and habits are similar to those of the species infesting the tulip and so also are the measures for its control.

TERRAPIN SCALE.[55]

How injurious.—Maple, especially sugar maple, and sycamore and poplar, among shade trees, are particularly subject to infestation by the terrapin scale, which occurs in several States west of the Mississippi River, and in all of those east of it. It is largely a twig scale.

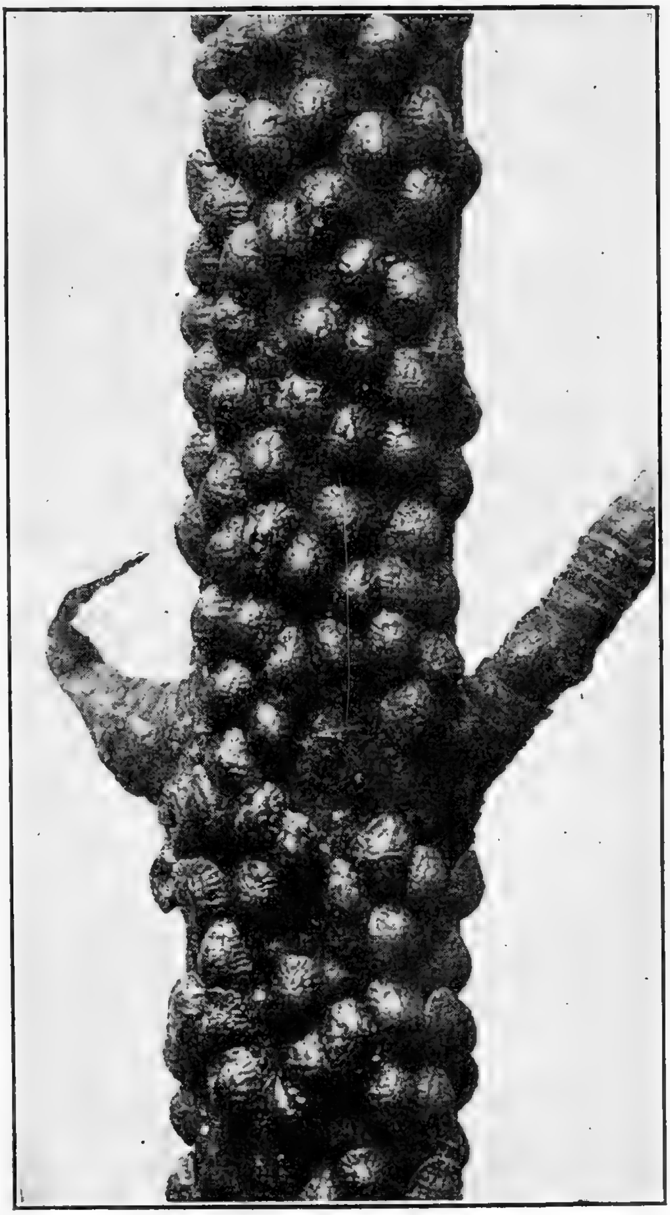

FIG. 57.—Terrapin scale. Adult females on twig of peach. Enlarged about three times. (Sanders.)

How recognized.—Infested twigs show the drain from which they are suffering by their wilting and dying foliage. The twigs are more or less heavily incrusted with raised reddish scales (fig. 57) about one-sixteenth to one-eighth inch long, about half as much in diameter, and ridged along the edges. Green shoots and the large veins of leaves are beset with young, licelike insects from midsummer on. Honeydew and black sootlike growth occur on and beneath infested twigs.

Habits.—In a half-grown condition the insect passes the winter on the bark of twigs and branches of its host, resuming feeding and growth as soon as spring starts. Toward the end of May, in the latitude of Washington, D. C., they are full grown and the females are filled with eggs, the young beginning to hatch about the middle

[54] *Neolecanium cornuparvum* Thro. [55] *Lecanium nigrofasciatum* Perg.

of June and continuing to hatch through most of the summer. Evidently only one generation is produced annually in the District of Columbia.

Remedies.—There is little doubt that kerosene emulsion (p. 12–13) or miscible-oil solution (p. 12), applied in the early spring before the buds have opened, will effectively kill off most of the pest.

COTTONY MAPLE SCALE.[56]

How injurious.—The cottony maple scale attacks a great variety of trees and vines. Its food consists of sap obtained by sucking it from within the plant tissues. Occasionally the insect appears in great numbers and at such times is apt to injure shade and other trees materially.

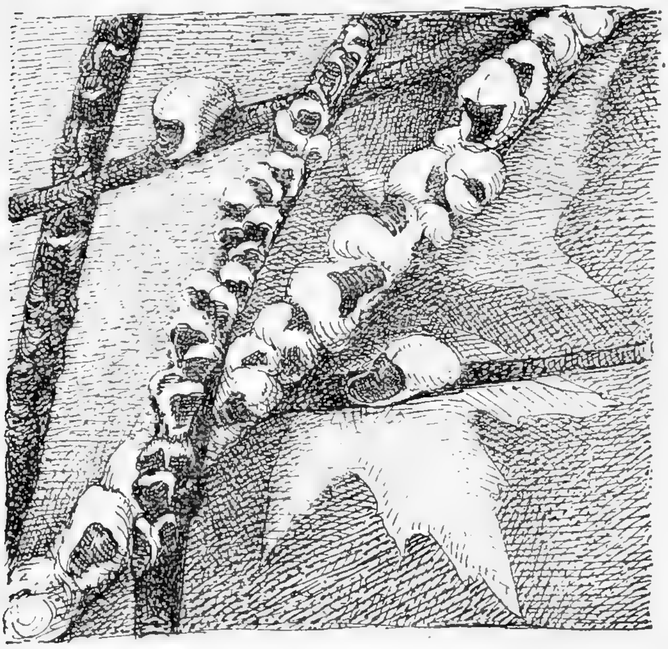

FIG. 58.—Cottony maple scale. Females with cottony ball full of eggs. (Howard.)

Seasonal history and habits.—This scale insect, even when present in great numbers, remains unnoticed until about June, when, at about the latitude of Washington, D. C., it is rendered strikingly conspicuous by the large, white, cottony egg mass which appears at that time at the end of the body of the female insects (fig. 58). The eggs hatch in early summer, though sometimes this hatching extends into August, and the young settle upon the twigs and underside of leaves. In the fall the females migrate to the twigs, where they remain unchanged through the winter, rapidly swelling in the spring and forming the egg mass in early summer. Thus only one generation is produced annually.

Remedies.—Remedies are rarely necessary. Where occasion arises for their use, a spray of dilute (summer strength) kerosene emulsion (p. 12–13) during the hatching of the eggs (June and July) is certain to prove effective.

EUROPEAN ELM SCALE.[57]

History and damage.—The European elm scale, an immigrant from Europe in about 1884, lives on the elm and may occur wherever this tree is grown in the United States. As a rule it does not kill

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[56] *Pulvinaria vitis* L. [57] *Gossyparia spuria* Modeer.

the trees, but it is often so very injurious, especially to young stock, that, together with the injury caused by the elm leaf-beetle, another importation from Europe, attack by bark-borers, etc., is induced and the trees do not recover.

How it lives and looks.—This scale spends the winter in crevices of the bark on the trunk and larger branches as brown immature males and females embedded in white cottony matter (fig. 59). On the appearance of warm weather, in May at Washington, D. C., these forms begin to move about, molt, and mate, after which the females attach themselves permanently on limbs and trunk. The young—clear, lemon-yellow, lice-like insects—issue during June and July, settling temporarily on leaves alone or on leaves and twigs, depending on the smoothness of the latter. In August they return to the larger branches and trunk to settle for the winter, thus completing in Washington the seasonal life cycle.

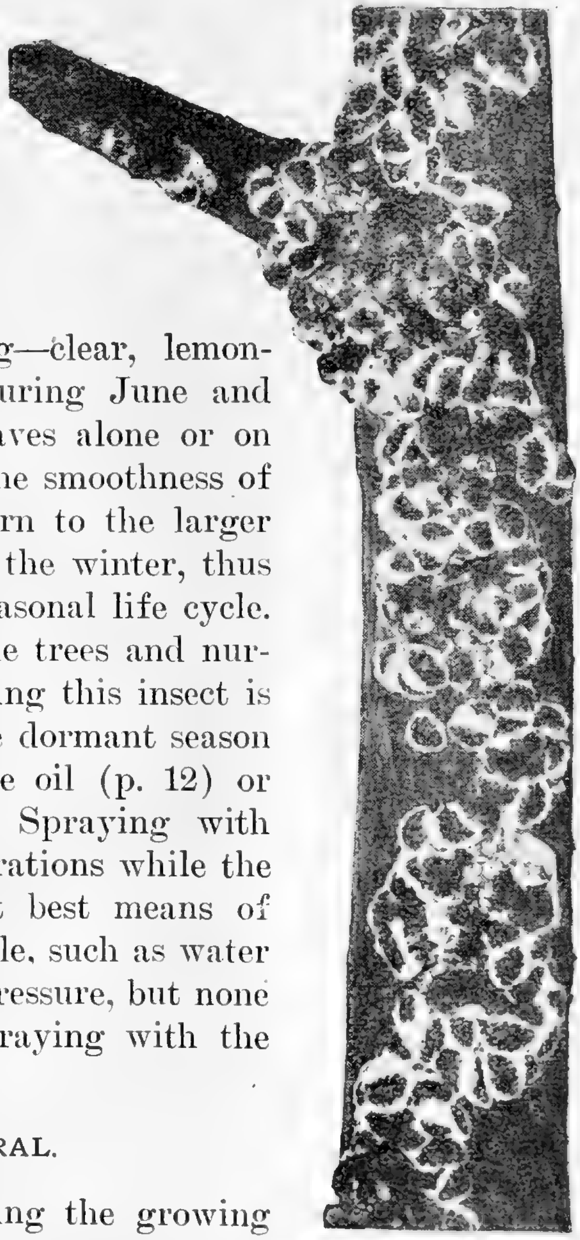

FIG. 59.—European elm scale: Mature females. (Photograph by Sanders.)

Remedies.—In the case of shade trees and nursery stock the best means of killing this insect is to spray infested trees during the dormant season with a water solution of miscible oil (p. 12) or kerosene emulsion (p. 12–13). Spraying with summer strengths of these preparations while the young are hatching is the next best means of control. Other means are available, such as water applied with a hose under high pressure, but none of them is as satisfactory as spraying with the solutions mentioned.

APHIDS IN GENERAL.

Evidence of infestation.—During the growing season aphids or plant-lice occur in winged and wingless form in greater or less numbers on branches, twigs, and leaves. They feed on the sap, which they suck up from within the tissues by means of their pointed beaks, hence are classed as sucking insects. Under favorable conditions aphids suddenly appear in great numbers, particularly in the spring. Their presence is indicated by an abundance of sticky "honeydew" on and under the infested plants, by the presence of ants which feed on the honeydew but do not harm the plant, and by the curling and the abnormal falling of the leaves. When this honeydew is very copious, the black film which forms upon it gives the leaves and other portions of the plant a dirty appearance and clogs their breathing pores. Many aphids also produce various growths, called galls, on the tree parts they inhabit.

Control.—Notwithstanding their great numbers, aphids are usually incapable of doing permanent harm to an otherwise vigorous tree. They are never excessively abundant for long periods, being decimated by their numerous insect enemies, and a sharp change in the weather to hot and dry makes their disappearance as sudden as their appearance. Hence treatment, which involves labor and expense and requires an adequate spraying equipment, is in most cases safely dispensed with. When conditions warrant, however, it is possible and not difficult to check aphid injury artificially, as described under the several species. The strength of the solution used should be in proportion to the resistance of the plant to be sprayed; that is to say, the more delicate the plant the weaker the solution. Thoroughness and early application, before the leaves begin to curl, is indispensable to success. Often a forceful stream of water out of a hose directed against the aphids will dislodge and destroy them. Cooperation with neighbors in the purchase and operation of equipment, or in the employment of reliable and competent persons who make a specialty of the work, is desirable where feasible.

NORWAY MAPLE APHIS.[58]

How injurious.—This aphis frequently occurs in large colonies during much of the summer on the underside of Norway maple leaves, which are evidently its favored food. It is a copious producer of honeydew, which accumulates on the leaves and the pavement beneath them. Many of the leaves either develop brown blotches or fall off later, littering the ground and temporarily disfiguring the tree, besides seriously checking growth generally.

How recognized.—The leaves are off color, with honeydew, a sticky sweetish liquid, on them and on the ground below them, and many, mostly wingless, yellowish green, brown marked, licelike insects of various sizes with reddish eyes and long hairy antennæ are found on the underside of the leaves.

Habits.—Our knowledge of the habits of this insect, beyond what has been indicated above, is limited. Fortunately, what is known helps considerably in controlling the insect.

Remedy.—A spray of 40 per cent nicotine sulphate (p. 13) mixed with soap and diluted in the usual manner will prove quite effective,

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[58] *Periphyllus lyropictus* Kess.

and as little time as possible should be lost between the discovery of the insect and the application of the remedy. The spray solution should be directed especially at the underside of the leaves.

BOXELDER APHIS.[59]

How injurious.—This is an insect of the Middle West where the boxelder is its sole host. Its feeding stunts the young leaves, and its honeydew, together with dust and sooty fungus, soils the tree so that it looks most unattractive.

How recognized.—Numerous tiny, pale green, licelike insects are noted on the leaves and tender twigs, and there is a sootlike covering on the leaves and twigs or a sticky liquid on the leaves and on the ground beneath the tree. Drops of this liquid also hit persons beneath infested trees.

Habits.—The winter is passed in the form of eggs laid on boxelder bark. In the spring, as buds begin to push out, the eggs commence hatching and the emerging insects migrate to the new growth, where they forthwith insert their beaks and begin to feed. On reaching maturity they begin to produce living young, each " shelling out " as many as a hundred or more in the course of 20 days or so. Four or five generations thus follow one another in quick succession until about early June, when a generation of a quiescent, inactive form appears, gradually increasing in proportion to the others until August, when only occasional active individuals are to be found. The " dimorphs," as the resting insects are called, do not feed, but rest on the leaves throughout the summer, when the growth seems to take on a new lease on life. Early in September the dimorphs change to the normal, active form and produce another generation or two of living young. All of the individuals hitherto spoken of are females and most of them are wingless. The last generation of the season alone is composed of males and females, and the latter, after mating, deposit their eggs on the bark of twigs and branches, where they overwinter, thus completing the cycle.

Remedy.—A spray of 40 per cent nicotine sulphate (p. 13) applied at the time new growth starts is a pretty sure and safe remedy.

TULIP-TREE APHIS.[60]

Appearance and injury.—The sole injury of the tulip-tree aphis consists in the abnormally heavy dropping of the leaves, but in a yard or on a street the littering of the ground is a serious objection. The falling tulip-tree foliage, on the other hand, usually indicates the presence of this insect in great numbers on the leaves. The insects

[59] *Periphyllus negundinis* Thos. [60] *Macrosiphum liriodendri* Mon.

have the characteristic appearance of aphids, the winged ones being reddish brown with a pale green abdomen, and there are a few pale reddish individuals scattered among them.

Remedy.—Forty per cent nicotine sulphate (p. 13) applied as soon as the insects are observed will control them.

WOOLLY MAPLE AND ALDER APHIS.[61]

How injurious.—While this insect can not be considered a serious enemy of the maple, which is the more important of its two hosts, owners of infested trees are greatly distressed by the masses of white cottony fluff they find covering the leaves of their favorite shade tree in the spring, and are insistent on knowing the nature of it and the remedy.

FIG. 60.—Colony of woolly maple and alder aphis on underside of maple leaf. (Pergande.)

How recognized.—The abundant, bluish white, cottony fluff on the underside of folded-over maple leaves (fig. 60), in the midst of which, from spring to midsummer, winged or wingless (immature) insects are found, is an indication of the presence of this aphis.

Habits.—The aphids in the white woolly masses which appear on the young maple leaves early in the spring come from eggs that were laid the previous fall in cracks and under loose bark on the trunk of the tree. As they reach maturity and acquire wings they migrate to alder, which may be quite a distance away. This may last until midsummer, when all have abandoned the maple. On the alder the migrants settle on the underside of leaves and produce living young, which move over to the bark of twigs, branches, or stems, and settle, feed, and grow there, several generations succeeding one another. Some of the last generation here produced fly back to the maple in the fall, there producing a generation of males and females, the latter laying the eggs with which the cycle was started. Those on the alder that did not migrate in the fall crawl down to the ground, hiding for the winter on the roots and in the leaves and débris at the bottom of the plant, and not coming out until the sap rises the following spring, whereupon they resume the usual activities of feeding and reproduction.

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[61] *Prociphilus tessellatus* Fitch.

Remedies.—Since it is not a dangerous insect and treatment of large trees is usually costly, it is not imperative to do anything. Under certain conditions there might be justification for either destroying or treating alders in the neighborhood, and the maple trees, of course, may be treated direct. Both kerosene emulsion (p. 12–13) and 40 per cent nicotine sulphate (p. 13) are efficient agencies for killing this pest.

FIG. 61.—Woolly beech aphis on underside of leaves.

BEECH-TREE BLIGHT APHIS[62] AND WOOLLY BEECH APHIS.[63]

How injurious.—While not a menace to the life of trees, the beech-tree blight aphis and woolly beech aphis frequently occur in such abundance as not only to mar the appearance of the trees but also to kill twigs and young trees. The woolly beech aphis (fig. 61) is found to be specially abundant on copper beech leaves.

How recognized.—The masses of bluish-white woolly aphids on the underside of the limbs are the beech-tree blight aphis and those on the underside of the leaves are the woolly beech aphis.

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[62] *Prociphilus imbricator* Fitch. [63] *Phyllaphis fagi* L.

Habits.—Nothing unusual is known as regards the habits of these insects, so that a reference to any of the other aphids discussed in this bulletin will give an adequate idea on this subject.

Remedies.—Kerosene emulsion (p. 12–13) or 40 per cent nicotine sulphate (p. 13), applied when the aphids are observed, will give necessary relief.

WOOLLY ELM BARK APHIS.[64]

How injurious.—The vitality of trees is not seriously affected by the woolly elm bark aphis but the knotting and gnarling of twigs and trunks (fig. 62) of young elm trees disfigure them. The white elm appears to be its favorite host tree.

FIG. 62.—Work of woolly elm bark aphis on large elms at Albuquerque, N. Mex. (Photograph by Whitesides, Dec. 13, 1919.)

How recognized.—When this insect is present and at work the trunk and branches show roughened knots with clusters of a white, woolly substance and licelike insects during the spring and summer.

Habits and remedies.—This insect spends its entire life on the elm bark so that treatment on this tree will effectively check its injurious activity. There should be no difficulty in controlling it with 40 per cent nicotine sulphate (p. 13), kerosene emulsion (p. 12–13), or a 5 to 7 per cent solution of a standard miscible oil (p. 12) applied to the bark, the latter in winter.

GALL-MAKING INSECTS AND MITES.

GENERAL.

Leaves and branches of many kinds of trees, particularly oak, maple, hickory, and hackberry, are subject to a great variety of peculiar growths called galls, most of which are made by insects or mites and which may become so numerous at times as to appear alarming. They vary much in shape, size, color, and structure, each being so characteristic of the kind of insect that makes and inhabits it as to afford a reliable guide to the specific identity of the architect in very many cases.

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[64] *Eriosoma rileyi* Thos.

Rarely is a tree harmed by these galls sufficiently to menace its life or even good health. Likewise are they seldom numerous many years in succession, but while they last they do mar the appearance of otherwise healthy and beautiful trees, and their spectacular aspect tends to alarm the less informed tree owners and wardens.

Because of their evanescence and comparative harmlessness, treatment for gall insects is rarely imperative. Another deterrent factor in the undertaking of control measures against this sort of injury is the necessity of rather expensive spraying machinery for the work in many cases, and the cost of purchase or hire of this, as well as of its operation, added to the cost of the requisite insecticides, is apt to be rather excessive. It can only be justified where cost is no consideration, and even then, where the injury is not likely to receive general treatment in a neighborhood, the results of the operation are likely to be unsatisfactory on account of reinfestation from untreated near-by trees.

LEAF-STEM AND OTHER POPLAR GALL INSECTS.[65]

How injurious.—The vitality of trees infested with these aphids is never seriously affected. When the insects are abundant, the galls they make and their feeding frequently cause a heavy dropping of the foliage during the growing season, which, like the misshapen galls produced by some of them, is objectionable because it temporarily disfigures the tree and litters the ground.

How recognized.—The presence of these aphids is shown by heavy premature falling of the leaves, which bear rather prominent swellings on the midrib or leaf stem, the licelike insects lining the insides of them.

Habits.—Of the several species of these aphids known to make galls on poplar leaves, leaf stems, and twigs, the seasonal history of only the species here noted [65] has been worked out. This is somewhat complicated but rather interesting and is, briefly, as follows: By the time the galls are full grown in the fall, winged forms are developed in them and these migrate to the roots of cruciferous plants like cabbage, turnip, etc., where they breed until the following spring. At that time a generation of winged forms is again produced and these fly back to poplar where they give birth to wingless males and females on the bark. After mating the female lays one egg which hatches into the form known as stem mother. The young stem mother appears about the time the leaves begin to develop and migrates to and settles to feed on a stem of a leaf, which begins to swell and grow around her until she is completely enveloped by the

[65] *Pemphigus populi-transversus* Riley et spp.

gall. Within this gall she reaches maturity and gives birth to the numerous living lice that we find filling it in midsummer. The characteristic feature of the gall made by this species is that its mouth, which later serves as an outlet for its inhabitants, runs crosswise of the leaf stem. This seasonal history applies to the South where the study was made, and while in the main it doubtless applies also to the North there may be some seasonal differences.

FIG. 63.—The hickory phylloxera (*Phylloxera* sp.): Galls on pecan. (Gill.)

Remedies.—For reasons advanced in connection with other less injurious insects, circumstances are rarely such as to merit or justify control measures. In extreme cases, however, the application of remedial measures might be considered. Depending on conditions, control in such cases may be centered either on cruciferous plants or on poplar trees. In the latter, removing and burning of the infested leaves or dipping them in kerosene to kill the insects would greatly assist in reducing their numbers.

HICKORY GALL-INSECTS.[66]

Evidence of infestation.—In the spring, when the leaves and twigs are forming on the hickory, these are frequently more or less deformed by peculiar tumorlike growths of various shapes and sizes (fig. 63). These are caused either by gall-lice related to the grape phylloxera or by gall midges. When these galls occur in large numbers they disfigure the affected parts and attract attention, but this rarely affects the vitality of the tree materially. Their great variety—30 species of Phylloxeridae and 28 of Itonididae, beside 3 mites (Eriophyidae) are listed under hickory in the latest work on American gall insects—and their

[66] Families Phylloxeridae and Itonididae.

general distribution entail heavy infestation at some place in the country each season, with consequent frequent inquiry as to the cause and remedy, so that consideration of them here is made necessary, if for no other reason, to allay the prevailing fear of the consequence of their attack. The similarity of effect and economic relation invite joint consideration of all hickory gall insects.

Seasonal history and habits.

Phylloxeridae.—From early June of one year to early April of the next, or about 10 months of the year, is passed by these insects in the egg stage located in cracks and crevices, old galls, etc., on the hickory tree, particularly on the upper part of it. Coincident with the bursting of the buds in the spring these eggs begin to hatch, and the larvæ ultimately become the so-called stem mothers. These stem mothers settle on the young twigs, leaf stems, midribs, or forming nuts and each of them starts the formation of a gall with an inner cavity. In about 20 days from the time the gall is started the stem mothers deposit large numbers of eggs from which, in about 20 days, a generation of winged, migrating females develops. By this time the gall begins to open, thus allowing the insects to escape and fly. These migrants in turn lay eggs on the trees, and in about 10 days the young develop into wingless males and females and the mature females lay fertile eggs, which remain on the tree until the following spring, when the complicated life cycle is repeated. Most of the known species of this group infest hickory trees.

Itonididae.—Very little is known about the habits of the hickory gall midges except that, where an egg is laid and a larva hatches from it and develops, the plant tissue produces abnormal growth resulting in a larger or smaller gall, constant in shape and in other respects for each given species.

Artificial control.—Under wild or forest conditions artificial control is entirely impracticable and unnecessary, but in the case of valued shade or nut-producing trees that are regularly infested by the galls, it may be desirable to spray the trees with kerosene emulsion (p. 12–13) at the time the buds are opening in the spring, which should kill the stem-mothers or young maggots, as the case may be, and thus prevent the development of the galls.

HACKBERRY GALL-INSECTS.[67]

How injurious.—The galls made by this group of insects occur only on hackberry trees. In general outer appearance these galls do not differ from the almost equally numerous fly galls that occur on these trees, nor are they more injurious. They occur on the leaves, leaf stems, and twigs and, when very numerous, disfigure the appearance of the foliage, but that is about all the harm they do.

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[67] *Pachypsylla* spp.

How recognized.—Affected parts bear greater or smaller numbers of protuberances or deformities of various more or less uniform shapes and sizes. These are provided with openings and when fresh contain one or more pink tinged, bluish green, immature insects.

Habits.—The insects in the galls attain maturity in the fall, and in this state pass the winter in cracks of the bark on hackberry or among the débris on the ground. At the time buds on these trees begin to swell and open in the spring the insects begin feeding on the tender growth and laying eggs on the leaves. In about three weeks the eggs hatch and the feeding of the ensuing insects causes swelling of the tissue around them until they are almost completely inclosed. Thus one life round is completed in a year.

Remedies.—In the rare instances when remedial measures are warranted, application of a contact insecticide like kerosene emulsion (p. 12–13) or water-soluble oil (p. 13), at the time the young appear on the leaves in the spring and before the galls are entirely closed, should give considerable relief.

OAK GALL-INSECTS.[68]

How injurious.—Over 400 species of gall-making insects are known to affect oaks, and great is the variety of these galls in shape, size, and structure, all parts of the tree from the root up, including buds, flowers, and fruits, being subject to these deformities. A tree or part of it, particularly its foliage, may be literally covered with the galls of one or more species or may be completely changed by them, and, while the aspect is not always agreeable, the life or health of the tree is never menaced thereby.

How recognized.—Either the size, the shape, the color, or the number of these abnormal growths leads to their ready detection, especially on the foliage. The specific identity of the particular architect, however, can be determined only by the special student of this group of insects. To tree wardens this identity is of secondary consideration, since the injury is so rarely of more than secondary importance.

Habits.—No general outline of the habits applying to all these gall builders can be given. Not all of them are known, and there are too many even of those known for enumeration in this bulletin. Roughly, however, the habits are as follows:

The gall wasps.—In some of the gall wasps a life cycle has been found made up of several generations, only one of which consists of the two sexes. The females of the original generation usually lay their eggs between March and May, and frequently during the period from November to January, while those of the paired generation lay their eggs between June and August. The eggs are laid either on or in the particular portion of the plant they infest, and the developing

[68] Gall wasps (family Cynipidae); gall gnats (family Itonididae).

egg starts and stimulates the growth of the gall around it. The grub which hatches from the egg is footless, creamy or white in color, and feeds, grows, and transforms to the adult four-winged fly in a cell in the gall and then bores its way out into the open.

The gall gnats.—The adult insect is usually a rather small, two-winged gnat, seldom recognized by other than entomologists. In the course of flight the eggs are laid on the surface of the object of attack, which may be leaf, flower, fruit, bud, or stem. Wherever the egg is laid the tissue around it reacts by producing an unusual growth culminating in a closed gall wherein the creamy, greenish, yellowish, or pinkish maggot feeds and may be found while the gall is still green. The pupa is formed within the gall, or else the maggot, upon reaching full growth, drops to the ground and there transforms to the pupa and subsequently to adult fly. There is apparently only one generation a year in most of these flies.

Remedy.—Where some action is imperative—and this can only be true of very highly prized trees after several years of repeated infestation—cutting and burning of gall-laden wood or fallen leaves while the insects are still within the galls is bound to result in considerable benefit if the work is carried out on the infested oaks of a sufficiently extensive area.

RED SPIDERS.[60]

Character and extent of damage.—During a protracted drought the red spider is likely to become very injurious, attacking a great variety of plants. Whole trees, especially seedlings and nursery stock, are apt to have their foliage killed by it.

Evidence of infestation.—Pale brownish spots which may later cover the foliage of the entire plant and a web sometimes so dense as to be plainly visible at a considerable distance appear on the leaves. On examination with a magnifying lens the affected leaves are found to bear numerous, tiny, pearl-like eggs, brownish or reddish little creatures running about, or the glistening empty eggshells and cast skins of the mites.

Seasonal history and habits.—"Red spider" is the name most often applied to two species of web-spinning mites. Mites differ from true insects in having four pairs of legs in the adult stage (fig. 64). They pass the winter as adult females on various wild plants. In the spring they ascend plants and start egg laying at the rate of 5 to 10 eggs a day for a period of 8 to 12 days. During hot, dry weather the eggs hatch, in about 4 days after having been laid, into young mites which commence feeding almost immediately. They reach maturity in 10 to 14 days after hatching, depending on the season and locality. Many generations follow one another in the course of one

[60] *Tetranychus telarius* L. and spp.

summer. Usually by the time their presence is discovered they are already very numerous. They live and feed in colonies and their feeding consists in sucking the juices from leaves.

Remedies.—A stiff stream of water, frequently applied, will rid plants of the red spider in many cases. Individual trees may be sprayed with lime-sulphur (p. 11–12) mixed with soapy water or kerosene emulsion (p. 12, 13). Kerosene emulsion or miscible oil mixed with nicotine sulphate in the usual proportions should also give satisfactory results. Make at least two applications with a 10-day interval between them, the first as soon as the mites appear.

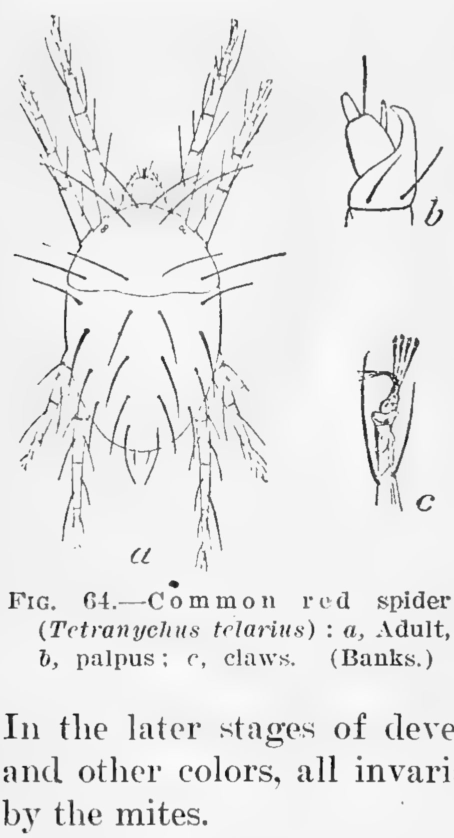

FIG. 64.—Common red spider (*Tetranychus telarius*) : *a*, Adult, *b*, palpus ; *c*, claws. (Banks.)

GALL-MAKING MITES.[70]

How injurious.—The galls made on shade trees by these microscopic animals are most often located on the leaves or other tender part of the growing plant and, while the affected parts may be badly misshapen or discolored, serious harm to the vitality of vigorous trees is rare.

How recognized.—The mite-made gall is always open and the opening is fringed with hairy growth, or, in fact, the very gall may consist of but a larger or smaller clump of such hairs. In the later stages of development some of these galls assume red and other colors, all invariably turning brown after being deserted by the mites.

Habits.—The mites overwinter hidden under bud scales and probably also bark scales, and start feeding and reproduction early in the spring, in known cases before the buds open. The number of generations produced during the growing season by any given species is not definitely known, but evidently there are several of them. When the food supply on a given spot gives out the mites migrate to another, often covering whole leaves or deforming the buds of entire trees in the course of a season. Their eggs are laid on the surface of the affected area and the feeding is supposed to cause the irritation which produces the abnormal growth. No explanation is yet available for the characteristic gall made by each species of mite, even though produced on the same plant.

Remedies.—Thorough spraying of infested trees during the dormant season with a contact insecticide, like kerosene emulsion (p. 12–13) or miscible-oil solution, should well-nigh exterminate a bad colony.

[70] Family Eriophyidae.

DECIDUOUS SHADE-TREE INSECTS ARRANGED ACCORDING TO THE MANNER OF ATTACK AND KIND AND PART OF TREE SUBJECT TO IT.

ALDER.

See Maple, p. 98.

ASH.

Mite.

Deformed buds---------------------------------*Ash-bud gall-mite,* p. 94.

Borer.

Wood of trunk especially near base, honeycombed, burrows packed with granular frass--------------------------------*Parandra borer,*[71] p. 61.

BOXELDER.

Sap suckers.

(1) Masses of a reddish bug on tree trunk and branches and a nuisance about dwellings in fall---------------------*Boxelder plant-bug,* p. 75.

(2) Leaf sap-sucking, licelike insects------------*Boxelder aphis,* p. 85.

BEECH.

Sap suckers.

(1) Masses of bluish-white, woolly aphids on underside of limbs--------- *Beech-tree blight aphis,* p. 87.

(2) Masses of bluish-white, woolly aphids on underside of leaves---- - *Woolly beech aphis,* p. 87.

BIRCH.

Borer.

Reddish or rusty brown spots on white bark of trunk and larger branches, which, on being cut through, usually disclose peculiar winding burrows in bark and wood; ridges in the bark on the branches which often develop over the burrows; dying tops of the trees------------------- *Bronze birch borer,* p. 59.

BUTTERNUT.

See Walnut, p. 100.

CATALPA.

Leaf chewer.

Leaves eaten by yellow and black striped caterpillars having a short horn near hind end of body; caterpillar droppings beneath trees----------- *Catalpa sphinx,* p. 33.

CHESTNUT.

See Oak, p. 98–99.

COTTONWOOD.

See poplar, p. 99.

ELM

Leaf chewers.

(1) Leaves show holes in early spring; later, abrasions on underside and holes------------------------------------*Elm leaf-beetle,* p. 38.

(2) Holes in leaves with spindle-shaped bags near by----*Bagworm,* p. 31.

(3) Leaves partly or entirely eaten by spiny, black, red-marked caterpillars up to 2 inches long--------------*Spiny elm caterpillar,* p. 48.

(4) Twigs or branches covered with web containing hairy caterpillars. *Fall webworm,* p. 40.

(5) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back----*Forest tent caterpillar,* p. 35.

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[71] This borer is to be found in a great variety of species of both deciduous and coniferous trees.

(6) Leaves eaten by green looping caterpillars or measuring worms----
Spring cankerworm, p. 36.

(7) White, frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back--------
White-marked tussock moth, p. 41.

(8) Leaves blistered or eaten by coiled, yellowish-white worms with black line along back------------------------*Large elm sawfly*, p. 51.

Borers.

(1) End leaves turning brown and falling in summer; tops and branches fail to leaf in spring; trunk and branches show patches of dead, easily peeling bark with burrowing, roundheaded grubs beneath it---------
Elm borer, p. 55.

(2) Twigs wilt and break off, bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk------
Leopard moth, p. 68.

(3) Girdled twigs hanging on trees or lying on ground below trees------
Twig girdler, p. 71.

Sap suckers.

(1) Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail--------------------------------*Oyster-shell scale*, p. 77.

(2) Bark on trunk or branches bearing larger or smaller rough, white, meal-covered knots--------------------*Woolly elm bark aphis*, p. 88.

(3) Branches and trunk, especially at crotches, more or less crowded with stationary brownish insects bordered by cottony white----------
European elm scale, p. 82.

(4) Cockscomblike growth on leaves-----------------*Gall aphids*, p. 88.

GUM, SOUR.

Borer.

Girdled twigs hanging on trees or lying on ground below them-----------
Twig girdler, p. 71.

GUM, SWEET.

Leaf chewer.

Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back--------------*Forest tent caterpillar*, p. 35.

HACKBERRY.

Leaf chewers.

(1) Leaves partly or entirely eaten by spiny, black, red-marked, caterpillars up to 2 inches long----------------*Spiny elm caterpillar*, p. 48.

(2) Leaves being eaten by green caterpillars with pale spots and lines along back and projections on head and rear------------------------
Caterpillars of hackberry butterflies, p. 49.

Galls.

On leaves and twigs growths (galls) of various shapes and sizes----------
Hackberry gall insects, p. 91.

HICKORY.

Leaf chewer.

Leaves being eaten by gregariously feeding caterpillars which, when full grown, are black, covered with dirty gray hairs, and nearly 2 inches long--------------------------------------*Walnut caterpillar*, p. 46.

Borer.

(1) Leaves eaten at base of stem; tree sickly, bark inside and surface of outer wood with centipede-like engravings--*Hickory barkbeetle*, p. 72.

(2) Girdled twigs hanging on trees or lying on ground below trees------
Twig girdler, p. 71.

Galls.

Abnormal growth on leaves and leaf stems----------*Gall aphids*, p. 90.

HONEY LOCUST.

Leaf chewer.

White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back---------- *White-marked tussock moth*, p. 41.

Borer.

Girdled twigs hanging on trees or lying on ground below trees---------- *Twig girdler*, p. 71.

HORSE CHESTNUT.

Leaf chewer.

White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back------------ *White-marked tussock moth*, p. 41.

Borer.

Twigs wilt and break off; bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk------------ *Leopard moth*, p. 68.

Sap sucker.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail---------------------------------------*Oyster-shell scale*, p. 77.

LINDEN.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back--------*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back--------- *White-marked tussock moth*, p. 41.

(4) Leaves blistered or eaten by coiled, yellowish-white worms with black line along back-----------------------------*Large elm sawfly*, p. 51.

Borer.

(1) Toward end of summer tips dead and green bark eaten; large irregular burrows made by slender white grub under the bark and deep in the wood near ground--------------------------------*Linden borer*, p. 57.

(2) Girdled twigs hanging on trees or lying on ground below them------ *Twig girdler*, p. 71.

Sap sucker.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail----------------------------------*Oyster-shell scale*, p. 77.

LOCUST.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back------*Forest tent caterpillar*, p. 35.

(3) Foliage on tree as if fire scorched; leaves blistered and hollowed out--*Locust leaf-miner*, p. 43.

Borers.

(1) Trunk and branches gnarled, breaking, and showing wet spots and boring dust------------------------------------*Locust borer*, p. 63.

(2) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath-------------- *Carpenter worm*, p. 69.

MAGNOLIA.

Sap suckers, scale insect.

Wood of branches sickly, blackened, and underside beset with vivid gray or brown, raised, rather large scales---------*Magnolia soft scale*, p. 81

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MAPLE.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31

(2) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back--------*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back---------- *White-marked tussock moth*, p. 41.

(4) Leaves eaten by smooth, pale yellowish-green caterpillar, lengthwise striped with dark green and with a pair of black "horns" and black pegs along sides and rear end--*Green-striped maple worm*, p. 44.

Borers.

(1) Foliage on limb wilting and dying and sap with some frass oozing from some point on tree; limbs dead, ridges and dead spots on bark; naked scars on trunk near base of limbs; three-eighths to five-eighths inch oval holes at base of tree--------------*Sugar-maple borer*, p. 53.

(2) Twigs wilt and break off; bark split open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk--------- *Leopard moth*, p. 68.

(3) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath--------------- *Carpenter worm*, p. 69.

(4) Ground beneath tree strewn with hollowed-out, cut-off twigs; white grub with brown jaws in hollow when fresh--------------------------- *Maple and oak twig-pruner*, p. 70.

Sap suckers, scale insects.

(1) Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail---*Oyster-shell scale*, p. 77.

(2) On twigs and leaves in summer, white, fluffy cottonlike masses with darker blotch toward one end------------*Cottony maple scale*, p. 82.

(3) Tree ailing, bark of trunk and branches more or less incrusted and roughened by stationary, black, circular scales; also white circles---- *Gloomy scale*, p. 78.

(4) Tree ailing, twigs blackened and more or less thickly incrusted with raised, reddish scales, ridged along edges-------*Terrapin scale*, p. 81.

Sap suckers, aphids.

(1) Abundance of bluish-white wriggling cottony fluff on underside of maple leaves in spring and summer------------------------------------ *Woolly maple and alder aphis*, p. 86.

(2) Leaves discolored and sticky with honeydew and ground beneath trees covered with the same; yellowish green, brown marked, mostly wingless aphids of various sizes with reddish eyes and long hairy antennæ on underside of leaves-----------*Norway maple aphis*, p. 84.

(3) Leaves more or less densely covered with one or more of the following growths: "Pouch" or "nail" galls (mite made); "eye" spots (fly made)-----------------------*Gall insects and mites*, p. 88.

OAK.

Leaf chewers.

(1) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(2) Leaves being eaten by caterpillars with blue head and silvery diamond-shaped spots along the back---*Forest tent caterpillar*, p. 35.

(3) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back-------- *White-marked tussock moth*, p. 41.

(4) Leaves eaten by looping caterpillars or measuring worms------------ *Fall cankerworm*, p. 36.

Borers.

(1) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish-white, greenish beneath---------------- *Carpenter worm*, p. 69.

(2) Twigs wilt and break off; bark splits open, showing ugly scars; chips and matted excrement at entrance to burrow on twig or trunk-- *Leopard moth*, p. 68.

(3) Trees sickly, inside of bark densely scored by frass-filled mines running in al directions-------*Two-lined oak and chestnut borer*, p. 61.

(4) Ground beneath tree strewn with hollowed-out, cut-off twigs; white grub with brown jaws in hollow when fresh-------------------------- *Maple and oak twig-pruner*, p. 70.

Sap suckers, scale insects.

(1) Leaves and tender shoots crumpled up, older leaves and twigs studded with stationary brown, pea-shaped scale insects--------------- *Pubescent oak Kermes*, p. 79.

(2) Tree ailing, smooth bark of trunk and branches more or less incrusted and roughened by stationary black, circular scales; also white circles------------------------------------*Obscure scale*, p. 79.

Galls.

Swellings of various shapes and dimensions on upper and under side of leaves or on twigs----------------------------------*Oak galls*, p. 92.

PERSIMMON.

Borer.

Girdled twigs hanging on trees, or lying on ground below trees---------- *Twig girdler*, p. 71.

POPLAR.

Leaf chewers.

(1) Leaves with holes bitten part way or entirely through, later entirely consumed by spotted, soft-bodied, short, stoutish grubs and spotted or striped beetles one-half inch long------------------------------------ *Cottonwood, poplar, and willow-leaf-beetles*, p. 50.

(2) Holes in leaves with spindle-shaped bags near by---*Bagworm*, p. 31.

(3) Leaves partly or entirely eaten by spiny, black, red-marked caterpillars, up to 2 inches long---------------*Spiny elm caterpillar*, p. 48.

(4) Leaves blistered or eaten by coiled yellowish-white worms with black line along back------------------------*Large elm sawfly*, p. 51.

(5) Leaves being eaten by caterpillars with blue head and silvery, diamond-shaped spots along the back----*Forest tent caterpillar*, p. 35.

(6) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair pencils on back---------- *White-marked tussock moth*, p. 41.

(7) Twigs or branches covered with web containing hairy caterpillars--- *Fall webworm*, p. 40.

(8) Leaves being eaten by caterpillars with long, soft, drooping, yellow hairs and with five rather long, stiff tufts of black hairs along the back; when at rest, curled up on underside of leaf-------------------------- *Cottonwood dagger moth*, p. 47.

Borers.

(1) On trunk at crotches irregular scars from which sap oozes and fibrous borings protrude----------------------------*Aspen borer*, p. 58.

(2) Dead or dying limbs, swellings and dead patches of bark often cracked open on limbs and trunk; fading foliage; sawdust and oozing sap at points of attack; injured twigs with burrow along middle with white, fleshy, footless grub at some point------------------------- *Mottled willow and popular borer*, p. 65.

(3) Trees breaking, tops sickly, shredded boring dust in piles on ground beneath trees; borer work under bark close to ground________________ *Cottonwood borer*, p. 66.

(4) Smaller twigs wilting, strings of frass dangling from holes in bark, worm in burrows vivid reddish white, greenish beneath_______________ *Carpenter worm*, p. 69.

(5) Girdled twigs hanging on trees, or lying on ground below trees______ *Twig girdler*, p. 71.

Sap suckers, scale insects.

Young bark more or less covered with brown or gray, elongate, more or less curved, shell-like bodies, readily raised with knife point or finger nail____*Oyster-shell scale*, p. 77.

Sap sucker, gall-maker.

Leaves bearing prominent swelling on stem and dropping prematurely___ *Poplar leaf-stem gall-aphis*, p. 89.

SYCAMORE.

Leaf chewer.

(1) Holes in leaves with spindle-shaped bags near by___*Bagworm*, p. 31.

(2) White frothlike egg masses on tree trunk; leaves more or less eaten by yellow caterpillars with black and red hair-pencils on back________ *White-marked tussock moth*, p. 41.

Sap sucker, bug.

Leaves off color in spots or entirely; underside shelters colonies of slow-moving, lacelike bugs and their young________*Sycamore lace bug*, p. 74.

TULIP TREE.

Sap sucker, aphid.

Leaves discolored, dropping, with numerous aphids on underside, sticky with honeydew____________________________________*Tulip-tree aphis*, p. 85.

Sap sucker, scale insect.

Sickly, blackened branches beset with vivid gray or brown, rather large, high scales__________________________________*Tulip-tree soft scale*, p. 80.

WALNUT.

Leaf chewer.

Leaves being eaten by gregariously feeding caterpillars which, when full grown, are black, covered with dirty gray hairs, and nearly 2 inches long____*Walnut caterpillar*, p. 46.

WILLOW.

See Poplar, p. 99.

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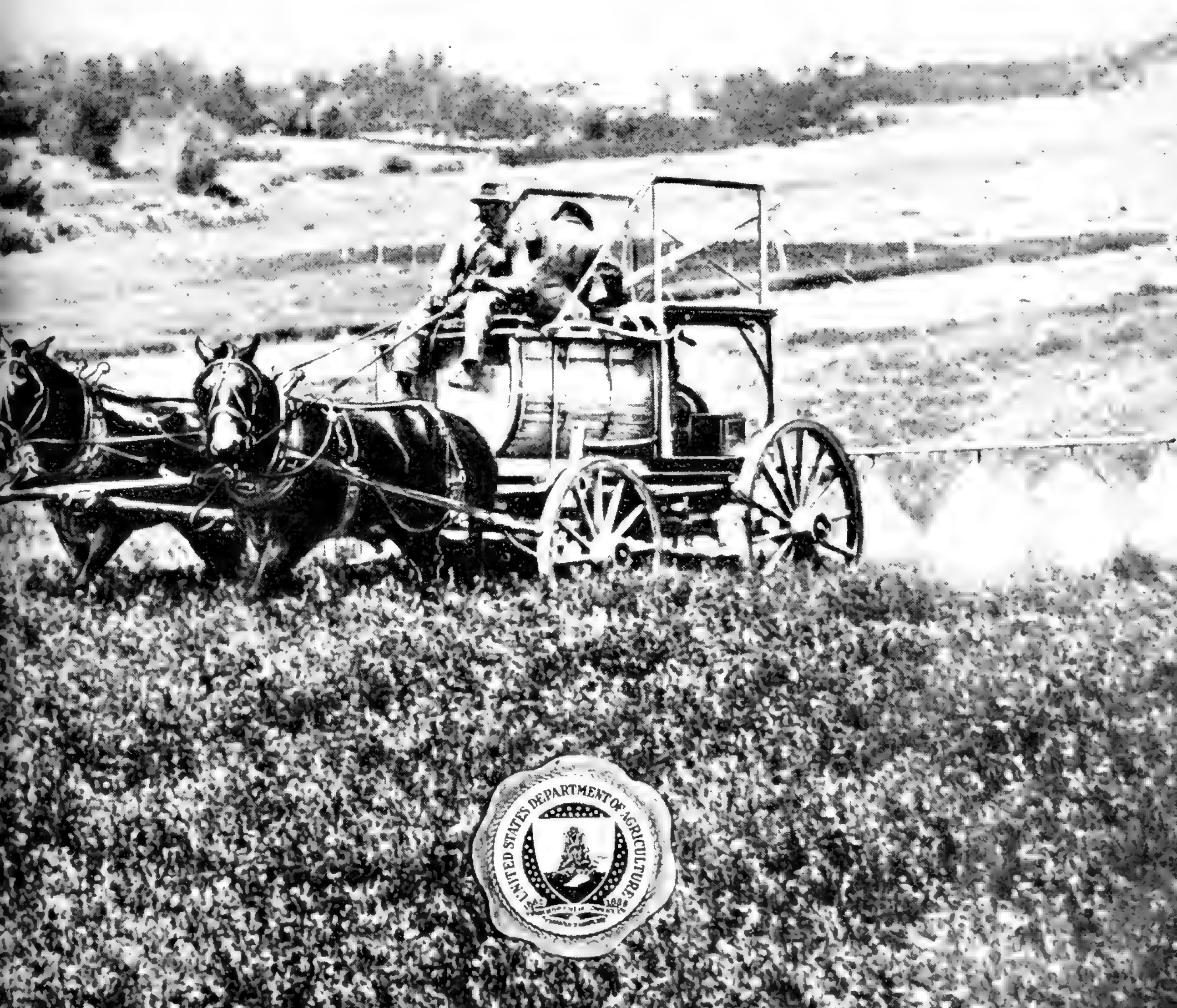
FARMERS' BULLETIN 1185
UNITED STATES DEPARTMENT OF AGRICULTURE

SPRAYING FOR THE ALFALFA WEEVIL



THIS BULLETIN, devoted chiefly to a description and illustration of the control of the alfalfa weevil by means of arsenical sprays, is intended for the man who is already well acquainted with the appearance of the pest and its effect upon his crop.

There are thousands of such farmers in Utah, Idaho, Colorado, and Wyoming, and their aggregate losses from this cause reach hundreds of thousands of dollars each year. The treatment described in these pages can be used throughout most of this territory and is suitable for both large and small acreages. It has been prepared during seven years of study and experiment and one season of thorough field trial in cooperation with farm bureaus, in the course of which over 4,000 acres were successfully sprayed by practical farmers, many of whom were without experience in any kind of spraying. The Farm Bureau News, of Sevier County, Utah, reports a saving of $15,000 by this means and estimates from other sources raise the total to $40,000.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. December, 1920

SPRAYING FOR THE ALFALFA WEEVIL.

GEO. I. REEVES, *Entomological Assistant*, T. R. CHAMBERLIN, *Scientific Assistant*, and K. M. PACK *Field Assistant, Cereal and Forage Insect Investigations.*

CONTENTS.

THE TURNING POINT IN WEEVIL INJURY DETERMINES THE TIME TO SPRAY.

THE BEST TIME TO SPRAY for the alfalfa weevil is determined by the progress of weevil injury in the alfalfa field. The seasonal activity of the weevil is as follows: The adult beetles or weevils, after hibernating in the fields, come out in early spring, feed sparingly upon the leaves and stems, and deposit eggs, at first in the softer dead stems on the ground and later in the green stems. The eggs develop slowly at first and faster as the temperature rises, until in May and June they hatch within two weeks after they are laid.

The feeding of the larvæ begins early in the spring and increases steadily until after the height of the hatching season in May, but the plants outgrow the injury until shortly before cutting time, when the young larvæ become so numerous that they completely destroy the growing tips and thus stop the growth of the plants (fig. 1). This is the *turning point in injury*, and after it is passed the appearance of the field changes rapidly; the leaves are consumed until nothing is left but woody fibers, and the tops of the plants are as white as if they had been frostbitten. This condition is shown in figure 2. The injury spreads downward, and before the normal cutting time, if the field is allowed to stand, the whole plant is bare

FIG. 1.—The "turning-point" in alfalfa-weevil injury. The plant on the right is almost uninjured, that in the middle has reached the turning point, and that on the left is nearly destroyed.

of leaves and the green covering has been stripped from the stems. The feeding continues for two or three weeks longer and delays the growth of the second crop unless the larvæ are killed.

The *turning point*, then, coming from one to two weeks before the first crop is ready for cutting, is the best time to spray the field. The feeding larvæ are now most numerous and the conditions for poisoning them accordingly most favorable. On the other hand, the crop is not yet too badly damaged to recover quickly after the killing of the larvæ. Figure 3 shows the result of treatment at the proper time. The work may be done a week earlier or several days later, as the owner's experience and the character of the season may dictate. It has been done as early as April 20, entirely preventing damage to the crop, and in other cases it has been delayed until the plants had been stripped of their foliage, in spite of which they

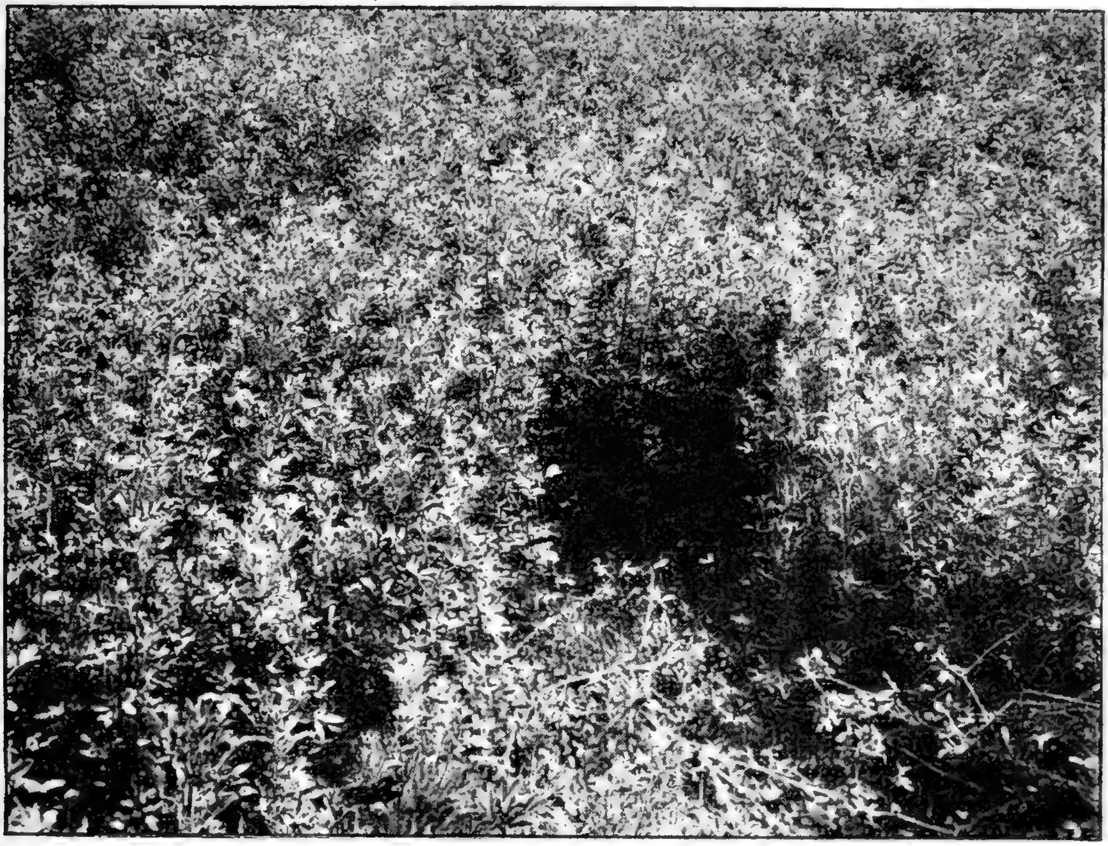


Fig. 2.—A field of alfalfa which has passed the turning-point. The lower foliage is still sound, but the tops are white and the buds have been killed.

were able to recover and bloom. The early spraying, however, is uncertain, as its success depends partially upon poisoning the adult beetles, which feed but little, while late spraying allows the destruction to go too far and makes recovery too slow.

THE TIME OF THE TURNING POINT IS GOVERNED BY WEATHER CONDITIONS.

The time of the turning point varies from year to year with weather conditions. If the weevils were affected by these conditions in the same way as the alfalfa it might be possible to name a definite stage in growth of the plant at which spraying should be done, but this is not always true.

In warm seasons the plants get an early start, which tends to postpone the turning point, but since this is more than offset by the rapid development of the weevils the damage is likely to come early. An extreme case of this occurs when the season is dry as well as warm: then the drought retards only the alfalfa, while the weevils develop without hindrance, and check the growth while it is still too small for profitable handling. It is in such circumstances that spraying yields its greatest returns.

In cold, backward seasons the situation is the opposite of that just described. The growth of the plants is hindered by the weather, but not so much as the weevil's egg laying, hatching, and feeding, and

Fig. 3.—First crop ready to cut, ten days after spraying. The white area is an unsprayed strip.

the crop becomes nearly mature before its growth is halted. In the abnormally late season of 1917, when in Utah March temperatures were delayed 30 days, and April and May temperatures 15 days behind the normal schedule, the first crop was fully mature before any injury had taken place, and the result was the only good first crop since the introduction of the alfalfa weevil. At such times the effect of spraying upon the first crop is least pronounced, and its effect upon the second crop becomes the principal consideration.

A heavy frost during the growing season has but little effect upon the insect, merely delaying the egg laying, hatching, and feeding for a few hours, but it may seriously stunt the alfalfa plants and thus put them at the mercy of the weevil larvæ, somewhat as does the cutting of the first crop. Spraying has been done in such cases, apparently with good results, but this is still a matter for experiment.

In the average season the conditions lie between those of the two extremes just described. The checking of growth occurs about 10 days before the first crop is ready to cut, and spraying at that time enables the crop to finish its growth. This fully repays the cost of the treatment and is one of the principal arguments for it, especially in districts where the scarcity of late water makes the first crop the important one.

Fig. 4.—Second crop saved by spraying. The strip of bare stubble near the fence was left untreated at the spraying of the first crop.

SECOND-CROP PROTECTION.

In well-watered sections of the country, where a second crop can be grown, the profit realized by the first crop is only part of the results of spraying. The greater gain is in protection of the second crop, as shown in figure 4, from the larvæ which gather upon the small buds and prevent all growth during the three weeks or more that their feeding continues. Spraying produces a more uniform second crop than does brush dragging, as shown in figure 5. If the larvæ have been poisoned through spraying of the first crop, the second crop sprouts and grows without delay, and no treatment of the stubble is necessary.

STUBBLE SPRAYING NOT RECOMMENDED.

Stubble spraying has been successfully done by a number of farmers, but it requires getting upon the field immediately after cutting, which is not always possible, and further, a much larger quantity of liquid per acre is needed than if it were applied to the first crop. In years when the damage to the first crop is slight it might seem more convenient to cut it first and then spray the stubble, but the results of many trials show that this is not usually true. The time to poison the larvæ most easily is when they are feeding upon the tips of the first crop, and not when they are clustered below the surface of the

FIG. 5.—Brush-dragged portion of field shown in figure 4. The uneven growth is a characteristic result of this treatment.

ground upon the buds of the stubble. Stubble spraying can only be advised when earlier spraying has been impossible.

PREPARATION OF MACHINERY.

Before using spraying machinery it is necessary to overhaul and repair it. To make sure that the nozzles, hose, and connections, and the packing of valves, pistons, and cylinders are in good condition, the engine in working order, and the pump and pipes free from rust and scale, takes about three days, and should be done long enough in advance so that the necessary repairs will be finished in time. Spraying is less profitable if too much cleaning and repairing are left to be done after spraying begins, while the crew waits and the weevils destroy the hay crop.

If machinery must be purchased or hired and fitted for alfalfa spraying, it should be ordered months in advance. Local dealers in any community where people are beginning to spray for the alfalfa weevil are likely to have sold out their stock long before the season has begun.

NECESSARY EQUIPMENT.

The necessary equipment for spraying alfalfa consists of (1) a truck or vehicle; (2) a tank with an agitator; (3) a pump; (4) a pressure gauge; (5) an engine and pumping jack, unless the pump is to be driven by hand; (6) a strainer; (7) a boom or pipe, for distributing the liquid from the pump; and (8) spray nozzles.

FIG. 6.—A homemade spray outfit. No part of this equipment was originally designed for spraying. Even the nozzles were homemade. In convenience and utility it is equal to any spray machinery manufactured.

These essentials may all be contained in a barrel-pump outfit carried in a wagon, or they may be in the form of a 200-gallon tank mounted with a gasoline engine and pump on a special frame and truck. Any pump, with brass lining, valves, and pistons, capable of delivering four-fifths of a gallon or more per minute and maintaining a pressure of 75 pounds, can be used for this purpose on a scale suited to its size. Figure 6 shows a spray outfit which was assembled under difficulties from materials already on hand.

CAPACITY OF THE OUTFIT.

The size of the outfit should be adapted to the work it is to perform and can best be calculated by beginning at the nozzle and taking up the various items in an order nearly the reverse of that in which they have just been mentioned. The best results have been obtained with nozzles working 2 feet above the alfalfa, each nozzle as it moves across the field spraying a strip 2 feet wide. A single nozzle in spraying an acre, which is 43,560 square feet, therefore covers a strip 2 feet wide and 21,780 feet long, or, in other words, travels 21,780 feet. It is now considered desirable to apply 100 gallons per acre, and in order to do so the nozzle must deliver 1/21,780 of that quantity to each linear foot of the strip; and as 200 feet per minute is an average walking gait for a team hauling the outfit, the nozzle must deliver 200/21,780 of 100 gallons, or 0.9 of a gallon per minute.

The same figures show that the time required to spray an acre with one nozzle is 21,780÷200, or 109 minutes. If twice as many nozzles are used the strip sprayed will be twice as wide and one-half as long, and the time required will be one-half as great; and so the time and the amount of driving required will vary as the number of nozzles is increased, but the rate of flow of each nozzle must be kept the same so long as the driving gait and the quantity per acre are unchanged.

Knowing the number of gallons with which each nozzle must be supplied per minute it is easy to compute the capacity required of the pump for a given number of nozzles, or the number of nozzles which a given pump will support. It is also possible to calculate how large an outfit will be needed to spray a given area in a given time, or how large an area a pump already on hand can spray in a given time, according as the controlling factor is the kind of pump which is available, the number of acres which must be sprayed, or the time which can be devoted to it. Thus 10 nozzles, each discharging 0.9 of a gallon per minute, will require a pump which can deliver 9 gallons in that time, and such an outfit will spray an acre in about 11 minutes of actual work. Such a machine is shown in figure 7.

The capacity of a pump depends upon the size of the plunger, the length of its stroke, and the number of strokes per minute, and can therefore be ascertained by a simple calculation. The area of the plunger is found by dividing its diameter, in inches, by 2, multiplying the result by itself, and that result again by 3.1416. This result, multiplied by the length of the stroke in inches, gives the contents of the cylinder in cubic inches, which is reduced to gallons by dividing by 231, and gives the quantity delivered by a stroke of the pump. If the latter is double-acting, as most of the better spray pumps are, this must be multiplied by 2. The delivery per minute is then obtained by multiplying the number of gallons per stroke by the number of strokes per minute.

One-cylinder pumps operated by hand are usually rated on the basis of 30 strokes per minute, and those driven by power at 50 strokes per minute. Duplex and triplex pumps are driven at a speed of 40 to 50 revolutions per minute, giving, respectively, 80 to 100 strokes per minute for the former and 120 to 150 for the latter.

If it is necessary to estimate the size of pump needed for a given kind of work the process is reversed; for example, it has just been shown that a 10-nozzle outfit applying 100 gallons per acre and traveling 200 feet per minute uses about 9 gallons per minute. To maintain this flow a power pump at 50 strokes per minute must deliver 9÷50, or 0.18 gallon per stroke. If it is a double-acting pump,

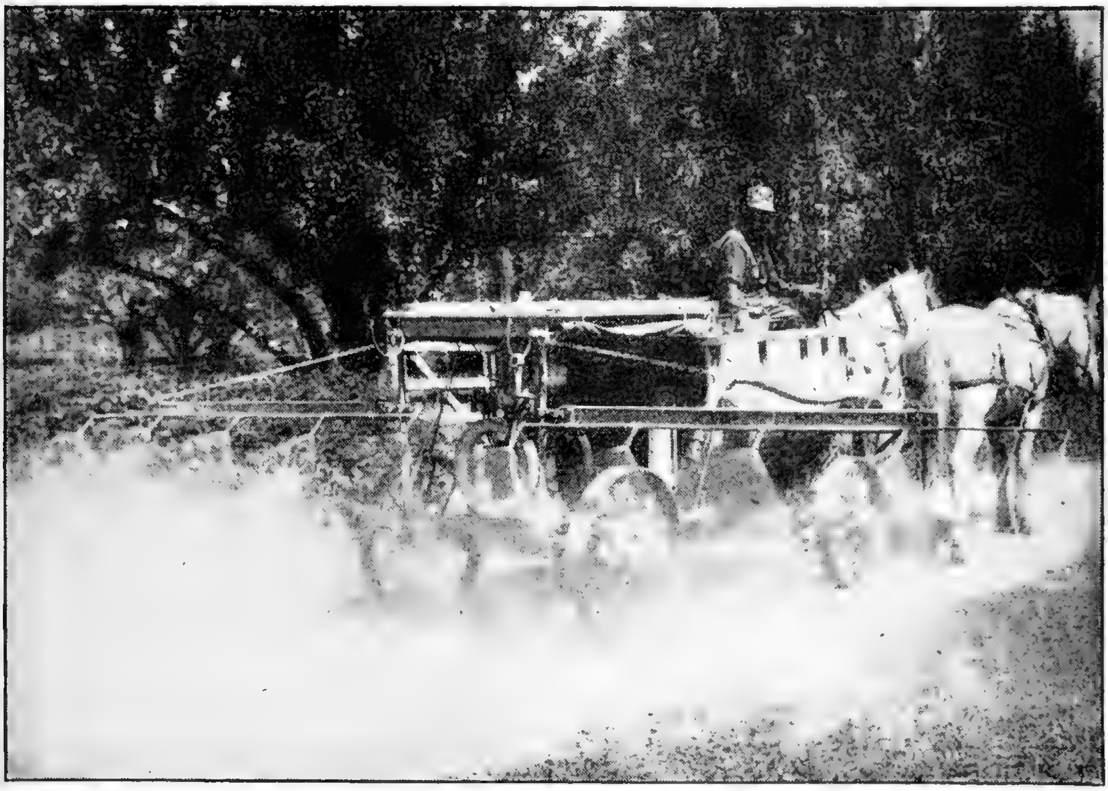


FIG. 7.—An excellent outfit adapted for alfalfa-weevil spraying by the Colorado Experiment Station in cooperation with the authors.

each stroke fills and empties the cylinder twice, and the contents of the cylinder must be 0.09 of a gallon or 20.79 cubic inches. The area of a 3-inch plunger is 1.5 by 1.5 by 3.1416, or 7.0686 square inches, and the length of stroke required to give a capacity of 20.79 cubic inches is therefore 20.79÷7.0686, or 2.9 inches. A $2\frac{1}{2}$-inch cylinder would need to have a stroke of about $4\frac{1}{4}$ inches.

A triplex pump operated at 50 revolutions (150 strokes) per minute would need only one-third the capacity of a single-cylinder pump, 0.06 gallon. Calculation shows that this can be obtained with a $2\frac{3}{4}$-inch cylinder and $2\frac{1}{3}$-inch stroke.

Table I gives the flow per stroke, in fractions of a gallon, of the common sizes of double-acting pumps.

TABLE 1.—*Capacity of cylinders of double-acting spray pumps, in fractions of a gallon.*

Diameter of cylinder, in inches.	Length of stroke, in inches.			
	$2\frac{1}{2}$	3	4	5
2	0.068	0.082	0.109	0.136
$2\frac{1}{4}$	.086	.103	.139	.172
$2\frac{1}{2}$	.106	.127	.170	.212
$2\frac{3}{4}$	.129	.154	.206	.257
3	.153	.184	.245	.306

The smallest barrel pumps will hardly supply a single nozzle, and can only be used for small patches of alfalfa, while some double-acting hand pumps with 3 by 5 inch cylinders deliver as high as 9 gallons per minute, and therefore are capable of supporting 10 nozzles. Such a pump will spray an acre in about 11 minutes, if labor is available to keep it going at 30 strokes per minute. The same pump driven by a 2-horsepower gasoline engine at 50 strokes per minute will deliver 15 gallons per minute and easily supply 10 nozzles, each delivering $1\frac{1}{8}$ gallons. This is 25 per cent above the requirements of an outfit moving 200 feet per minute and makes it possible to drive 250 feet per minute and spray an acre in nine minutes.

Modern orchard spray outfits are usually of the duplex or triplex type with small cylinders and short stroke, and are designed to give a comparatively small flow and high pressure. They are less suitable for alfalfa spraying than the older pumps with larger cylinders and longer stroke, designed for larger flow and lower pressure. Seventy-five pounds pressure is enough for successful spraying for the alfalfa weevil, although it is possible that a better distribution of the poison is obtained at a pressure of 100 to 125 pounds. Higher pressures cause needless wear and strain upon the machinery.

The necessary capacity of an outfit having been decided upon, it remains to select the parts to conform to it and to the conditions under which the work must be done. Capacity is not the only thing to be considered in selecting or assembling an outfit. The truck, tank, pump, engine, boom, and nozzles can be chosen in such a way as to avoid later trouble and expense.

THE VEHICLE.

Almost any kind of wagon or truck can be used to haul the equipment. For a light outfit an express wagon or an ordinary farm wagon, preferably with no sides, is satisfactory. If planks are used for the bed, the engine, pump, and jack can be bolted to one of them. If an ordinary wagon box is used, a plank to which the machinery is bolted can be slid into it lengthwise and nailed or bolted down.

For a permanent structure a frame of 4 by 6 inch timber may be fitted to the wagon and a 200-gallon tank mounted with the other machinery upon it. The most convenient homemade truck is a flat rack. Commercial orchard spray trucks, usually furnished with low wheels and broad tires, may be used, but high wheels are better for spraying tall alfalfa, not because they break down less alfalfa, since this is only temporary, but because they make it easier to attach the spray boom at the proper height, and cause less jolting of the machinery in driving over rough ground.

THE TANK.

Commercial spray tanks are usually in the form of a half cylinder, made of redwood, cypress, or steel, with a capacity of 200 gallons. Homemade tanks are usually 50-gallon barrels, four of which, with an engine and pump, can be carried on an ordinary wagon or a flat rack. Two hundred gallons of water is load enough for a team in most fields. If the water has to be hauled a long distance a second team and a thrasher tank should be used for that purpose instead of the spray outfit.

The most important item connected with the tank is the agitator. Since the poison is not dissolved in the water, but merely mixed with it, it will gradually settle to the bottom of the tank, leaving only a weak mixture to be applied to the plants, unless the liquid is stirred constantly and vigorously. For this purpose commercial outfits use a paddle or propeller within the tank, operated by a shaft, sprockets, belt, or drive rod from the pump or jack. In barrels the liquid can be stirred by a paddle or dasher worked by the jack or pump or by hand.

A strainer of 20-mesh brass or bronze screen should be fitted over the opening through which the water enters the tank and another over the outlet from it which leads to the pump. The former may be at the end of the suction hose, if one is used for filling the tank. If a cloth cover is used to keep the tank or barrels from slopping over it should be of canvas rather than burlap or any other linty fabric.

THE PUMP.

In spray pumps of all sizes certain structural features are important because of the corrosive nature of the liquid and the need of a uniform flow at comparatively high pressure.

The cylinder lining, plunger, valves, valve seats, and other working parts in which a close fit is required, and which also come in contact with the arsenic, must be of brass, bronze, porcelain, or some other substance which is less rapidly corroded by the chemicals than are iron and steel. To maintain the pressure without waste of power requires carefully fitted valves and properly packed stuffing boxes. All commercial spray pumps are built in this way, but pumps which were intended for other purposes should be refitted when used for spraying.

The suction hose leading from the tank to the pump should be 1 inch in diameter, with a heavy wall to prevent collapse. About 10 feet of it is needed.

Every engine-driven outfit must have a relief valve near the pump, permitting the surplus flow to return to the tank. This regulates the pressure and also acts as a safety valve to prevent the development of dangerously high pressures when the outlet is purposely or accidentally closed.

The pump must have an air-pressure chamber large enough to keep the flow steady and thus insure even distribution of the poison. Its capacity in gallons for a double-acting or duplex pump should be about equal to the number of gallons per minute discharged by the pump, which is much more than the capacity of the chamber usually furnished with force pumps and even of many spray pumps which are intended to be used with a smaller number of nozzles. Triplex pumps need air chambers only two-thirds as large. The pressure chamber should be attached to the line near the pump, but not between it and the relief valve, and it should be mounted in a vertical position to enable the settlings to drain out. It is best to provide the pipe leading to it with a check valve to retain the pressure in the chamber without strain upon the pump.

A cut-off should be inserted between the pressure chamber and the strainer (described below), to prevent loss of pressure during short stops. A plumbers' stop-and-waste cock is suitable for this purpose because it opens and closes with a single motion. The two ends are not alike, and it must be attached so that the closed end is toward the pump when the cock is turned off.

THE PRESSURE GAUGE.

A pressure gauge is necessary for good work with either a large or small outfit, because it is impossible without it to maintain the even pressure which is indispensable for the uniform spread of the poison. The gauge should be attached to the air-pressure chamber, or near it, and at a distance from the relief valve and the nozzles.

THE STRAINER.

Clogging of the nozzles by rust, scale, and fibers from the interior of the pump and the pipes can be prevented by inserting a strainer, so constructed that it can be cleaned easily, at some convenient place in the pressure line beyond the cut-off (fig. 8). A 1½-inch **T** is used as the shell, and the pipe from the pump is screwed into its middle opening. The **T** is turned so that the other two openings point up and down and a plug is screwed into the lower opening whence it can be removed to clean out the strainer. The strainer itself is a cone of 20-mesh brass or bronze screen strengthened by crossed hoops of No. 14 galvanized wire, both soldered to the inside of a 1½ by 1¼ inch bushing, which is then screwed into the upper opening of the large **T** so that the cone points down into the **T**. This bushing is connected by suitable bushings with the hose leading to the boom. The spray

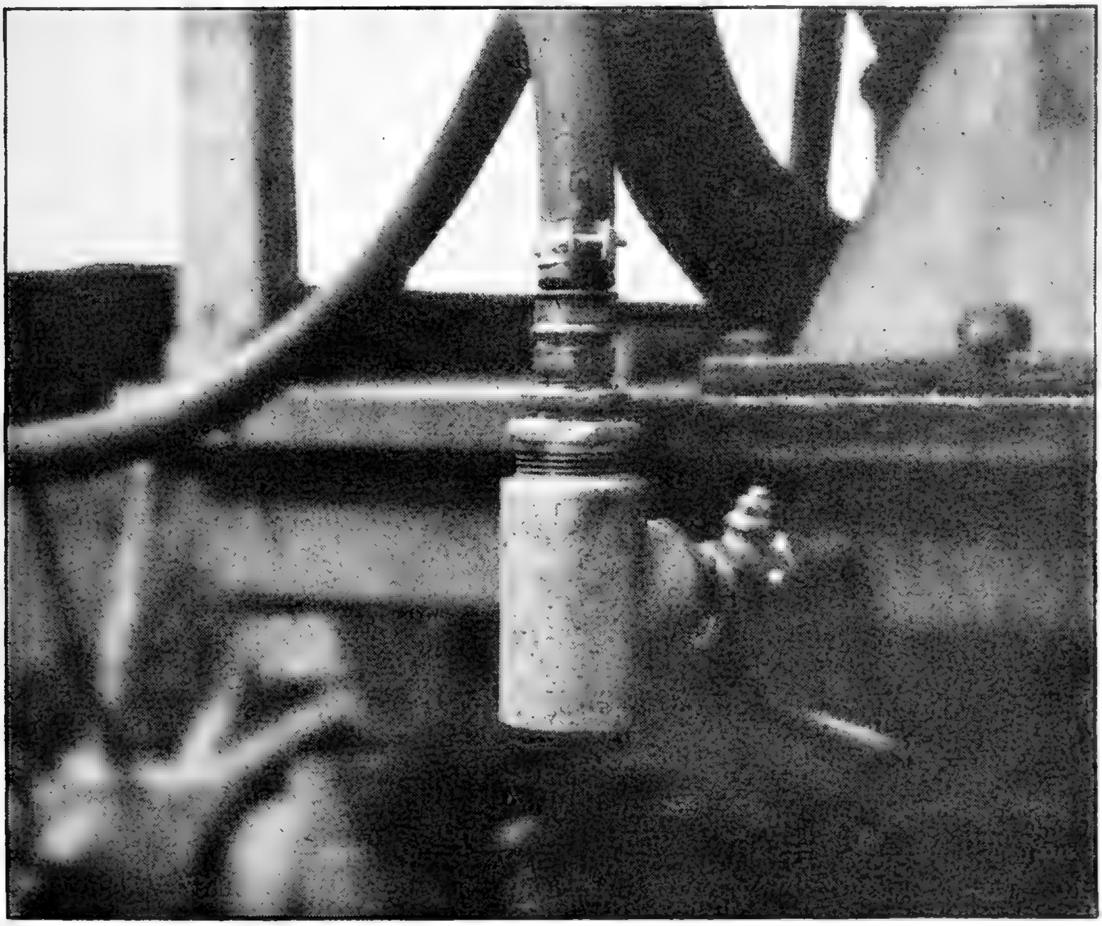


FIG. 8.—Pressure strainer attached to spray outfit.

liquid from the pump enters the shell at the side opening and flows upward through the screen cone and out at the top toward the nozzles, leaving the dirt on the outer lower side of the cone, from which it can be removed after taking out the bottom plug (fig. 9).

THE ENGINE.

The capacity of the gas engine should be about 1 horsepower for each 4 gallons per minute pump capacity. The power is transmitted to the pump through a jack, driven by a belt or gears, which should give a gear reduction of about 10 to 1. Some spray pumps are built with a crank shaft or eccentric shaft, which takes the place of the jack.

THE BOOM.

The boom which carries the nozzles and supplies them with liquid from the pump is made of 2-foot pieces of $\frac{1}{2}$-inch galvanized-iron

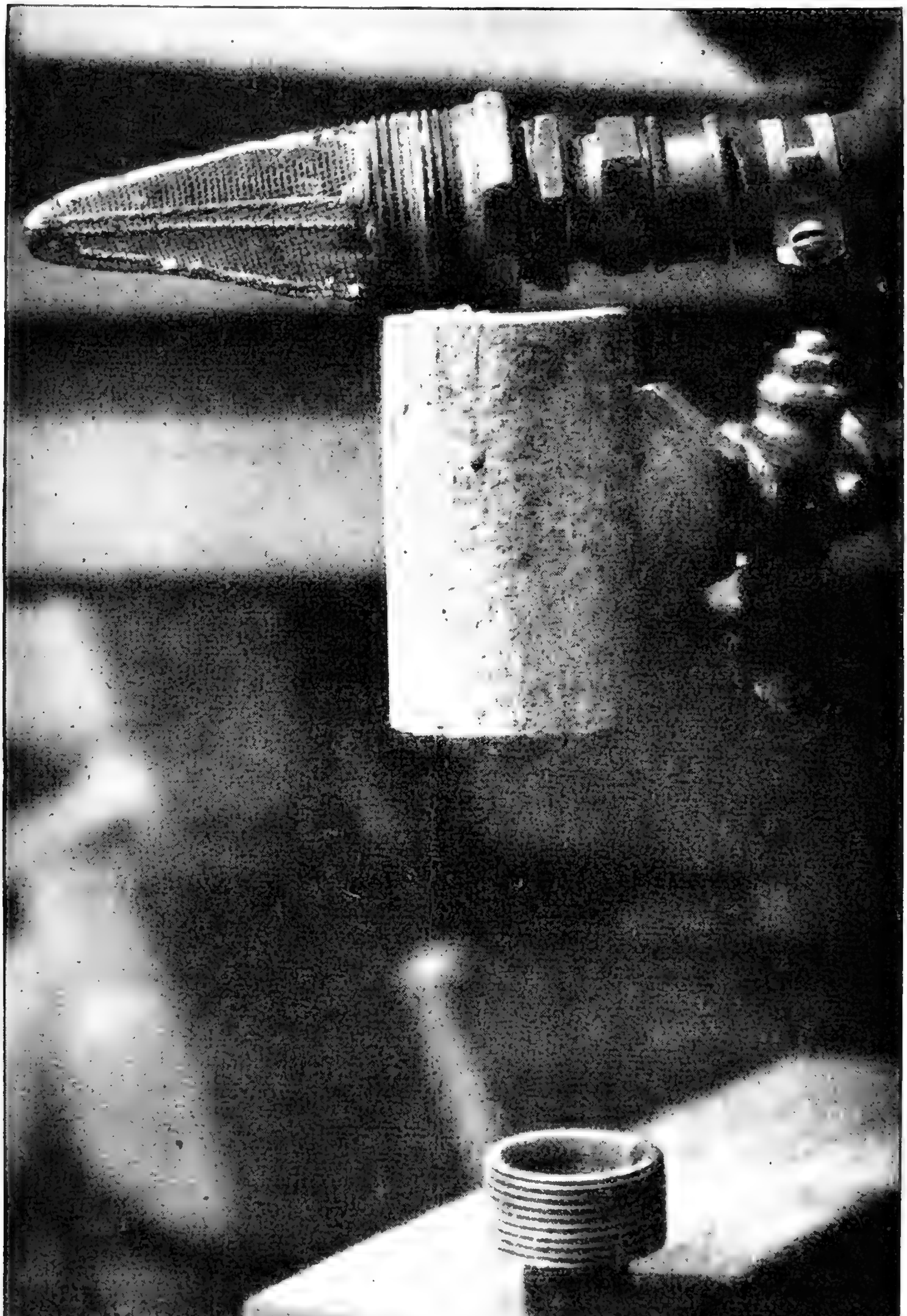


FIG. 9.—Parts of strainer shown in figure 8.

pipe, joined by tees, each of which affords an opening for the attachment of a nozzle. The boom may be all connected in one piece, in which case a cross must be used in place of one of the central tees to allow for the hose connection with the pump, or it may be built in two independent halves, each swung separately from the frame of the vehicle and supplied by a separate pressure hose from the pump. In case the pump has but one lead and another is desired, it may be provided by adding a T or a Y. The divided boom is more convenient than the other for driving through gates and, the parts being shorter, is less likely to be broken on rough ground.

The boom is connected with the pump by a ½-inch, 5-ply or 7-ply pressure hose, to which it is joined by a hose coupler having a ½-inch pipe thread on one end and a ¾-inch hose thread on the other. The attachment of the nozzles to the boom is provided for by fitting each T with a ½ by ¼ inch bushing and a ¼-inch nipple about 1½ inches long, which fits the ¼-inch female thread of the nozzle.

The boom, whether in one piece or two, should not be expected to support its own weight. The best support is a 2 by 4, clamped or hinged to the truck, with the boom stapled, bolted, or wired to it. This prevents the slender pipe from whipping and breaking at the threads. The one-piece boom must be attached so that it can be quickly unfastened and removed when the outfit is driven through a gate. An advantage of the 2-piece boom is that the wings can be hinged so as to swing out of the way.

Twenty feet is the limit of length for the spray boom, owing to the amount of swinging at the ends caused by the wheels of the truck when moving over rough ground. Even when a shorter boom is used it is best to keep on hand one or two extra tees and sections of pipe to repair accidental breaks.

THE NOZZLES.

Plain nozzles, designed to give a misty spray, sometimes called hollow-cone, eddy-chamber, cyclone, whirlpool, and cover-spray nozzles, without strainers or other complications, are best for this work, since the purpose is to place a fine, even coating of poison upon the upper foliage, where the larvæ chiefly feed. This kind of nozzle has a base threaded to fit a ¼-inch pipe. On the other end is screwed a brass cap which holds in place the steel discharge disk with its central discharge opening, and back of that a gasket ⅛ inch thick, within the circle of which is the eddy chamber or whirlpool chamber, which breaks the jet of water into a hollow cone of fine mist and gives the nozzle its various names. Back of this space is the directing disk, a flat piece of metal pierced with one or two holes situated midway between the center and the edge and slanted so that the liquid passing through them gives a whirling motion to the contents of the eddy chamber. This disk should be removable from the body of the nozzle for cleaning, but it is sometimes a part of the single-piece shell. For alfalfa spraying it should not have a central direct hole such as some orchard nozzles have.

The rate of flow of a nozzle depends upon many details of size, shape, and design, but in nozzles of the same pattern it is governed by the size of the discharge opening and the pressure supplied by the pump. Thus a certain nozzle which is in common use, when provided with a five sixty-fourths-inch opening and a pressure of 125 pounds, delivers a little more than four-fifths of a gallon per minute. For each additional 25 pounds of pressure the flow is increased one-sixteenth gallon. The same nozzle with a six sixty-fourths-inch opening delivers as much liquid at 75 pounds as with a five sixty-fourths-inch opening at 150 pounds, and increases one-eighth gallon for each added 25 pounds.

The discharge disk must be renewed occasionally, because the continued friction of the liquid wears away the edges of the opening, enlarging it and increasing the rate of discharge so that the material is wasted and eventually it becomes impossible to maintain the proper pressure.

There is some difference of opinion as to whether the nozzles should point directly downward or slant backward. The writers have tried various angles and failed to find any advantage in one position over the others.

The character of the spray produced by a plain nozzle of the type described in the foregoing paragraphs depends principally upon the pressure. With pressures below 75 pounds many of the particles of spray are so large that they roll down the surfaces of the foliage, collect in drops, and fall to the ground. At 75 pounds pressure the particles remain separate long enough to dry and form a fairly even coating, and as the pressure increases the spray becomes finer and the cover more nearly perfect. As the success of the work depends largely upon covering as nearly as possible all the upper foliage, the pressure should not fall below 75 and might well be kept at 100 to 150 pounds.

TOOLS.

The tools needed in fitting up and using a spray outfit are, in addition to the usual hammers and wrenches, two 12-inch or 14-inch Stillson wrenches and a pair of pliers. The cutting and threading of the pipe used for the boom can be done at a plumber's shop more economically than by buying the tools which would be required for doing the work at home.

THE POISON.

Arrangements should be made for obtaining the poison at the time when the machinery is being purchased or overhauled. Arsenate of lead and arsenite of zinc have been used on a large number of fields with complete success, and it is likely that other arsenical poisons which are recommended for orchard spraying are equally good. There is practically no danger of burning the foliage of alfalfa, and therefore the range of suitable poisons is larger than in fruit-tree spraying. The principal considerations are the cost of the poison and its capability for sticking to the leaves, and in both these respects arsenate of lead is slightly superior.

The dry, powdered form of the poison is better than the paste, because it costs less to ship and keeps better from year to year.

The poison is made much more effective by adding soap to make it spread more readily and stick to the leaves, which are so hairy that the particles of spray tend to collect in larger drops and run off.

The poison is weighed or measured for use at the rate of 2 pounds of the powder or 4 pounds of the commercial paste for each 100 gallons of water, and is stirred with a little water in a pail until it becomes a thin paste without lumps. It is then diluted and strained into the tank through brass milk-strainer gauze, which may be mounted for the purpose on a hoop or a frame which fits the opening in the tank. Two pounds of laundry soap for each 100 gallons is added.

The materials and utensils should be kept free from dirt and lint, which might later cause clogging of the nozzles, and when cloth is used for straining liquids or covering containers it should be canvas or muslin and not a linty fabric like burlap. The spray liquid should be mixed just before use and kept stirred up until it is all used, to prevent the settling and wasting of the poison and the clogging of the pipes.

APPLICATION OF THE SPRAY.

The spray outfit is ready for work when the tank, pump, pipes, and nozzles have been cleaned and, together with the engine, tried and found to be in working order and regulated so as to deliver 100 gallons of spray mixture per acre and maintain a pressure not lower than 75 pounds.

The weather most favorable for spraying is at the beginning of a warm period, because in warm weather the larvæ feed more freely and it is desirable to have them do so for several days immediately after the application of the poison. If it is put on just before a cold spell the weather may cause some of the feeding to be postponed until the alfalfa has grown a few inches and provided fresh unpoisoned food for the larvæ. Nevertheless, good results have usually been obtained in spite of unpromising weather, and all that is necessary is to give the poison a chance to dry thoroughly upon the foliage before it is exposed to storms.

One man is needed to drive the team and another to operate the machinery, if a power outfit is used. The number of men needed with a hand pump depends upon its size; the smaller pumps can be worked by one man, but the larger ones require two men or even three, each working two-thirds of the time.

Twenty-five acres can be covered easily in a day with a 10-nozzle machine, and this speed, with the low cost and the protection given to both crops at one operation, makes the spraying method superior to all others for the control of the alfalfa weevil. The actual cost is about $1 per acre, and growers who did the work for their neighbors in 1919 charged from 75 cents to $2, in addition to the cost of the poison, which was 60 cents per acre.

The results of the work begin to appear in about three days, and many dead larvæ can then be found, but the full effect is not obtained until the fifth day. By that time from two-thirds to nine-tenths of the larvæ have perished and the field takes on a brighter green. Remarkable contrasts are often produced by leaving a small strip unsprayed, as shown in figure 3.

DANGER OF POISONING STOCK.

There have been many inquiries as to the danger of poisoning live stock by feeding sprayed hay, which are all answered by the fact that such hay is shown by analyses and feeding tests to contain too little poison of any kind to injure farm animals. Many of the cattle which are fed upon it probably take in more arsenic with their drinking water than with their hay, and as for the lead content, few of them would under any circumstances live long enough to show the least effect of it.

CONCLUSION.

Seldom has any newly recommended method of insect control been so thoroughly safeguarded against failure as alfalfa weevil spraying. It has been tested every season for seven years, and the conditions necessary to success have been carefully ascertained. It is believed that most of the difficulties have been provided against, and it is certain that the farmers who tried it in 1919 are satisfied. The cost of the operation is trifling compared with the returns. Improvements will doubtless be made in the machinery and the arsenical poisons, but the method is at present a practical success, and no farmer in the territory infested or threatened by the alfalfa weevil can afford to overlook it.

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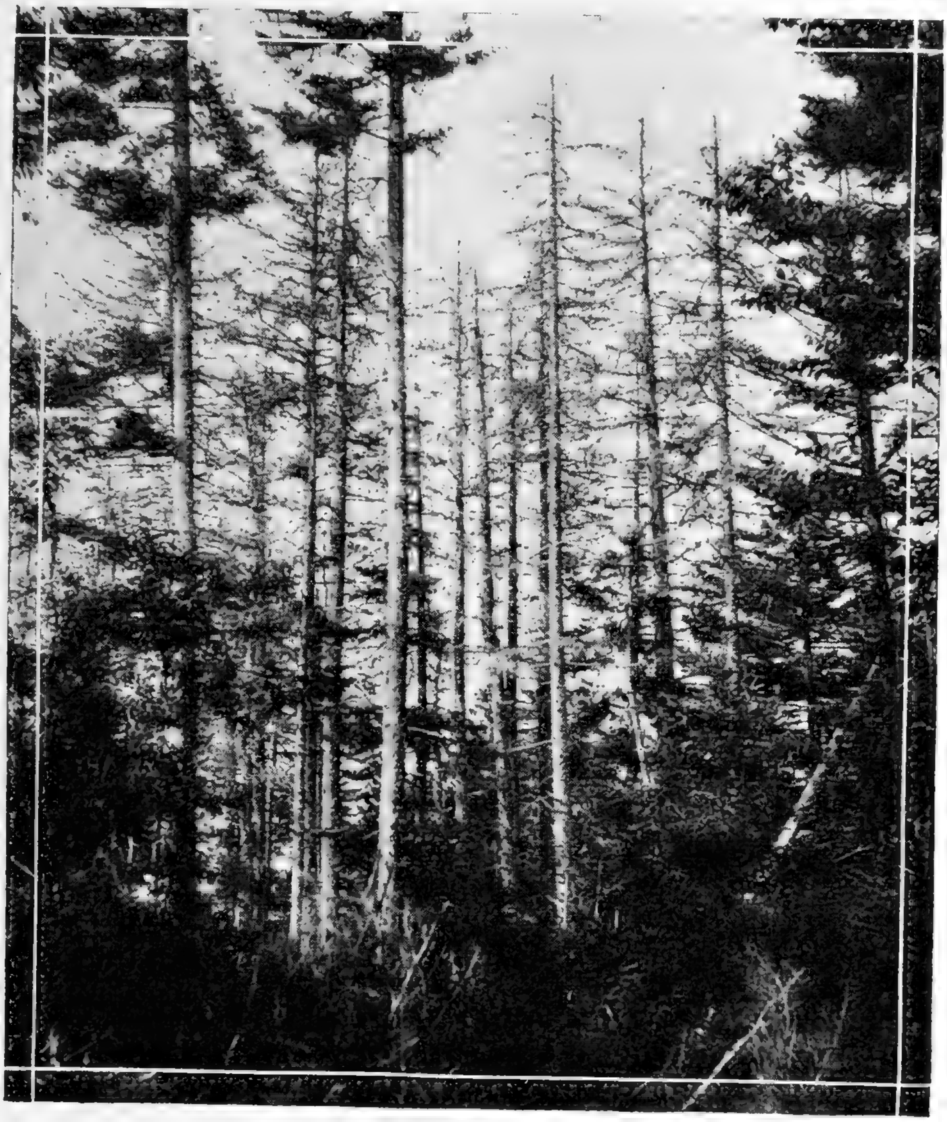
THE SOUTHERN PINE BEETLE

A Menace to the Pine Timber of the Southern States

A. D. HOPKINS

Forest Entomologist, in Charge of Forest Insect Investigations



FARMERS' BULLETIN 1188

UNITED STATES DEPARTMENT OF AGRICULTURE

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. March, 1921

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THE SOUTHERN PINE BEETLE is the most destructive enemy of the pines of all species in the Southern States from Pennsylvania to Texas. It has killed more merchantable-sized timber during the last 30 years than has died from all other causes combined. Between 1890 and 1893 it killed a very large percentage of the yellow, pitch, and white pines of West Virginia and Virginia, and, since the earliest records in 1842, has killed a vast amount of timber in the Atlantic and Gulf States, most of which has been a total loss.

The prevention of serious outbreaks and the control of this menace to the great timber resources of the South are not only possible but entirely practicable. It is only necessary to cut, and utilize for fuel or lumber during the fall and winter months, all trees that die during the late summer and fall, making sure that the bark of the main trunk is burned.

THE SOUTHERN PINE BEETLE:[1]

A MENACE TO THE PINE TIMBER OF THE SOUTHERN STATES.

By A. D. Hopkins,

Forest Entomologist, in charge of Forest Insect Investigations.

CONTENTS.

THE SOUTHERN PINE BEETLE: WHAT IT IS AND WHAT IT DOES.

THE SOUTHERN PINE BEETLE is a small brownish or black beetle, somewhat smaller than a grain of rice. It flies from March to December in the more southern sections, and from May to November in its northern range. It attacks the middle to upper portions of the trunks of healthy pine trees, causing their death by excavating long, winding burrows, or egg galleries (figs. 1 and 3), which extend through the inner layers of the living bark and mark the surface of the wood (fig. 2). Eggs are deposited along the sides of these galleries, from which young grubs (larvæ) hatch and then feed on the inner bark until they have attained the size of the parent beetles, when they mine into the outer bark and transform to the dormant (pupal) stage, and later to the adult or beetle stage. The beetles then emerge to fly in search of other living trees, in which this process of attack and development is repeated.

The winter is passed in the bark of the living and dying trees in all stages of development. The more advanced individuals begin to emerge and fly in March to May, and the remainder continue to develop and emerge until about the last of July, so that by this

[1] *Dendroctonus frontalis* Zimm.; order Coleoptera, family Ipidae.

time all of the trees that were attacked during the previous fall and early winter are dead and abandoned by the beetles.

From three to five generations occur annually. The first generation begins with the eggs deposited by the first beetles that fly and attack the trees in the spring and by those of the overwintered broods as they make successive attacks during the spring and early summer.

The second generation begins with the eggs deposited by the adults of the first generation, and so on until cold weather stops their activities.

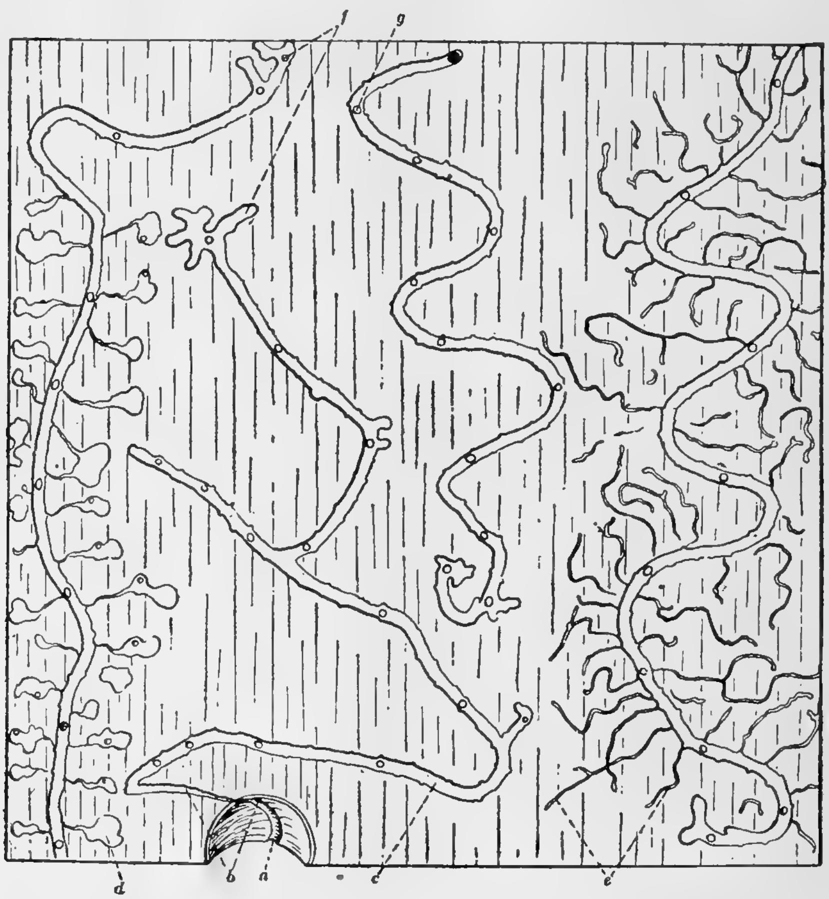

FIG. 1.—Egg galleries and larval mines of the southern pine beetle: *a*, Entrance; *b*, entrance burrow; *c*, egg gallery; *d*, normal larval mine; *e*, abnormal larval mine; *f*, terminal; *g*, ventilating burrows. Slightly reduced.

At all times there is a more or less complex overlapping of generations, so that emergence and attack are continuous during the entire period of activity; consequently, there is a continuous dying of trees within the infested areas.

Under average or normal conditions of the activities of this beetle a few scattering trees are killed by it each year in mature stands of pine timber throughout the Southern States where the pine is common. If, however, from any cause, conditions become favorable for the multiplication of the insect, it is able to kill groups of trees, and if these groups increase in number and size the following year they constitute the danger signal of an outbreak which may result in widespread devastations. The southern pine beetle is the most destructive enemy of the pine within its range; in fact, it is a constant menace to the living pine of all the Southern States. (See fig. 4.)

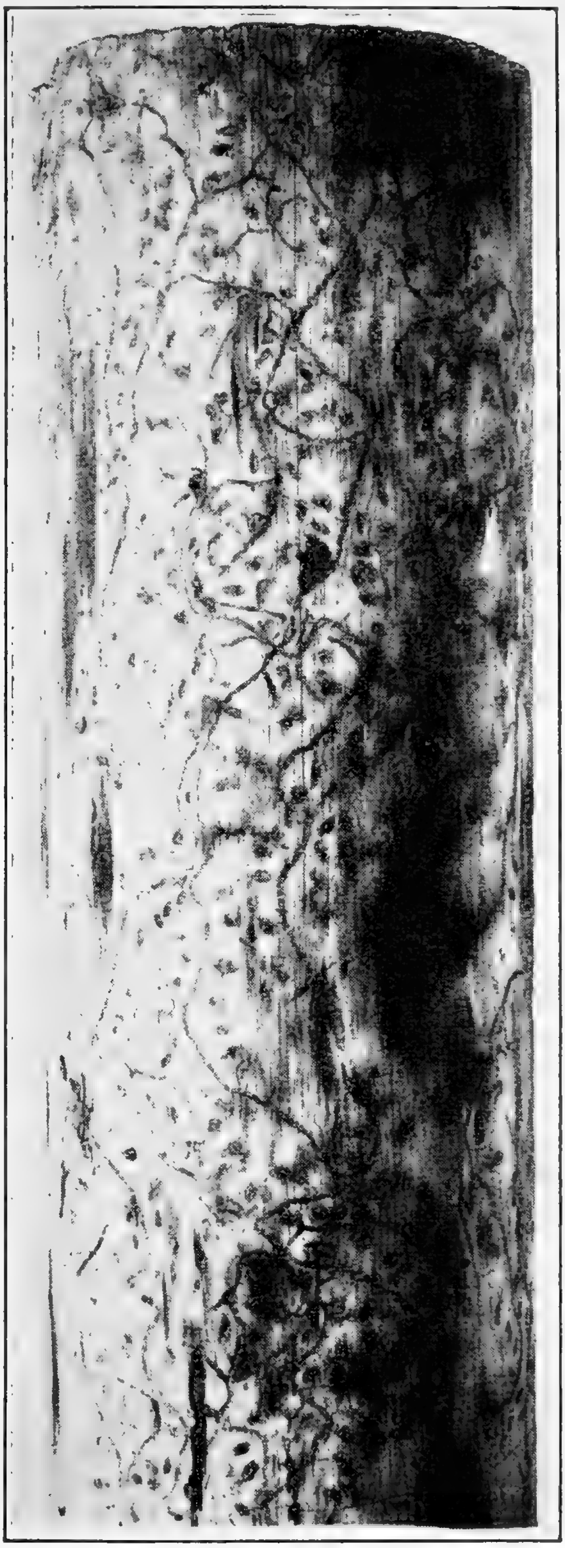

Fig. 2.—Section of pine trunk with bark removed, showing the marks of the egg galleries on the surface.

EVIDENCE OF THE DESTRUCTIVE WORK OF THE BEETLE.

The presence of this beetle in dangerous or destructive numbers is plainly indicated by patches of dying and dead pine, which show no evidence of injury by fire or other destructive agencies.

The trees infested by the developing broods are indicated by the fading green, greenish brown, and yellowish red of the foliage and positively determined by the removal of some bark from the *middle* of the trunks of a few of the dying trees and the finding of the characteristic work in the inner bark and on the surface of the wood, as shown in figures 2 and 3.

The trees which have been killed and abandoned by the developed broods of the beetles are indicated by the reddish-brown foliage (abandoned "red tops"), the fallen foliage (abandoned "black tops"), and the decaying standing or fallen trees (abandoned "broken tops" and "snags," fallen trees, etc.). The cause of the death of trees of any of these stages is determined by examining the dead bark for evidence of the work of the beetle.

EXTENT OF LOSSES.

Extended observations in all of the Southern States between 1891 and 1911 led the writer to conclude that if all of the pine that has

FIG. 3.—Bark from pine tree showing galleries of the southern pine beetle, which kills the trees, and the larger mines of the "sawyer," which does not kill trees.

been killed during this time by this beetle were living in 1911 its stumpage value would have amounted to from $10,000,000 to $20,-000,000 or more. Studies of the depredations wrought by it in the

South Atlantic and Gulf States in the years 1908 to 1911 indicate that at least $2,000,000 worth of pine was killed during that time. It is evident that if active steps had not been taken in 1911 by the principal owners in the infested areas this loss would have increased to another million dollars within the next year.

Since 1911 no extensive outbreaks have been reported or observed, but there is constant danger that the beetle may again multiply to the danger point.

THE REMEDY.

It has been determined and demonstrated that if the larger part of the infestation within an area of 8 or 10 square miles is disposed of according to the methods discovered and recommended by the

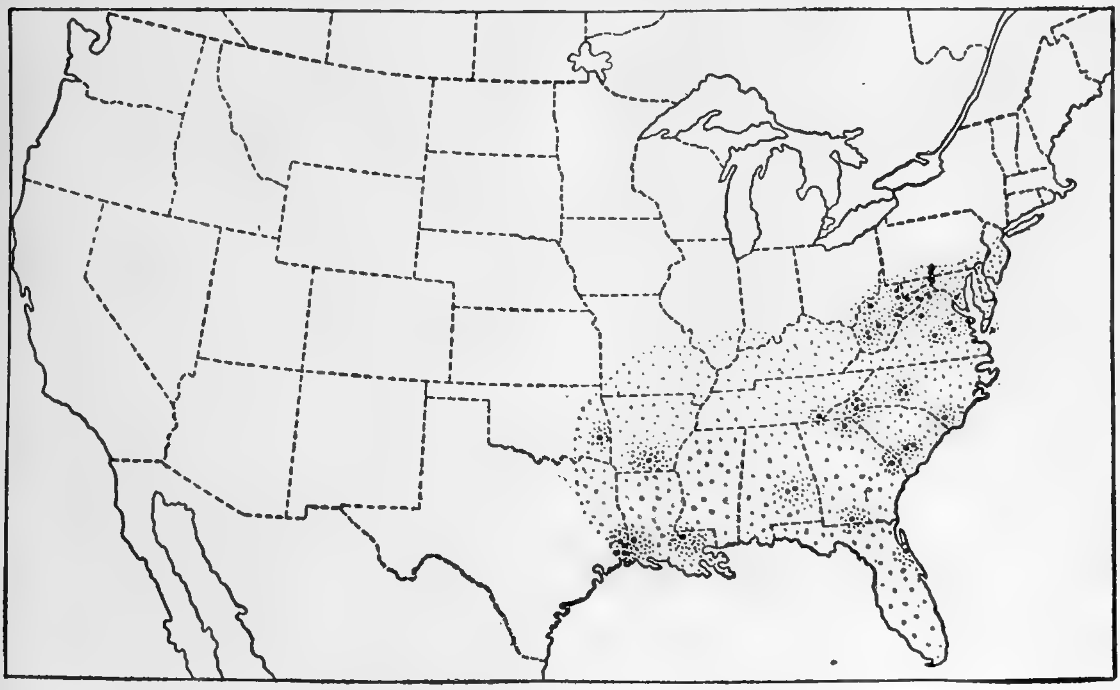

FIG. 4.—Map showing distribution of the southern pine beetle.

experts of the Bureau of Entomology it will bring the beetle under complete control in that area, and that thereafter control can be maintained with but slight trouble or expense. It is therefore evident that if the recommended methods are adopted and properly carried out the beetle can be controlled in any given community, district, county, State, or in the entire South.

Broadly stated, the method of control is to locate the infested trees during November, December, January, February, and March and destroy the overwintering broods in the bark of the main trunks, according to the recommendations on pages 10 to 13 of this bulletin.

THE COST OF CONTROL.

Experience has shown that while a large amount of timber may be dead in a given locality it may be an accumulation of several years or months through the continued dying of the trees, so that only a comparatively few infested trees are found at any given time. Therefore if this small number of dying and infested trees is disposed of at the proper time and in the proper manner the cause will be removed at small cost and the dying of the pines will stop.

The cost for the required treatment will ordinarily average about 30 cents per merchantable-sized tree.

Protecting the *living* pine of farmers' woodlots and small forests of average-infested areas of 10 to 15 square miles in the central Southern States through a direct control of the beetle will cost from 1 to 10 cents per acre for the first year and practically nothing thereafter for from 10 to 20 years.

The protection of the *living merchantable* pine within a similar average area will cost from 5 to 30 cents per thousand feet, board measure, or from ½ cent to 10 cents per cord for the first year and practically nothing during the next 10 to 20 years.

If the treated timber can be utilized for fuel, lumber, or any other purpose involving a commercial value, the cost will be reduced to a minimum, and in many cases a direct profit will be derived from the sale of the treated product.

INVESTIGATIONS IN THE SOUTHERN STATES.

From time to time since 1842 there have been reports of more or less extensive dying of pine timber in the Southern States.

Extended investigations of the problem were begun by the entomologist of the West Virginia Experiment Station in 1891 and continued at intervals in West Virginia until 1901, and by the experts on forest insects of the Bureau of Entomology at different times and in all of the Southern States from July, 1902, until 1911.

The results of these investigations have shown that the death of a large percentage of the pine of Virginia and West Virginia in the period from 1890 to 1893 was due to an invasion of the southern pine beetle, which attacked the healthy trees and girdled and killed them by excavating long winding burrows beneath the living bark on the main trunks of the trees.

It has also been shown that this beetle has existed in the Southern States for at least 78 years, and there is good evidence that it has occupied this region from time immemorial, but it is only at comparatively long intervals that it increases to such numbers as to cause widespread depredations.

During the summer and fall of 1910 and the winter and spring of 1911 correspondents of the Bureau of Entomology in different sections of the South, and especially in the Atlantic and Gulf States, reported that the pine was dying in patches, and that in some places the trouble was alarming. Therefore it was made the subject of special investigation in May, June, and July, 1911, which resulted in the location of a forest insect field station at Spartanburg, S. C., for the purpose of studying the character and extent of the depredations and conducting a campaign of instruction and demonstration on the proper methods for controlling the beetle and protecting the remaining living timber. This work was prosecuted in such a manner as to convince the majority of the owners of pine within the areas covered by the representatives of the Bureau of Entomology that the southern pine beetle is a menace to the pine forests of the Southern States. There was a general and widespread interest manifested throughout the worst affected sections, and there is evidence that sufficient action was taken by the owners, in the utilization or treatment of infested trees according to the recommendations, to protect the remaining living pine from further depredations.

CHARACTER AND RANGE OF DEPREDATIONS IN 1911.

The study in 1911 of the character and extent of the depredations by the southern pine beetle in South Carolina, Georgia, Alabama, North Carolina, Mississippi, Texas, Florida, Virginia, Louisiana, Maryland, Arkansas, Missouri, and Tennessee, and information conveyed by correspondents from all sections of the South, showed that in the aggregate a vast amount of timber had been killed by the southern pine beetle during 1910 and 1911. The dying and dead trees occurred as scattering individuals or in clumps, large patches, and in some places whole forests. All were more or less conspicuous by their fading, red, black, or denuded tops, plainly indicating the presence of the beetle or the progress of its work.

PATCHES OF DYING PINE A MENACE TO THE HEALTHY TREES.

It was found that each patch of dying trees, with their fading and greenish-brown tops, located anywhere in the Southern States is a menace to the living pine within a radius of 3 or 4 miles. The broods of the southern pine beetle developing in the bark of the trees of one such center of infestation may swarm in any direction and settle in the healthy timber. Thus one or more additional patches are killed, until nearly all of the large as well as the small pine over an extensive area is dead.

When these centers of infestation are numerous within the confines of a county, or even a larger section of territory, they can only be compared with the starting of so many forest fires; and, as has been demonstrated, they *may lead to far greater destruction of merchantable pine than has ever been recorded as resulting from fire in the Southern States.* Therefore they demand similar prompt and radical action on the part of the owners in order to protect their living pine.

THE MORE IMPORTANT EVIDENCES OF THE PRESENCE AND WORK OF THE BEETLE.

(1) If in clumps or patches of pine, where there is no plain evidence of serious injury by fire, the foliage fades to pale green and changes to yellowish and pale brown, it indicates that the trees are dying from the attack of the southern pine beetle and that the bark on such trees is infested with the developing broods of minute white grubs and transforming beetles. Therefore such infested trees are a *menace to the living trees.*

(2) If the trees have reddish brown and partially fallen foliage, or if all of the foliage has fallen, it indicates that the broods of beetles have emerged *and that such trees are no longer a menace to the living ones.*

(3) If the trees die during the period between the 1st of March and the 1st of October they will be abandoned by the broods of beetles within a few weeks after the foliage has begun to fade.

(4) If the trees begin to die during the period between the 1st of October and the 1st of December the broods of beetles will remain in the bark until the following March or April.

HOW TO LOCATE THE INFESTED TREES.

The location of trees that are infested by the southern pine beetle is the first and one of the most important things to be done before definite plans are made for the active work of cutting the trees. Some of the essential things to be remembered are as follows:

(1) The southern pine beetle attacks the upper and middle portions of the trunks of healthy trees.

(2) A freshly attacked tree may show pitch tubes on the trunk or reddish boring dust around the base, or there may be no external evidence of attack until the leaves have begun to fade.

(3) By the time the tops are faded and the bark on the middle and upper trunk is dead the broods of the beetle are in an advanced stage of development, yet at the same time the bark on the lower third of the trunk may be living and show no evidence of attack or may be attacked by other kinds of insects which are not responsible for the death of trees.

(4) As soon as the bark begins to die on any part of the trunk it is attacked by numerous other insects, including the adults of the "sawyer" borers which do not attack healthy trees. (See fig. 3.)

(5) By the time the tops have changed from pale green to greenish brown the broods of the southern pine beetle have nearly all developed to the stage when they enter the outer bark to transform to the adults.

(6) By the time the tops have changed to a reddish hue the broods have developed and are either emerging or have emerged.

(7) During the warm months the broods will develop and emerge from a tree within about 30 to 40 days after it is attacked.

(8) Trees attacked in November will usually carry the broods over winter. The foliage of some trees will fade and reach the reddish stage before spring; other trees attacked in December or later may not fade until the warm days of February, March, or April.

Therefore, in estimating the character and extent of an infestation within any given area, or in locating infested trees and marking them for utilization or treatment, one has only to consider those with fading or greenish brown foliage or the first stage of the yellowish red tops.

ESSENTIAL DETAILS IN METHODS OF CONTROL.

There are certain essential details in the recommended methods of combating the southern pine beetle which must be observed in order to avoid not only serious mistakes but possibly ultimate failure:

(*a*) The principal clumps or patches of *dying* trees which are actually infested by the broods of the destructive beetle, as indicated by the *fading and dying* foliage, or otherwise, should be located and marked during the months of November, December, January, and February. In order to do this work, proper experience or special instruction is required. Therefore, some one who has had instructions should have charge of the work in each important area in which control work is to be undertaken.

(*b*) *The broods of the beetle* in the bark of the *main trunks* of 50 to 75 per cent of the medium to larger sized dying infested trees within an area of 8 or 10 square miles or more must be destroyed in order to stop their depredations.

(*c*) The broods may be destroyed by *one* or *more* of the following methods, the work to be done between the 1st of November and the 1st of March.

(1) Removing and burning the infested bark from the trunks of the standing trees; or

(2) Removing and burning the infested bark from the trunks of the trees after they have been cut down; or

(3) Scorching the infested bark, or burning the wood with the bark after the trees are cut down; or

(4) Placing the infested portions of the trunks in water; or

(5) *Converting the trunks of the infested trees into cordwood and using the wood for fuel before the beetles leave the bark the following spring;* or

(6) *Converting the infested trees into lumber or other products and burning the slabs or bark.*

(*d*) It is not necessary to burn the tops or branches of treated trees or to cut and burn small infested saplings *if the larger infested trees are disposed of.*

(*e*) It is not necessary to remove or destroy the bark on the lower portion of the trunks or on the stumps if it is not infested with the destructive beetle, and it is not necessary to cut or treat dead trees from which the beetles have emerged.

(*f*) It is necessary and essential that the broods of the destructive beetle in the bark of any portion of the main trunks of the medium to larger sized dying infested trees of any given locality should be destroyed.

(*g*) If the wood of the infested trees can be utilized for fuel, lumber, or other purposes, its value should cover the cost of the work. If the work of felling and barking the trees is done at direct expense, the cost will average 20 to 30 cents per tree.

(*h*) The cost of protecting the living timber of any locality with average infestation should not exceed an average of from 1 to 5 cents per acre for the total area of pine-covered land, and if estimated on a basis of volume it should not cost over 2 cents per cord of the living timber protected.

(*i*) The best time to conduct control operations against the southern pine beetle is during the period between November 1 and March 1.

(*j*) If a pine tree standing among or near a grove of woods of living pine is either struck by lightning or felled and barked or split into cordwood *during the summer* and early fall, it will, as a rule, attract the beetles within a radius of three or four miles and result in the starting of a new center of infestation and in the death of a large number of trees. It is dangerous to cut pine trees in the summer months when the southern pine beetle is killing trees in the neighborhood.

(*k*) The principal owners of pine in each community should cooperate in the disposal of the required infestation, but should not undertake the work until *some one or more of the owners is sufficiently familiar with the essential details of the proper methods.*

REQUIREMENTS FOR SUCCESS.

To succeed in any effort to protect the living pine from the destructive attacks of the southern pine beetle the broods of the beetle in the bark of the main trunk of the dying infested trees must be destroyed before they leave the bark. This may be done by utilizing the infested trunk, adopting one or more of the methods given, or by treatment at direct expense in cases where the wood can not be utilized.

The attainment of the best success from the practical application of any of these methods will depend on their adaptation to local conditions and requirements for disposing of the infested timber, and strict adherence to certain details which are absolutely necessary to the destruction of the broods.

From the 1st of November to the 1st of the following March is the period in which to locate and mark the trees that are actually infested and in which the marked trees should be utilized or treated to kill the broods. In northern localities the period may be extended to the 1st of May.

The method of destroying the broods which in each case is the most economical and effectual can be determined by the owners in each community if they are sufficiently informed on the essential facts.

Detailed advice, recommendations, or conclusions as to the most economical and effective method of procedure for any given area should be deferred until certain reliable information is at hand regarding the local condition as to (*a*) the character and extent of the infestation, (*b*) the interest manifested by the people of the community in the value to them of the pine and the importance of protecting it as the source of future revenue, (*c*) the assurance of the majority of the owners that concerted action will be taken according to a definite plan and purpose, and finally, if a demonstration is desired, that local facilities will be offered for its successful prosecution.

If the owners of pine will consider the protection of their timber from the standpoint of a common interest and will realize the necessity for concerted action in the control work, success will be assured.

PUBLICATIONS RELATING TO INSECTS INJURIOUS TO FORESTS AND FOREST PRODUCTS.

AVAILABLE FOR FREE DISTRIBUTION.

Powder-post Damage by Lyctus Beetles to Seasoned Hardwood. (Farmers' Bulletin 778.)
Carbon Disulphid as an Insecticide. (Farmers' Bulletin 799.)
Gipsy Moth and Brown-tail Moth and their Control. (Farmers' Bulletin 845.)
Common White Grubs. (Farmers' Bulletin 940.)
White Ants as Pests in the United States and Methods of Preventing their Damage. (Farmers' Bulletin 1037.)
California Oak Worm. (Farmers' Bulletin 1076.)
Aspen Borer and How to Control It. (Farmers' Bulletin 1154.)
Insect Damage to the Cones and Seeds of Pacific Coast Conifers. (Department Bulletin 95.)
Sequoia Pitch Moth, a Menace to Pine in Western Montana. (Department Bulletin 111.)
European pine-shoot Moth; a Serious Menace to the Pine Timber in America. (Department Bulletin 170.)
Huisache Girdler. (Department Bulletin 184.)
Zimmerman Pine Moth. (Department Bulletin 295.)
Cypress Bark Scale. (Department Bulletin 838.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Report on Gipsy Moth Work in New England. 1915. (Department Bulletin 204.) Price 30 cents.
Cone Beetles: Injury to Sugar Pine and Western Yellow Pine. 1915. (Department Bulletin 243.) Price 10 cents.
Food plants of the Gipsy Moth in America. 1915. (Department Bulletin 250.) Price 10 cents.
Douglas Fir Pitch Moth. 1915. (Department Bulletin 255.) Price 5 cents.
Dispersion of Gipsy Moth Larvae by the Wind. 1915. (Department Bulletin 273.) Price 15 cents.
Solid Stream Spraying against the Gipsy Moth and the Brown-tail Moth in New England. 1917. (Department Bulletin 480.) Price 15 cents.
Termites, or "White Ants" in the United States: their Damage and Methods of Prevention. 1916. (Department Bulletin 333.) Price 15 cents.
Flat-headed Borers Affecting Forest Trees in the United States. 1917. (Department Bulletin 437.) Price 10 cents.
Control of the Gipsy Moth by Forest Management. 1917. (Department Bulletin 484.) Price 20 cents.
Protection from the Locust Borer. (Department Bulletin 787.) 1919. Price 5 cents.
Danger of General Spread of the Gipsy and Brown-tail Moths through Imported Nursery Stock. 1911. (Farmers' Bulletin 453.) Price 5 cents.
Two-lined Chestnut Borer. 1897. (Entomology Circular 24.) Price 5 cents.
White Ants. (Entomology Circular 50.) 1902. Price 5 cents.
White-Pine Weevil. 1907. (Entomology Circular 90.) Price 5 cents.
Insect Injuries to Wood of Dying and Dead Trees. 1910. (Entomology Circular 127.) Price 5 cents.
Insects in their Relation to Reduction of Future Supplies of Timber and General Principles of Control. 1910. (Entomology Circular 129.) Price 5 cents.
Oak Pruner. 1910. (Entomology Circular 130.) Price 5 cents.
Insect Damage to Standing Timber in National Parks. 1912. (Entomology Circular 143.) Price 5 cents.
Dying Hickory Trees, Cause and Remedy. 1912. (Entomology Circular 144.) Price 5 cents.

Insect Damage to Mine Props and Methods of Preventing Injury. 1912. (Entomology Circular 156.) Price 5 cents.
Gipsy Moth as Forest Insect, with Suggestions as to its Control. 1913. (Entomology Circular 164.) Price 5 cents.
Insect Enemies of Spruce in Northeast, with Recommendations for Preventing Losses. 1901. (Entomology Bulletin 28, n. s.) Price 10 cents.
Catalogue of Exhibit of Economic Entomology at Lewis and Clark Centennial Exposition, Portland, Oreg., 1905. 1905. (Entomology Bulletin 53.) Price 10 cents.
Black Hills Beetle, with Further Notes on Its Distribution, Life History, and Methods of Control. 1905. (Entomology Bulletin 56.) Price 5 cents.
Some Insects Injurious to Forests. 1906–1910. (Entomology Bulletin 58, 5 pts.) Price 20 cents.
Locust Borer. 1906. (Entomology Bulletin 58, pt. I.) Price 5 cents.
Western Pine-Destroying Bark Beetle. 1906. (Entomology Bulletin 58, pt. II.) Price 10 cents.
Additional Data on Locust Borer. 1917. (Entomology Bulletin 58, pt. III.) Price 5 cents.
Southern Pine Sawyer. 1909. (Entomology Bulletin 58, pt. IV.) Price 5 cents.
Insect Depredations in North American Forests and Practical Methods of Prevention and Control. 1909. (Entomology Bulletin 58, pt. V.) Price 10 cents.
Practical Information of Scolytid Beetles of North American Forests: 1, Bark Beetles of Genus Dendroctonus. 1909. (Entomology Bulletin 83, pt. I.) Price 25 cents.
Report on Field Work against Gipsy Moth and Brown-tail Moth. 1910. (Entomology Bulletin 87.) Price 35 cents.
Biology of the Termites of the Eastern United States, with preventive and Remedial Measures. 1915. (Entomology Bulletin 94, pt. II.) Price 20 cents.
Dispersion of Gipsy Moth. 1913. (Entomology Bulletin 119.) Price 20 cents.

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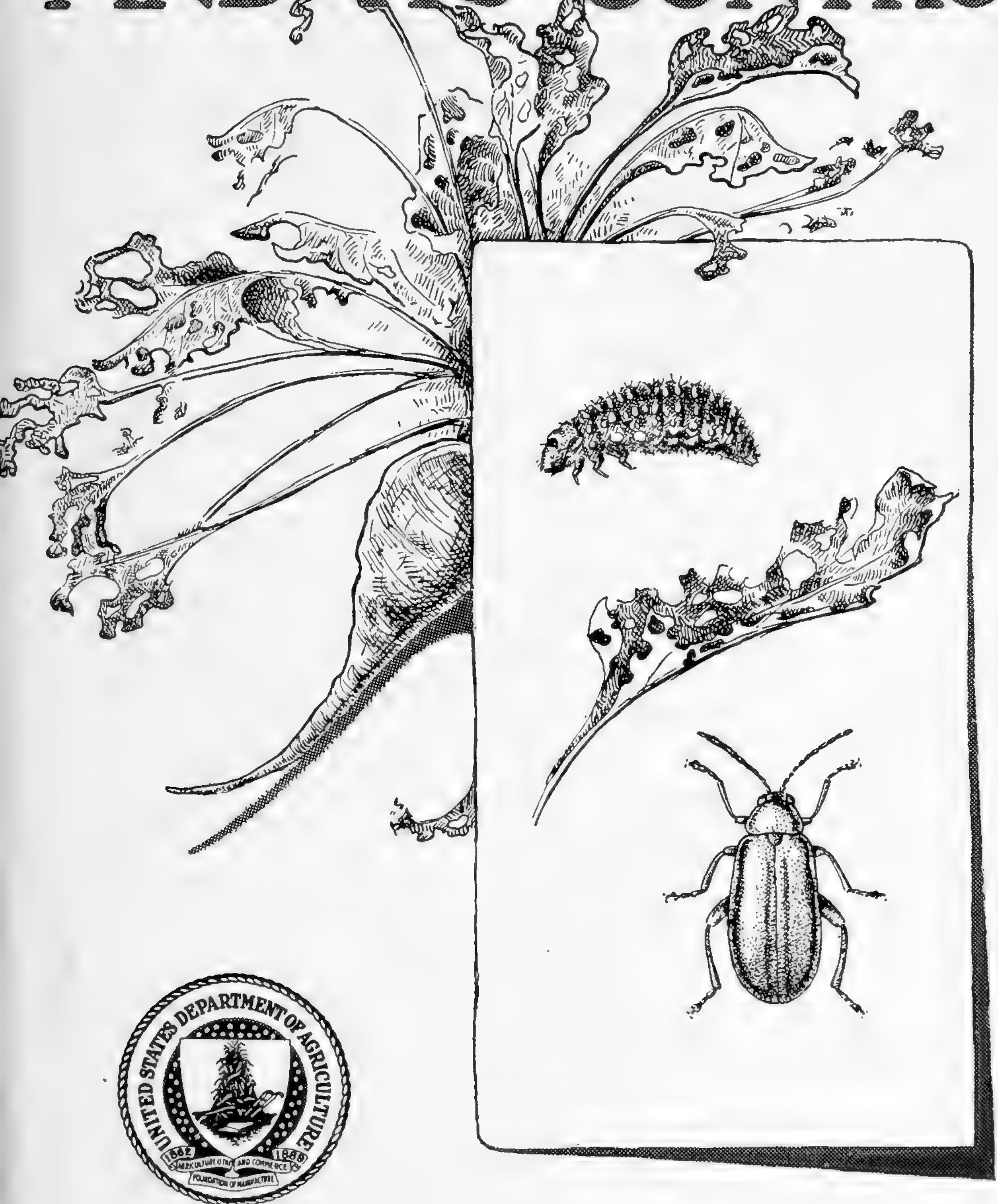
FARMERS' BULLETIN — 1193
UNITED STATES DEPARTMENT OF AGRICULTURE

THE BEET LEAF-BEETLE AND ITS CONTROL



THE SUGAR-BEET industry of the Rocky Mountain States is menaced by the presence of the beet leaf-beetle. Both the larva and beetle stages injure the foliage, especially of young sugar beets, and also attack table beets of all kinds and spinach.

The beetles may be trapped by placing heaps of weeds or bundles of hay or straw where the beetles will seek them for winter quarters. Here they may be destroyed by burning between the middle of November and March.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. March, 1921

THE BEET LEAF-BEETLE[1] AND ITS CONTROL.

F. H. Chittenden,
Entomologist in Charge, Truck-Crop Insect Investigations.

CONTENTS.

AN IMPORTANT ENEMY TO SUGAR BEETS IN THE ROCKY MOUNTAIN STATES.

IN THE Rocky Mountain States the sugar beet is subject to injury by a yellowish beetle known as the beet leaf-beetle or "alkali bug." The main injury is due to attack by the larvæ or young, but the beetles also inflict considerable damage, hundreds frequently being found on a single plant, which is either entirely consumed or so injured that it shrivels and dies. Prior to 1897, when injury was noted both in New Mexico and in Colorado, injury by this insect was unknown, it having confined itself to such plants as sea-blite, Russian thistle, and saltbush.

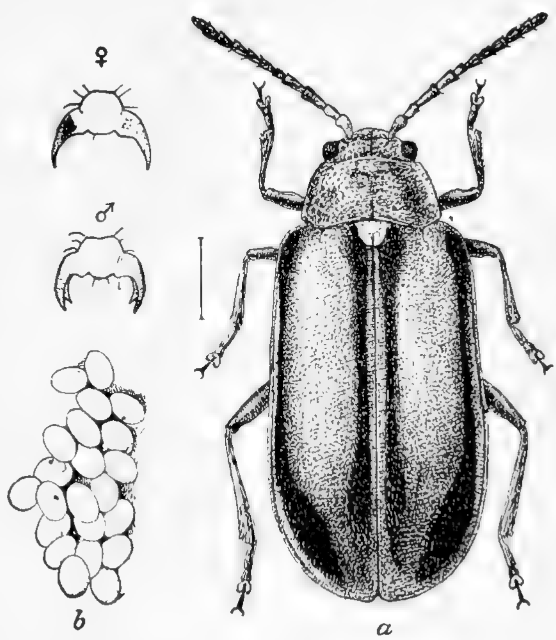


Fig. 1.—The beet leaf-beetle: *a*, Beetle; *b*, egg mass; ♀, claw of leg of female; ♂, ditto of male, *a*, Much enlarged; *b*, more enlarged; ♀, ♂, highly magnified.

DESCRIPTION.

The adult beet leaf-beetle measures from one-fourth to one-third of an inch in length, is of oblong form narrowed in front, and in color is pale yellow or buff, sometimes becoming smoky or nearly black, with the wing-covers yellowish or darker and more or less distinctly striped with black. (See fig. 1, *a*.)

[1] *Monoxia puncticollis* Say.; family Chrysomelidae, order Coleoptera.

The egg (fig. 1, *b*) is rounded, oval, pale orange-yellow when first laid, changing to dull brownish gray, convex above, flattened on the lower side where attached to a leaf, and the surface is minutely pitted. Eggs are deposited usually on end in irregular clusters, sometimes in layers, varying in number from 2 to 50 on either the upper or lower surface of leaves of beets and other food plants. The larva, when mature, is dark olive brown, spotted with pale yellow tubercles arranged in rows. (See fig. 2.) The head is shiny black, as are portions of the legs, which are rather long and slender. The length is about three-sixteenths of an inch.

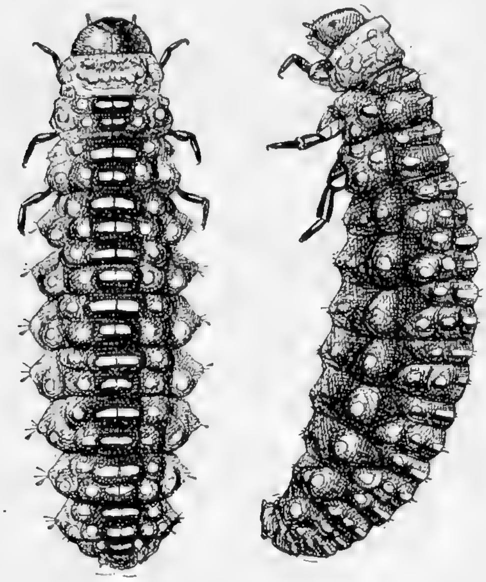


FIG. 2.—Beet leaf-beetle: Dorsal view of larva at left; profile view at right. Much enlarged.

The pupa (fig. 3) is nearly twice as long as wide, pale yellow, the head prominent, bent downward with the legs folded, as shown in the illustration. The length is from one-fourth to five-sixteenths of an inch.

DISTRIBUTION.

The beet leaf-beetle occurs along the Atlantic Seaboard from Massachusetts to Florida, in California near the seacoast,[2] and in the alkaline regions of Colorado, Utah, New Mexico, Arizona, Idaho, and Montana. In its eastern occurrence it is maritime and not injurious. It also occurs in portions of Kansas and Texas. See map (fig. 4).

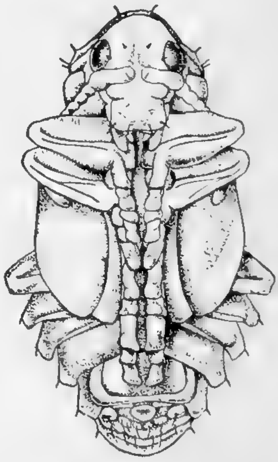


FIG. 3.—Beet leaf-beetle: Pupa much enlarged.

FOOD PLANTS.

The adults feed on sugar beets (figs. 5, A, B, and 6), garden or table beets, mangelwurzel, Swiss chard, and spinach; on lamb's-quarters (fig. 5, C), sea-blite (fig. 5, D), Russian thistle, saltwort, saltbush, sea-purslane, and pigweed.[3] The larvæ are more restricted in their diet, feeding on sea-blite, lamb's-quarters, Russian thistle, and sugar beet only, so far as observed. Eggs are often deposited on other plants, but the larvæ have not been observed to develop on them.

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[2] The innoxious maritime forms occurring along the Atlantic and Pacific coasts may be distinct geographical races.

[3] *Amaranthus retroflexus.*

The beet leaf-beetle, under normal conditions, subsists upon the weeds mentioned, which grow in waste alkali soil, and as long as there is a supply of these plants sugar beets are little damaged. In the spring, before the weeds are abundant, overwintered beetles often infest small young beets, completely destroying them. Later the insects develop in such numbers on the weeds that the latter are killed. The insects then resort to sugar beets for food. Many hundreds of acres of beets are thus infested every year. (Fig. 6.) The beet leaf-beetle is injurious also because it acts as a carrier or distributor of the spores of the leaf-spot disease of beets.[4]

The beetles cut large, irregular holes through the leaves of the sugar beet and the larvæ do similar injury, eating pits in the leaves, frequently without cutting through.

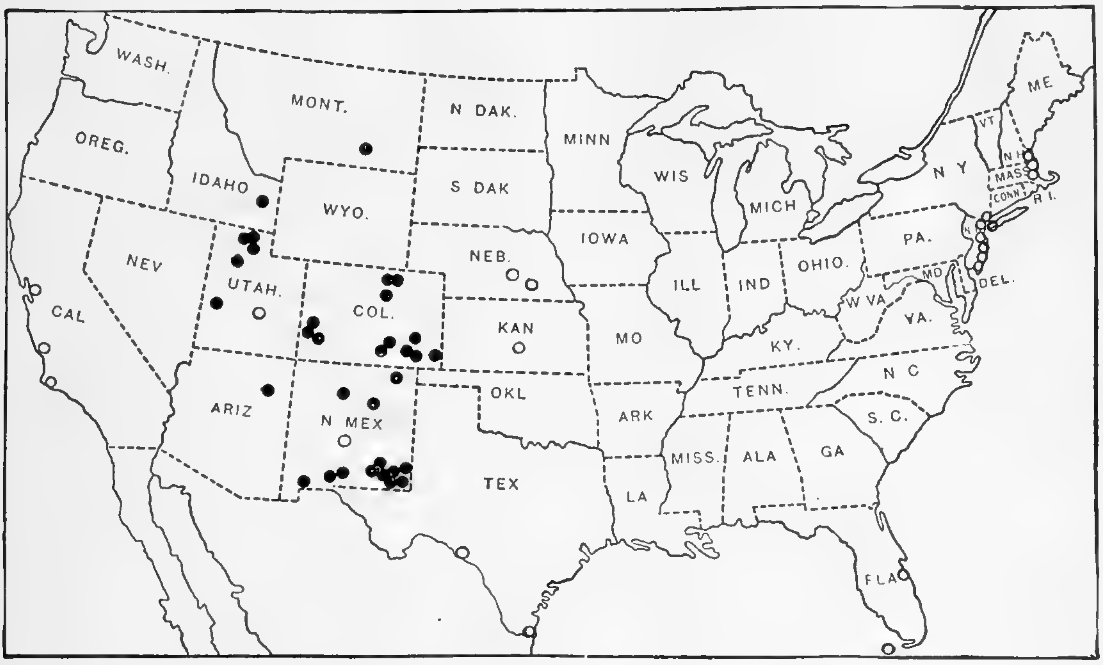

FIG. 4.—Map showing distribution of beet leaf-beetle. Large dots show injurious distribution; circles, innoxious localities.

When mature the larvæ leave the plants, burrow into the soil to a distance of half an inch or two inches, and form cells in which they transform to pupæ and then to adults.

LIFE HISTORY.

In the Arkansas Valley in Colorado and in regions having a similar temperature two generations or broods and a partial third brood are produced each year. The beetles pass the winter on the surface of the ground in alkali areas under tufts of grass, heaps of dead weeds, and other rubbish, a favorite location for this purpose being under tufts of "tickle grass,"[5] a habit which may be utilized to advantage in controlling the pest.

[4] *Cercospora beticola.*
[5] *Panicum capillare.*

The beetles issue from their winter quarters in March and April, feed, mate, and deposit their eggs. The first generation of beetles from these eggs, as observed in Colorado, appears late in May or

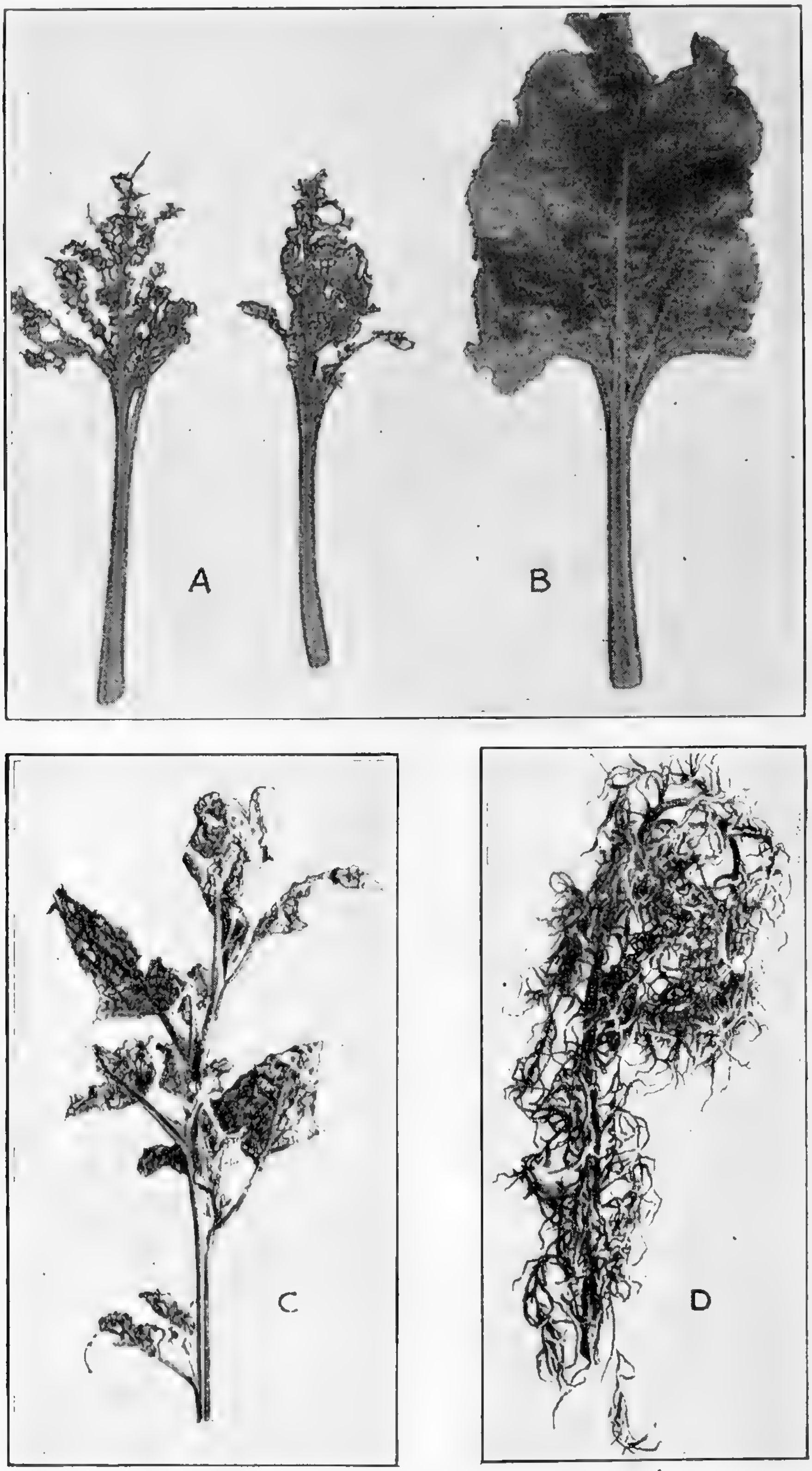

FIG. 5.—Food plants of beet leaf-beetle: *A*, Sugar-beet leaves riddled by beet leaf-beetle; *B*, a less injured leaf; *C*, lamb's-quarters killed by larvæ of beet leaf-beetle; *D*, sea-blite killed by same.

early in June, and the second generation becomes mature during the latter part of July. The eggs hatch in from 8 to 18 days, the larvæ

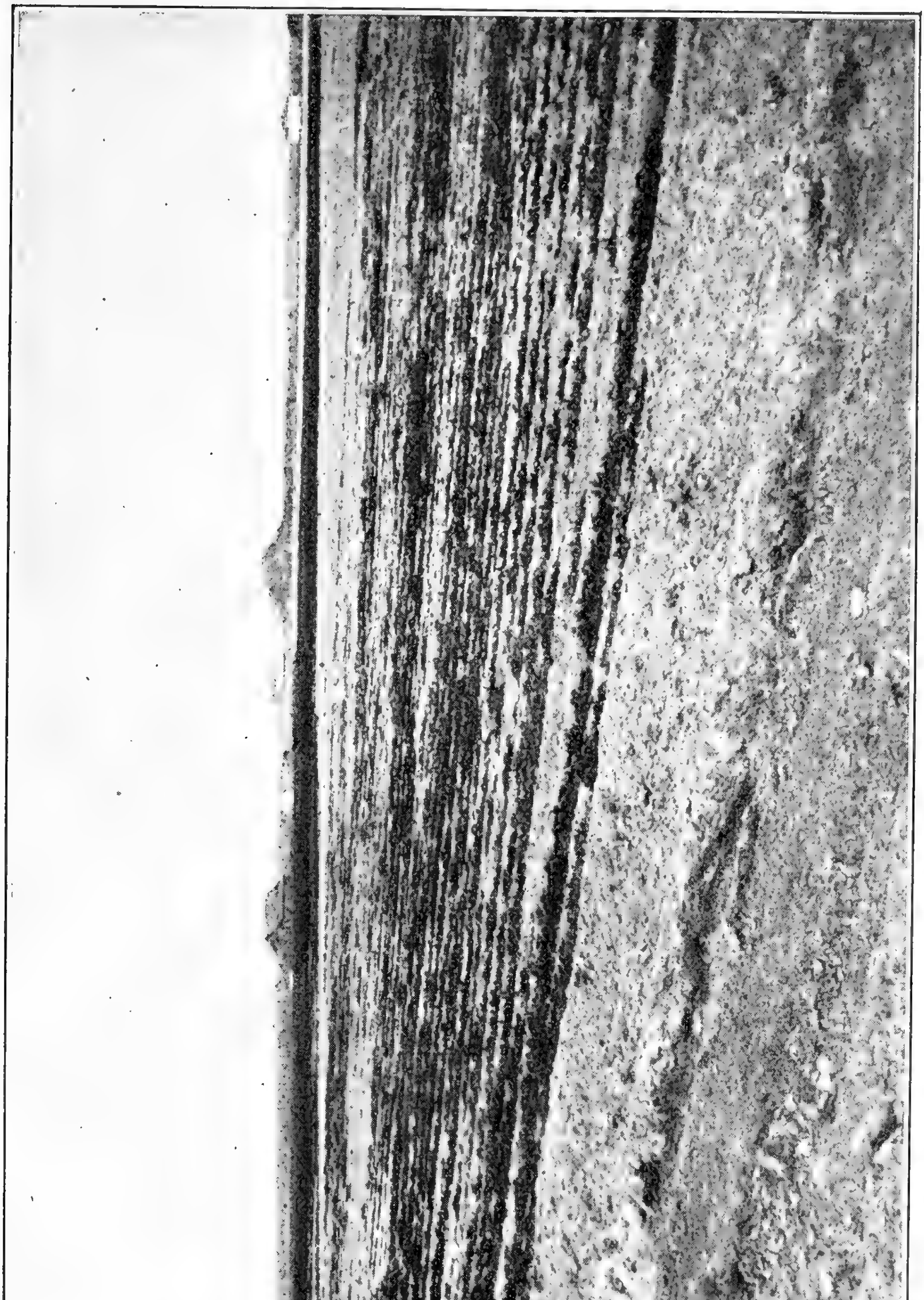

Fig. 6.—Sugar-beet field showing injury by beet leaf-beetle.

feeding for from three to four weeks before entering the ground to pupate. The pupa stage lasts 8 or 9 days. During September the beetles leave their food plants and go into winter quarters.

NATURAL ENEMIES.

Ladybird beetles of three species devour the eggs of this insect.[6] A bug[7] feeds on the larvæ and beetles. Mites and spiders also attack it, as does a fungous disease.[8] Wild birds of several species prey upon it and chickens feed readily on the beetles and have been utilized to advantage in destroying this leaf-beetle.

CONTROL MEASURES.

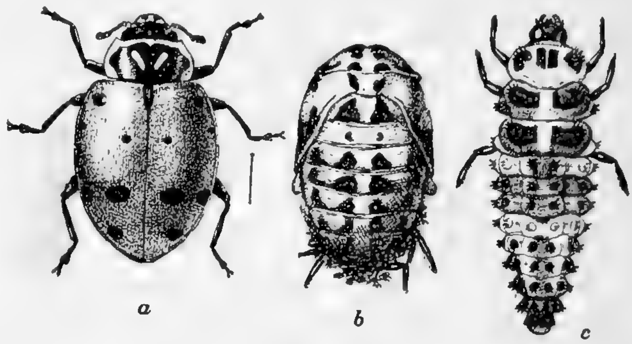

FIG. 8.—The convergent ladybird, an enemy of the beet leaf-beetle. Enlarged.

Taking advantage of the fact that the beetles pass the winter in alkali areas under tufts of grass, especially "tickle grass," dead weeds, and other rubbish, it is possible, by thoroughly burning these during the winter, to destroy the beetles in great numbers, as has been practically demonstrated. They may be trapped by placing heaps of weeds or bunches of straw or hay in these alkali areas which they frequent, and after they have gone into hibernation, the traps with the beetles are destroyed by burning. If this is done thoroughly, immense numbers may be destroyed, but careless, slipshod work will invariably fail to produce the desired result. The best time for this work is between the middle of November and the first week of March, when the dead grass and weeds may be easily burned.

Thorough tests with arsenicals and other insecticides have been made but without perfectly satisfactory results, neither dusting nor spraying being entirely effective.

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[6] The most useful are *Hippodamia convergens* Guer. (fig. 8), *H. sinuata* Muls., and *H. glacialis* Fab.

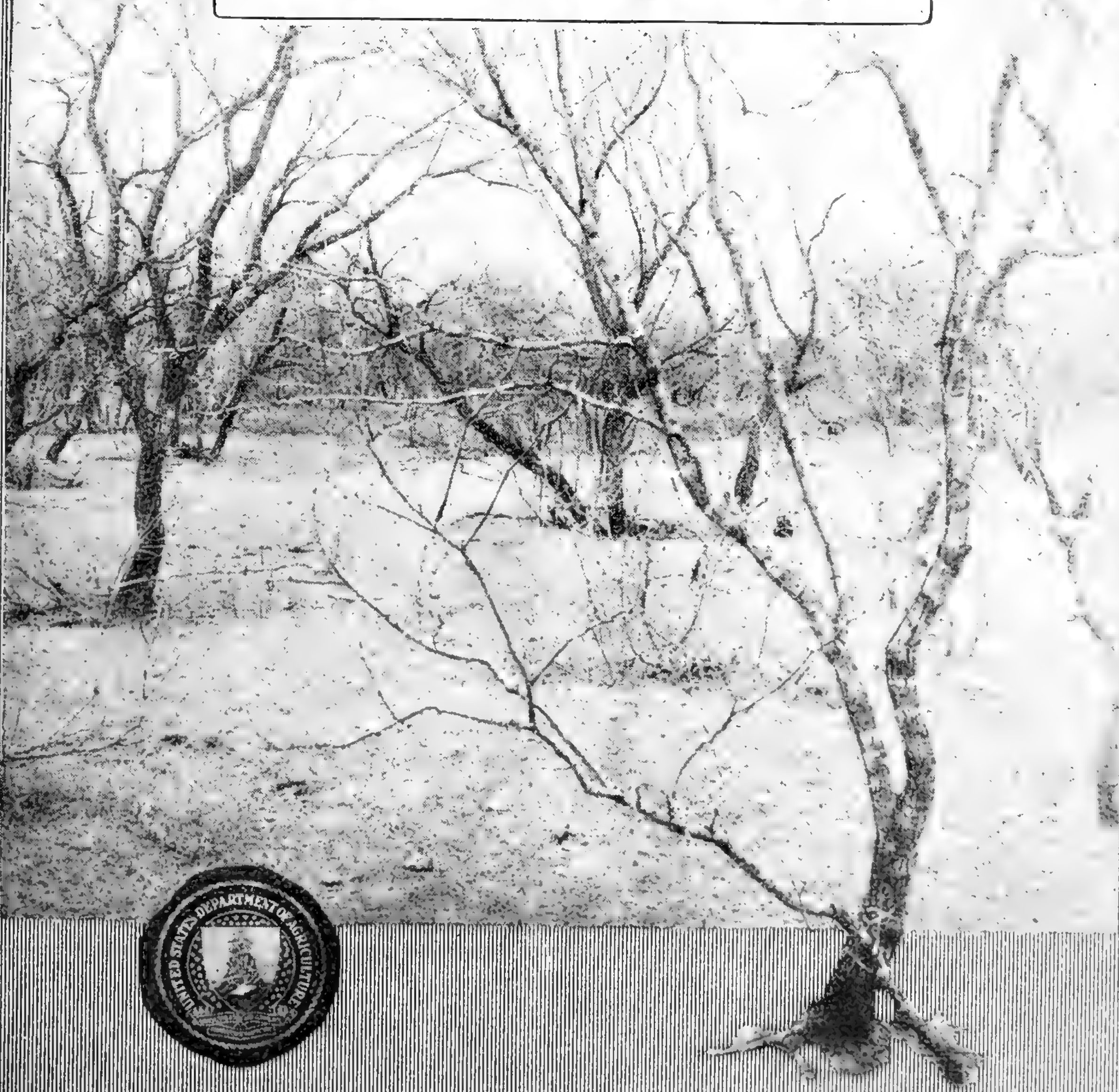
[7] *Perillus bioculatus* Fab., var. *claudus* Say.

[8] *Botrytis bassiana.*

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

FARMERS' BULLETIN --1197
UNITED STATES DEPARTMENT OF AGRICULTURE

Protection of MESQUITE CORDWOOD AND POSTS *from* BORERS



MESQUITE is used throughout the southwestern United States for many purposes, the most important of which are fuel and fence posts. In many sections it is the only tree available for any purpose whatever.

Certain borers completely destroy mesquite wood in a few months after it is cut, causing great loss and inconvenience. Wood cut for fuel is commonly piled in wood yards or along railways. In such locations it is subject to borer damage from February until October and is not infrequently reduced to a worthless pile of sawdust and honey-combed sticks. Fence posts are damaged by sapwood-feeding forms in such a way that staples become loose and the posts must be constantly replaced.

It has been found that by cutting fuel wood at certain seasons and turning more valuable products in the sun practically all insect damage can be prevented.

Washington, D. C. Issued May, 1921

PROTECTION OF MESQUITE CORDWOOD AND POSTS FROM BORERS.

By F. C. CRAIGHEAD,[1] *Specialist in Forest Entomology,* and GEORGE HOFER, *Entomological Ranger.*

CONTENTS.

IMPORTANCE OF THE MESQUITE.

Two or three species of mesquite (figs. 1, 2) occur in the southwestern United States and many more are widely distributed throughout the world. Mesquite's adaptation to arid climates makes it an extremely useful tree. In many countries it is chiefly valuable for the food product derived from the bean, although in the United States this is but little exploited at present. In much of the Southwest it is the only available wood.

All of the species or varieties occurring in the Southwest are put to many uses. The wood, being close-grained, hard, heavy, and very durable, makes excellent fence posts, frames for adobe houses, and, to a limited extent, mine props and crossties. The large roots and thickened bases of the stems furnish the best available fuel of this region.

The wood of all varieties of mesquite is the favored food of many borers, which completely riddle it and render it practically worthless a few months after it is cut. Some destroy the sapwood and honeycomb the heartwood within five months (fig. 3); others reduce the sapwood almost to dust within four months (fig. 4) so that fence staples drop out and let the wires down, necessitating constant replacing of the posts. It is not uncommon to see piles of cordwood so riddled that the individual sticks are easily broken and the spaces between the sticks are completely filled with boring dust. Dealers in mesquite fuel suffer considerable losses through such insect damage.

[1] Resigned Dec. 31, 1920.

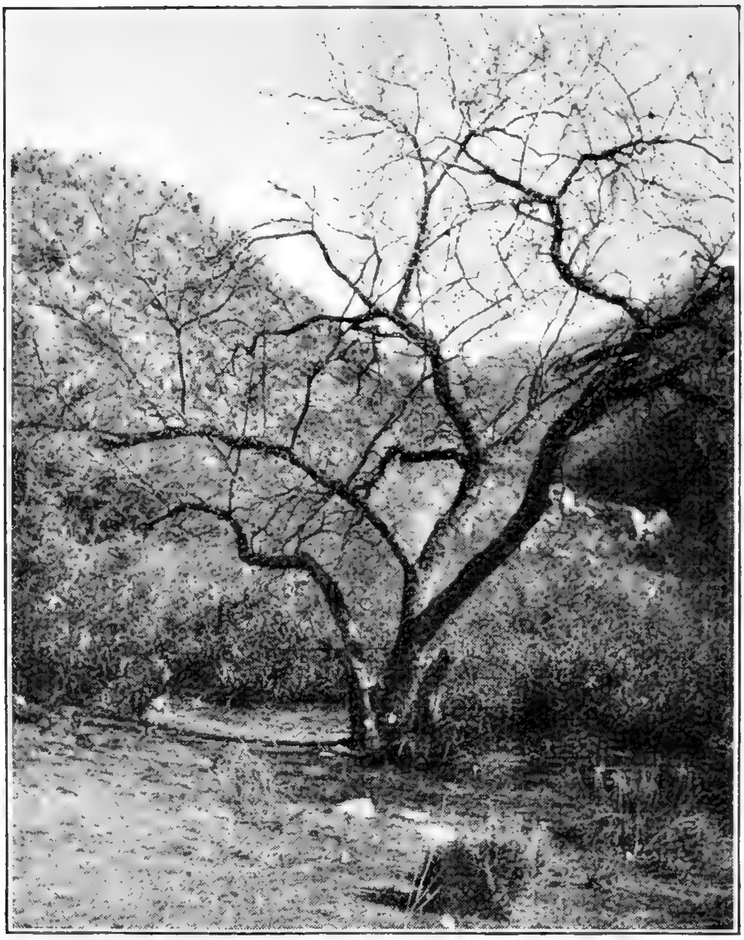


FIG. 1.—An average sized mesquite tree, showing characteristic form. Sabino Canyon, Catalina Mountains, Ariz.

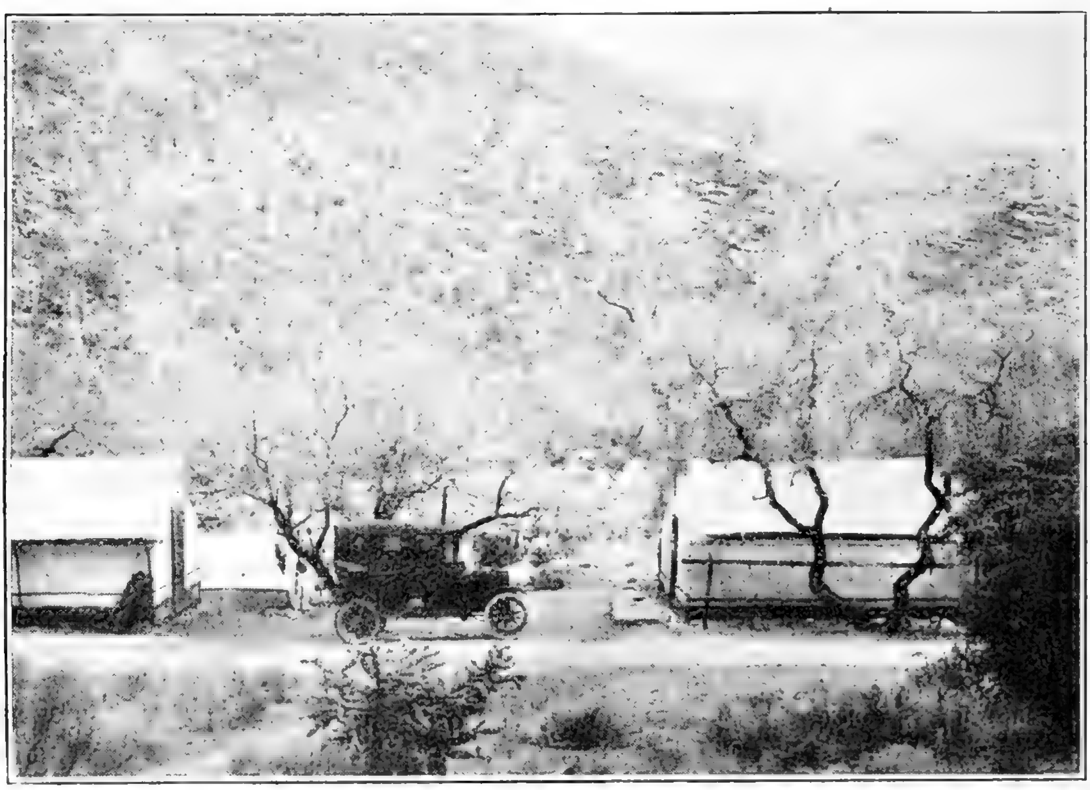


FIG. 2.—Forest Insect Field Station, Sabino Canyon, Catalina Mountains, Ariz. The trees growing close to the tents are mesquites.

Fig. 3.—Section of mesquite wood five inches in diameter, showing the sapwood destroyed and the honey-combed heartwood six months after attack by the roundheaded borer.

Fig. 4.—Section of mesquite stick after four months work by smaller powder-post grubs, showing depth to which sapwood is eaten. The small holes in the bark are made by the adults which have emerged.

INSECTS RESPONSIBLE FOR THE DAMAGE.

Although many different insects feed in the mesquite, not more than five or six are responsible for most of the injury in any locality, being numerically the more abundant or causing the greater damage by the character of their work.

These insects, according to their structure and the character of their work, may be grouped into three types or classes—namely, roundheaded borers, powder-post beetles, and flat-headed beetles. In the vicinity of Tucson, Ariz.,[1] where the experiments were conducted on which the results of this paper are based, there is only one roundheaded borer[2] of much economic importance, but this is the most destructive insect in mesquite. Three powder-post beetles are found, a large,[3] a medium,[4] and a small[5] form. One flat-headed borer[6] has been found to cause considerable injury.

FIG. 5.—Adult beetle of the roundheaded borer in mesquite. Enlarged.

CHARACTERISTICS OF THE INSECTS AND THEIR WORK.

All these insects have several distinct forms, known as the egg, the larva, the pupa, and the adult stages, but it is only the larval or

[1] In Texas another species of roundheaded borer (*Cyllene crinicornis* Chev.) and several other species of powder-post beetles (*Xylobiops* spp.) are equally numerous. Their habits are much the same and similar methods of treatment are effective.

[2] *Cyllene antennatus* White (Figs. 3, 5–8.)

[3] *Apatides fortis* Lec. (Figs. 9, 12.)

[4] *Dendrobiella aspera* Lec. (Figs. 4, 11, 13, 14.)

[5] *Xylobiops* sp. (Figs. 4, 14.)

[6] *Chrysobothris octocola* Lec. (Figs. 8, 10, 15.)

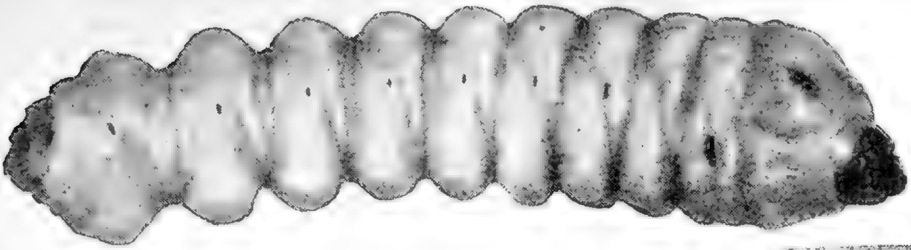


FIG. 6.—Larva, grub, or boring stage of the roundheaded borer in mesquite. Enlarged.

FIG. 7.—Section of mesquite with bark removed, showing larval mines and exit holes of the roundheaded borer.

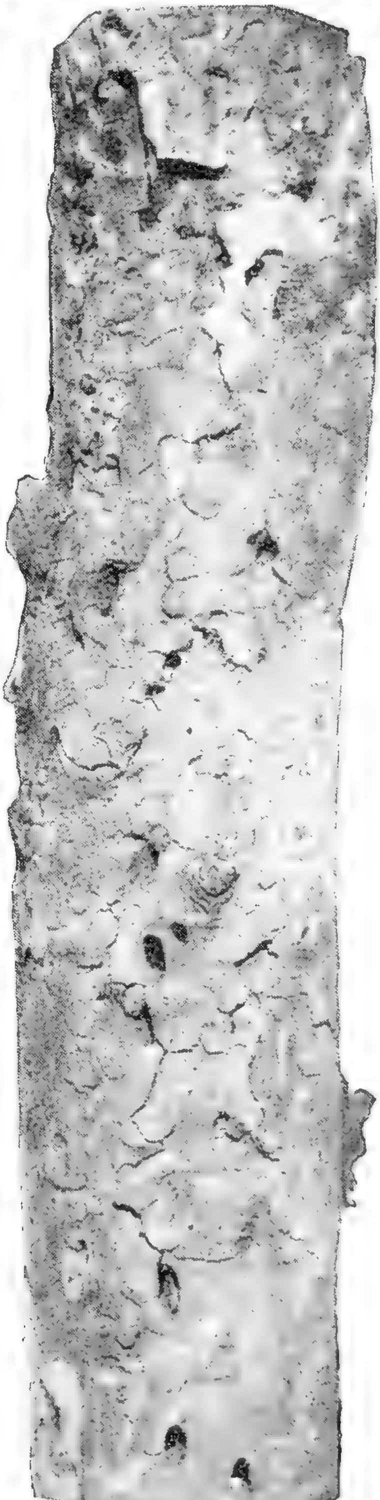


FIG. 8.—Mesquite stick with bark removed, showing larval mines of the roundheaded and flat-headed borers.

grub form that is responsible for the destruction of the wood. In all cases these larvæ hatch from eggs laid by the adult beetles. Some of these beetles are rarely seen, as they lie concealed during the day and deposit their eggs at night.

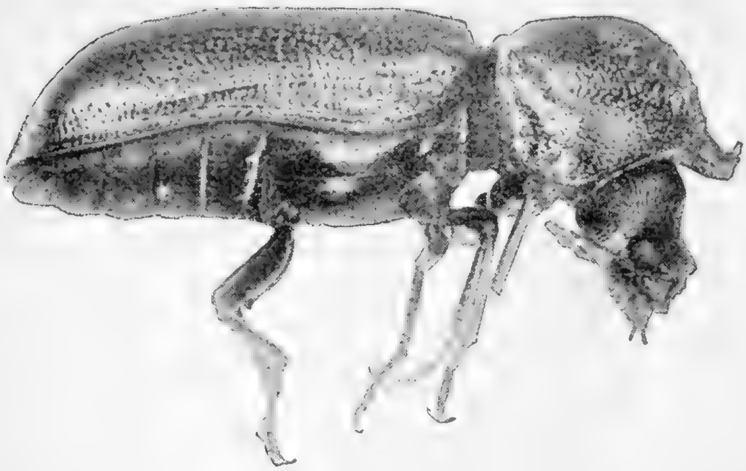


FIG. 9.—Adult beetle of the large powder-post borer in mesquite. Enlarged.

The adult round-headed borer (fig. 5) is a rather large beetle, slightly tapering behind, brown and gray mottled, one-half to one and one-quarter inches long, with quite long flexible horns. It places the eggs in crevices or under scales of the bark. From these eggs hatch tiny grubs that grow into rather large cylindrical borers (fig. 6), from three-quarters to one and one-half inches in length, yellowish white in color, and with a pair of strong brownish jaws. This is the largest of the borers in recently cut wood. The damage to the wood begins after these grubs hatch and bore in through the bark and sapwood, feeding as they go (figs. 3, 7, 8). They spend from 40 to 60 days mining in the sapwood, reducing it almost to powder, and then enter and honeycomb the heartwood by excavating long, oval galleries. Two months or more pass before there is any external evidence to show that the wood is seriously damaged. The boring dust expelled through a hole in the outer bark is the first and outward evidence of damage. This hole is enlarged as the borer increases in size, and through it the beetle finally emerges (fig. 7). This borer shows a preference for freshly cut wood, but has been known to attack wood cut five months, especially large limbs or sections of the trunk when they are in contact with the ground. It is the most destructive of the mesquite insects. The fact that a stick 4 inches by 2 feet contained over 60 of these large borers illustrates how thorough a honey-combing takes place.

FIG. 10.—Adult beetle of the flat-headed borer in mesquite. Enlarged.

The powder-post borers, as adult beetles (figs. 9, 11), are small to medium sized, short, cylindrical, dark brown to black, and hard shelled. The smaller forms bore through the bark and around the stem, laying eggs along this tunnel; while the larger form lays its eggs under scales of bark, as do the roundheaded borers. The grubs (figs. 12, 13) which develop from these eggs are curled like a closed finger, so that the head and the end of the body almost meet. They are thicker at one end, and range from one-quarter to three-quarters of an inch in length. The smaller forms appear in enormous numbers, completely riddling the sapwood with cylindrical holes tightly packed with fine powder that falls out when disturbed. By the time they are full grown they have almost destroyed the sapwood (figs. 4, 14). The grub of the larger form feeds only a short while in the sapwood and then goes into the heartwood, where most of the feeding is done. It seldom attacks freshly cut wood, but shows a decided preference for older and drier sticks and posts. It has only one generation each year.

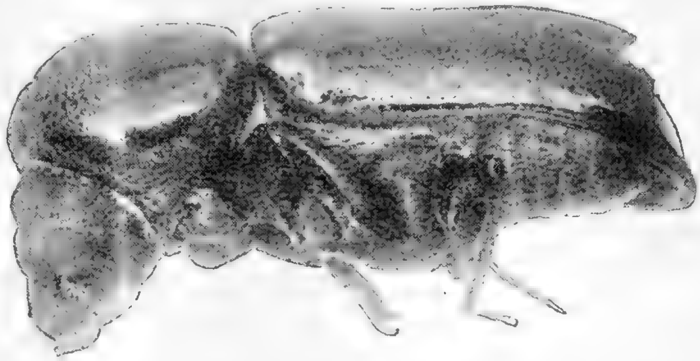


FIG. 11.—Adult beetle of the medium-sized powder-post borer in mesquite. Enlarged.

FIG. 12.—Larva, grub, or boring stage of the large powder-post beetle in mesquite. Enlarged.

The flat-headed borer, as an adult beetle (fig. 10), is hard shelled, flattened, oval, from one-half to three-quarters of an inch in length, and shining bluish black with light golden yellow spots on top. It lays its eggs on the bark. From these develop flattened yellowish white hammer-shaped worms (fig. 15), having the head end of the body much wider than the remainder. The larvæ mine between the bark and wood, grooving the sapwood with winding galleries until nearly full grown. (Fig. 8.) These mines are flattened in cross-section and filled with fine, tightly packed "sawdust" that does not easily fall out, and when it does so loosens in cakes.

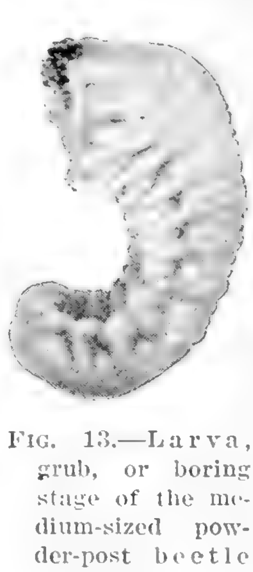


FIG. 13.—Larva, grub, or boring stage of the medium-sized powder-post beetle in mesquite. Enlarged.

SEASONAL ACTIVITY OF THE BORERS.

There is practically no month of the year in southern Arizona when some few of these beetles do not fly about seeking new wood on which to lay their eggs. During certain periods, however, their number is almost negligible.

The roundheaded borer has two generations a year and two periods during which the beetles are abundant. The overwintering forms mature and the adults emerge and fly chiefly during March and April. From these originates the summer generation, which develops in five months, the beetles emerging in August and September.

The powder-post borers fly as adults more or less during the entire year, although during November, December, and January very few are to be found. The medium and the smaller forms are most abundant from April to September, and during this time they develop very rapidly, producing two or three generations a year. During the hot part of the summer adult beetles develop from eggs in 60 to 70 days. The large powder-post beetle is active from July to September, having only one well-defined generation in a year.

The flat-headed borer flies about from March to October, being most abundant in April, May, and June. There is apparently only one main generation a year, although some develop more slowly than others, thus extending the period during which the beetles fly.

CONDITIONS FAVORABLE AND UNFAVORABLE FOR ATTACK.

The large powder-post beetle prefers wood which has dried out for several months, but all the other borers show a decided preference for freshly cut wood on which to lay their eggs. Some exceptions have been noted, but this is the general rule. Wood which is cut in the fall and seasoned during the winter months is very unattractive in the spring months when the beetles are flying about in search of suitable material for the development of their broods.

It has also been found that only the underside of logs or branches, or those pieces of wood not in the direct sunlight, are selected for feeding. During the greater part of the year the sun heats the upper surface so much that it is impossible for anything to live on it.

METHODS OF PREVENTING INJURY.

Upon a knowledge of the habits and seasonal activities of these insects must depend any method for combating them. It has been shown that during certain seasons of the year few of these insects fly about, that they do not like seasoned wood, and that they can not live beneath bark exposed to direct sunlight. Taking advantage of these factors, the following methods have been tried for preventing damage by them and have proved very successful for all practical purposes.

Fig. 14.—Mesquite stick showing exit holes of the medium and small powder-post beetles.

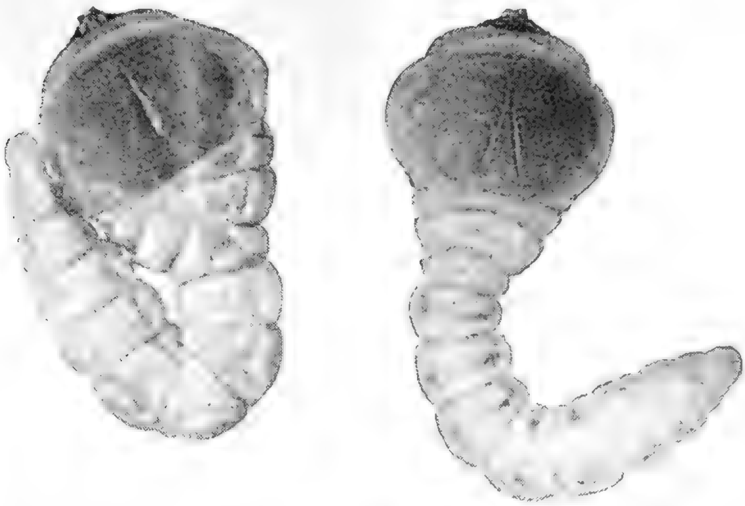


Fig. 15.—Larva, grub, or boring stage of the flat-headed borer in mesquite shown from above and below. Enlarged.

Fig. 16.—"Wigwam" method of piling mesquite cordwood. This type of piling is best, if the cutting is done between October 15 and December 15. It permits rapid seasoning of the wood during the period when the insects are not flying.

Except for immediate use mesquite cordwood should not be cut during the spring and summer months. Wood which is cut between the middle of October and the latter part of January and which is loosely ricked (figs. 16, 17), so that it quickly dries, is usually but little injured. The safest period, however, is from the middle of October to the end of November. Wood should not be stored longer than one year, after which much damage is done by the large powder-post beetle.

Fig. 17.—Mesquite ricked in open cribs, permitting of rapid seasoning. This is done in late fall and winter before the insects fly.

It has been found that extreme heat prevents attack and kills the grubs which may be in the sapwood. Therefore, the best method for treating posts and more valuable material that has to be cut between March and October is to lay them flat on the ground in the sunlight, then after two weeks turn bottom side up, and repeat the turning two weeks later. Two turns in six weeks are sufficient to kill the grubs or prevent attack. This method can be used effectively only between April 1 and October 1.

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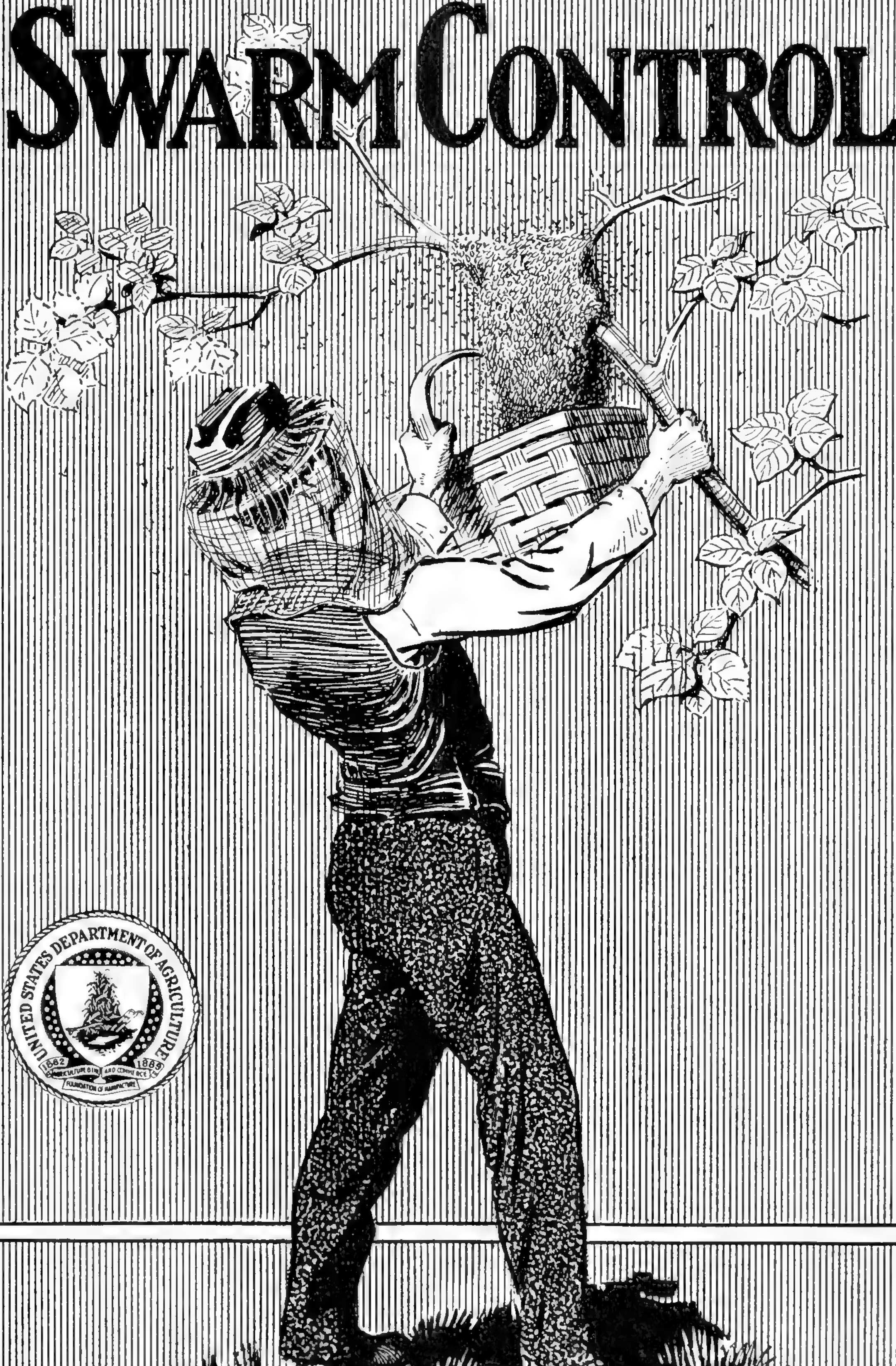
FARMERS' BULLETIN – 1198
UNITED STATES DEPARTMENT OF AGRICULTURE

SWARM CONTROL



WHEN honey is produced on an extensive scale it becomes necessary to distribute the colonies of bees in several apiaries to avoid overstocking. A serious problem when bees are kept in out-apiaries is the control of swarming.

Swarm control is less difficult in the production of extracted honey than of comb-honey. It is less troublesome in some locations than in others and during some seasons than during others. The reasons for these differences are important in the devising of measures for swarm prevention.

The tendency to swarm can be reduced by the introduction of superior stock, by the use of well-arranged hives and good combs, and by management which prevents a congestion of bees in the brood-nest. Swarming, therefore, can be prevented to a large extent by proper equipment and management.

The conditions which reduce the congestion in the brood-nest (preventive measures) are at the same time the conditions which induce the bees to work with the greatest energy in gathering nectar. When remedial measures are employed, the manipulation is such that the colony is thrown into a condition comparable either to the swarm or to the parent colony in nature.

These and other phases of the swarming problem are discussed in this bulletin.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. June, 1921

SWARM CONTROL.

GEO. S. DEMUTH,
Apicultural Assistant, Bee-Culture Investigations.

CONTENTS.

SUCCESSION OF EVENTS IN NATURAL SWARMING.

A COLONY OF BEES that is normal and prosperous increases its brood in the spring as its adult population increases, either until all the space available for brood-rearing is occupied or until the queen reaches the maximum of her capacity in egg laying. At first only worker-brood is reared; but as the colony increases in strength the rearing of drone-brood is begun, thus providing for male bees in anticipation of swarming. Finally, when the brood-nest becomes crowded with emerging and recently emerged young bees and the combs are well filled with brood, if nectar in sufficient quantity is available, several queencells are started and eggs are placed in them, this being the first definite preparation for swarming. About nine days from the time the eggs are laid the queen larvæ have developed to the point at which the queencells are sealed, and this is about the time the swarm usually issues. The exact time of the issuing of the swarm depends to some extent upon the weather, issuing sometimes being postponed by inclement weather and sometimes, especially in the case of Italian bees, being hastened by extremely hot weather.

In nature there is a marked slowing down in work of the colony after the queencells have been started preparatory to swarming, especially during the last few days previous to the issuing of the swarm, when the field workers in increasing numbers remain in the hive instead of working in the fields. In some cases in nature the instinct to gather nectar is almost entirely subordinated for several days at this time, the swarming instinct apparently becoming dominant. In well-managed colonies this is not universally true.

FIG. 1.—Swarm clustered.

When the swarm issues, a varying proportion of the adult bees, together with the old queen, fly from the hive, leaving in the original hive a greatly reduced number of adult worker bees, a large number of unemerged young bees, and several unemerged young queens. Some of the drones accompany the swarm, but many of them remain in the hive. After circling in the air the swarming bees form a dense cluster (fig. 1) on some convenient support, and after an interval they break the cluster and fly to a chosen abode for the inauguration of a new colony. After establishing themselves in a new home the bees begin almost immediately to build comb, the queen begins to lay eggs, and three weeks later young bees begin to emerge from the cells.

About a week after the issuing of the prime swarm the first of the young queens in the parent colony emerges from her cell. Instead of destroying the other young queens and establishing this first emerged young queen as the new mother of the colony, the bees usually swarm again about eight days after the prime swarm has issued, this afterswarm being accompanied by one or more young queens. Other afterswarms, each one smaller than the preceding, may issue with an interval of one or two days between until the colony is so reduced in numbers that further swarming is given up and all but one of the remaining young queens are killed. About 10 days after emergence the surviving young queen usually begins to lay, and normal brood-rearing is again established in the parent colony after an interval of at least 16 days during which no eggs have been laid. Each afterswarm establishes itself in a new abode, begins building its combs, and the young queen begins to lay about 10 days after emergence. If sufficient food is available such colonies may build up to normal strength for winter. This is the natural method of reproduction of colonies in the honeybee.

OBJECT OF SWARM CONTROL.

Swarm control is one of the most important factors in the recent development of commercial honey production on an extensive scale. It was practically unknown until within comparatively recent years. Formerly a colony swarmed when it got ready, and no attempt was made to foretell, forestall, or prevent the act. It was necessary to watch the bees constantly during the greater part of the day while the swarming season lasted to prevent the escape of issuing swarms. When a swarm issued it was hived in a separate hive, and in due time the parent colony sent out one, two, and often three or more afterswarms, thus dividing the original colony into several parts, each of which was too small for profitable honey production, except during an occasional season of abundance or in an especially favorable locality. The issuing of these prime swarms and afterswarms was looked upon as a part of the annual program of the bees.

Gradually methods were devised for the prevention of afterswarms, and systems of management were worked out whereby the actual working force of the colony is not divided by the issuing of the prime swarm. During more recent years methods have been devised by which swarming is either prevented entirely or the act of swarming is anticipated by the beekeeper, which permits the control of swarming without constant attendance. This has made it possible for a beekeeper to operate a series of apiaries without an attendant in each to watch for and hive the issuing swarms.

The beekeeper's problem at the beginning of the honey-flow is twofold: First, to prevent a division of the working force of the colonies; second, to stimulate the storing instinct to the utmost degree throughout the honey-flow. A division of the working forces or a subordination of the storing instinct at this time will cause a loss in the crop. Swarming can be prevented in many ways, but great care is necessary to avoid causing a subordination of the storing instinct, thus reducing the crop of honey, because the bees work with less vigor.

In extracted honey production it is now possible practically to prevent swarming in certain regions where the character of the honey-flow, its duration, and the time of its occurrence with reference to the advancement of the season are such as to discourage swarming, but this is by no means true for all regions. In comb-honey production it is possible greatly to reduce swarming by modern swarm preventive measures, but under some conditions in certain localities there are seasons when swarm control is still, as in the past, one of the greatest problems of the comb-honey producer.

FACTORS INFLUENCING THE TENDENCY TO SWARM.

Swarming is a fundamental instinct in the honeybee and can not be easily eliminated. Just what it is that brings uppermost the swarming instinct when conditions are favorable is not positively known, but it is well known that certain factors contribute to the tendency to swarm, and if care is taken to prevent their development in the colony this tendency is greatly reduced.

Colonies in the same apiary during the same season do not all behave alike as to swarming. Usually some colonies make no effort to swarm even during seasons when swarming is general; other colonies yield readily to ordinary preventive measures, while still others are so determined to swarm that gathering and storing are to a large extent subordinated until swarming is past. This variation may be partly due to a difference in hereditary characteristics and partly to a difference in the hives and the combs; but when these are nearly uniform throughout an apiary there is still a great variation in the tendency to swarm due to a difference in the distribution of the bees within the hive, a congestion of bees within the brood-nest being highly conducive to swarming while a distribution of the bees to parts of the hive other than the brood-nest, so that only enough bees are left there to care for the brood, usually results in no swarming. When young bees are emerging daily in great numbers, as during the spring brood-rearing period, they become the chief offenders in producing a congested condition within the brood-nest, on account of their habit of remaining on the brood-combs for some time after emergence before going to other parts of the hive or to the field.

In some cases failing queens may be superseded during the swarming season, and swarming may result from the presence of queencells begun in response to the supersedure impulse. Throughout this discussion of the factors which influence the tendency to swarm only normal swarming is included. Swarming through supersedure of queens, afterswarming, and swarming out because of hunger or advanced stages of brood disease have factors in the cause which do not apply to ordinary swarming.

INFLUENCE OF HEREDITY.

The variation as to swarming in different races of bees, and even within the race, has suggested the possibility of producing a non-swarming strain of bees. Considerable effort has been expended in this direction by breeding only from those colonies which show the least disposition to swarm, on the theory that the swarming instinct can be bred out. It is not possible to measure accurately the progress that has been made in this direction, largely because the breeder, during years of careful selection in breeding, may at the same time have modified his methods unconsciously, so that the bees swarm less because of better management. Considerable progress may have been made in reducing swarming by the elimination of undesirable stock, and it certainly is advisable to select as a breeding queen one whose colony shows little tendency to swarm, other factors being equal. It is a good rule to replace the queen of every colony that persists in swarming without sufficient cause by a young queen reared from the best breeding queen available. There is, however, no reason to expect that swarming will ever be eliminated by breeding alone.

INFLUENCE OF THE HIVE AND COMBS.

Some of the variation among colonies in the tendency to swarm is due to a difference in the hives and the combs. The size and shape of the brood-chamber, the character and arrangement of the combs, the facility with which the bees can ventilate every part of the brood-chamber and supers, and the ability of the bees to control the temperature of the air within the hive during hot weather are important factors which influence the tendency to swarm. Various hives, therefore, have been devised with the view of eliminating swarming.

SIZE OF THE BROOD-CHAMBER.

Usually there is more swarming from hives that have small brood-chambers than from those that have large brood-chambers. Under favorable conditions a good queen will increase the number of eggs which she lays in the spring, as the number of workers to take care of the resulting brood increases, until 70,000 or more cells may be occupied with brood at one time. If the room for brood-rearing is all occupied at any time before the maximum is reached, the colony may prepare to swarm, providing other conditions are favorable. To prevent swarming from this cause, therefore, it is necessary either to use a brood-chamber containing sufficient room for the spring brood-rearing or to give an additional brood-chamber during the spring if a small hive is used. So far as swarming is concerned, it is necessary to have a large brood-chamber only during the short period when brood-rearing is heaviest. Large hives, however, do not of themselves entirely prevent swarming.

CHARACTER OF THE BROOD-COMBS.

The combs of the brood-nest should be suitable for the rearing of worker brood throughout except for a few cells of drone-comb in the lower corners of some of the frames, which can not be entirely eliminated. It is quite possible to have a brood-chamber of ample size for the maximum amount of brood, but at the same time to have the brood-rearing space so reduced by imperfect combs that, so far as swarming is concerned, the effect is the same as if the brood-chamber were much smaller. Imperfect cells and drone-comb within the brood-chamber not only reduce its capacity for worker-brood but such imperfect comb may act as an obstruction to the queen in expanding the brood-nest in the spring. If combs unsuitable for brood-rearing are between the combs already occupied with brood and the perfect combs beyond, the imperfect comb stands in the way of a free expansion of the brood-nest, the queen may confine her work to but one side of the hive at a time, and swarming may follow. When two stories are used early in the season to supply the necessary brood-rearing space, it is important that combs which have perfect worker-cells to the top bar be used at least in the lower hive body to permit the queen to work readily through both stories. When combs having several rows of imperfect cells next to the top bar are used, the queen may be partially confined to one or the other of the hive bodies because of the space which intervenes between the available worker-comb in the two hive bodies. The partial confinement of the queen to one or the other of the two brood-chambers in this way may be equivalent to the use of but one brood-chamber, so far as available room for the queen is concerned.

As a swarm-preventive measure it is important, therefore, that all the combs used in the brood-chamber be suitable for the rearing of worker-brood throughout practically their entire area. Such combs can be provided only by the use of full sheets of foundation in the brood frames, together with special care in wiring the frames, imbedding the foundation, and having the combs built under favorable conditions. In extracted honey production much can be done to improve the character of the combs used in the brood-chamber by sorting out all imperfect ones for use only in the supers. Some beekeepers use special methods of wiring the frames by which the stretching of cells in the upper portion of the combs may be largely overcome. If brood is extended in new combs to the top bar of the frames during the first season, the combs are so strengthened by the cocoons that there is less tendency for them to stretch subsequently and cause misshapen cells in the upper portion.

Good combs so arranged that the brood-nest may be expanded without interruption until the maximum of the spring brood-rearing has been reached go a long way toward the prevention of swarming. Nevertheless, for reasons given later, these do not of themselves insure that there will be no swarming.

SPACE WITHIN THE HIVE.

Space that is not occupied by comb, especially within the brood-chamber, may influence the tendency to swarm. A deep space between the bottoms of the frames and the floor of the hive is undoubtedly advantageous in hot weather. This space may be as much as seven-eighths inch, with little or no trouble from the bees building comb below the frames unless they are badly crowded for room. Some beekeepers use a space 2 inches deep or more, but put under the frames a slatted rack to prevent the bees building comb there. This affords a large amount of room for the field bees during the night and also provides abundant opportunity for ventilation during the heat of the day.

Some extra space can be provided within the brood-chamber by spacing the brood frames farther apart. The bees will increase the thickness of that portion of the combs which contains honey, but they do not increase the thickness of that portion which contains brood, and the spaces between the combs are accordingly wider within the brood area. If the frames are spaced too far apart, however, the bees may build a thin comb between. Combs are usually spaced from $1\frac{3}{8}$ to $1\frac{1}{2}$ inches from center to center. The principle of wider spacing of brood-combs has been utilized in the construction of a nonswarming hive in which the combs are separated about an inch and slatted frames are inserted between the combs to prevent the bees from building in this space, but such hives have not come into general use.

VENTILATION.

Large entrances reduce the tendency to swarm by adding to the comfort of the bees during hot weather. Bees need much more ventilation during the honey-flow, when they are more active than at other times. It is sometimes advantageous to push one of the supers or the cover forward or backward on the hive far enough to make an opening for additional ventilation. Some beekeepers bore a hole an inch or more in diameter in one end of each super. These holes can be closed easily with a metal slide or a cork when not needed. It is usually not advisable to attempt to give ventilation in or between comb-honey supers because the bees are slow to seal honey adjacent to such openings, but ventilation may be given between the first comb-honey super and the brood-chamber by sliding the lower super forward far enough to form an opening for ventilation at the back.

FIG. 2.—Shade-board projecting beyond the hive on south side.

The location of the apiary should be such that there is a good circulation of air throughout the yard. Apiaries are sometimes located in hot nooks, where there is little circulation of air, and this usually results in an abnormal tendency to swarm.

SHADE.

Protection of the hives and supers from the direct rays of the sun during the hottest part of the day should decrease the tendency to swarm. Covers made of a single thickness of lumber, if unprotected, may cause great discomfort to the bees and may compel them to leave the supers during the heat of the day, which is a condition favorable to swarming. To prevent this, shade-boards large enough to project beyond the edges of the hive (fig. 2) may be used over the covers. These should be adjusted with one edge even with the north side of the hive so that the extra width projects on the south side, and there should be a space between the hive cover and the shade board to permit a circulation of air. The double covers which have an air space between the inner and outer parts afford more protection from the sun's rays than do single covers. but these do not shade the sides of the supers.

The hives, supers, and covers should be painted white, because the white surface better reflects the sun's rays. If no shade-board is used the covers should be repainted frequently. Other things being equal, it is to be expected that the tendency to swarm will be greater when dark or weather-beaten hive covers are used than when newly painted white covers are utilized, unless shade-boards are used over them.

The beekeeper who is much troubled with swarming can not afford to neglect the character and the arrangement of the combs, the size, shape, and construction of the hives, or even the color of the hives, if he desires to prevent swarming to the fullest extent, though the total prevention of swarming can not be expected from the character of the hives and combs alone.

INFLUENCE OF LOCALITY AND SEASON.

During some seasons few, if any, colonies attempt to swarm, while during other seasons and under similar management a majority of the colonies may prepare to swarm, especially if comb-honey is being produced. Generally speaking, bees are expected to swarm less during seasons of meager supply of nectar, whereas many swarms are expected in seasons of plenty; yet bees often swarm freely when nectar is not abundant and but little when it is abundant. The tendency to swarm, therefore, is not necessarily directly connected with the quantity of nectar available during the swarming season if a sufficient supply of food has been available previously to enable the colony to build up to swarming strength.

Furthermore, in some regions swarming may be troublesome during most seasons, even after years of careful selection in breeding, together with the best of equipment and management, while in other regions bees of almost any strain, when ordinary precautions as to equipment and management are taken, are practically nonswarming year after year. Why do bees swarm freely one season and refrain from swarming the next, if both seasons are prosperous, and why do bees in one region habitually swarm excessively, while bees of the same strain, in the same kind of hives, and under similar management, but in another region equally good, swarm little, if any? The answers to these questions are apparently closely connected with the rapidity with which the bees build up in the spring, together with the character of the honey-flow and the weather conditions during the swarming season.

INFLUENCE OF CHARACTER OF SPRING BROOD-REARING.

Throughout the entire country there is a definite period during fall and winter when brood-rearing is entirely suspended in all normal colonies. When brood-rearing begins again in the spring, if sufficient food is available, the amount of brood is usually increased until a certain maximum is reached, after which brood-rearing declines. When spring brood-rearing is most extensive the queen may lay more than 3,000 eggs daily, but she does this during a short time only. There is, therefore, a well-marked period of extensive brood-rearing in the spring. Apparently this spring expansion of brood-rearing is stimulated by the oncoming of spring following the period of little or no brood-rearing. It is stimulated also by early incoming pollen and nectar, but may occur even when these are lacking, provided a sufficient quantity of honey and pollen is stored in the hives and water is available. In this respect the spring period of extensive brood-rearing differs greatly from other periods of more or less extensive brood-rearing, since after the first great expansion in brood-rearing the presence of honey stored in the hive is not a sufficient stimulus to cause the bees to rear brood extensively.

In all regions swarming may be expected within a well-defined "swarming season" which coincides roughly with the period of maximum brood-rearing. When there is a well-marked secondary expansion in brood-rearing later in the season it may be accompanied by a secondary swarming season. When the primary period of maximum brood-rearing is prevented because of extreme weakness of the colony, or a dearth of food, swarming may simply be postponed until a later honey-flow and may then be expected as during the normal swarming season. If no period of extensive broad-rearing takes place during the season there is usually no swarming. Differences in seasons and differences in localities may modify the rapidity with which brood-rearing is carried on, so that the maximum amount of brood may be greater in certain years than in others and greater in certain localities than in others.

Other things being equal, the **tendency to swarm is the greatest in those localities in which,** on account of climatic conditions and available food, **the bees increase brood-rearing most rapidly in the spring.** In any locality the tendency to swarm is greatest **during those years when,** because of favorable conditions, **the bees build up in the shortest interval in the spring.** Among the colonies in the apiary the tendency to swarm is greatest **in those colonies which reach their peak of brood-rearing most rapidly.** When colonies of bees build up so rapidly in the spring that a maximum of 60,000 to 70,000 cells of brood is reached, they have during a certain period a large proportion of recently emerged and emerging bees. Such colonies are in the best possible condition to gather and store a crop of honey if the honey-flow begins at about the time they reach their maximum in brood-rearing, but they are strongly inclined to swarm.

When brood-rearing is conducted moderately, colonies may have as many workers when they reach their maximum strength, but they do not have as large a proportion of young bees at any time as those which build up more rapidly. Thus, two colonies at the beginning of the honey-flow may be equally strong as to the number of bees but differ decidedly as to the average age of the bees and, other things being equal, **the tendency to swarm is greater in the colony having the larger proportion of recently emerged and emerging bees.**

INFLUENCE OF YOUNG BEES.

The fact that the tendency to swarm is greatest at about the time the bees are rearing the greatest amount of brood has led to the belief that swarming is caused by the presence in the hive of a large proportion of young bees not yet old enough for field work. The measures in common use for the prevention of swarming tend to obviate this predominance of young bees or to relieve the crowded condition resulting from their presence within the brood-nest, and the successful remedies for swarming are those which correct this unbalanced condition in the population of the colony. Natural swarming itself removes the excess of young bees and brings about a condition in which none of the workers need be unemployed if there is a honey-flow. It is probable that the bees too young to work in the fields contribute to the tendency to swarm by their persistence in remaining for several days within the brood-nest near where they emerged from the cells, instead of going to the more remote and less congested parts of the hive, and in this way they produce a crowded condition within the brood-nest.

The sensation of strength in the colony is evidently not in proportion to the number of bees within the hive but depends largely upon their distribution. Even weak colonies may become crowded and swarm if most of the bees of the colony confine themselves to the small area occupied by brood, because this area is surrounded by sealed honey or imperfect combs, or because the more remote portions of the hive are so unattractive that the colony does not expand its activities beyond the brood area in proportion to the increasing numbers of oncoming young bees. On the other hand, a strong colony which rapidly expands its work into remote parts of the hive may apparently entirely escape the sensation of great strength because of the better distribution of the bees.

The distribution of the young workers during the first two weeks of their lives when they are emerging at the rate of 3,000 or more per day undoubtedly has much to do with the tendency to swarm. It is, therefore, highly important that those parts of the hive outside of the brood area be attractive and easily available for the oncoming young bees, so that they will expand into and occupy the more remote portions of the hive instead of crowding the brood-nest.

INFLUENCE OF HONEY-FLOW.

A colony of bees that is approaching its maximum of strength at the beginning of or during the honey-flow, having many young bees recently emerged, may be able to send but a comparatively small number of workers to the field because most of them are too young for field work. In this case the brood-nest is crowded with these unemployed young bees during the heat of the day, and the added prosperity of the honey-flow may quickly bring on the swarming tendency. On the other hand, a colony that has passed its maximum of brood-rearing some time previous to the honey-flow, having comparatively few emerging and recently emerged young bees, but most of its workers old enough to work in the fields, may send such a large proportion of its workers to the fields when the honey-flow begins that most of the workers are out of the hive during the heat of the day and swarming may be given up. The advent of the honey-flow, therefore, may have an opposite effect as to swarming upon colonies which are equally strong in number of bees but different as to the age of the workers. This may explain the variation observed in various regions as to the effect of the honey-flow on swarming.

INFLUENCE OF WORK IN SUPERS.

The giving of additional room and employment to attract the unemployed bees out of the brood-chamber is of great importance in the expansion of the activities of the colonies and has a direct bearing upon an advantageous distribution of bees throughout the more remote portions of the hive.

Usually the tendency to swarm is stronger during the early part of the honey-flow if the colonies are strong in young bees at that time. It is important, therefore, that each colony expand into and occupy promptly the first super that is given. To accomplish this it is necessary that this first super be attractive to the young hive workers. If supers, either for comb-honey or for extracted-honey, containing only foundation, be given to a strong colony just before the honey-flow the bees will not take possession of them and begin work on the foundation to any extent until the honey-flow has begun, and meanwhile the colony is crowded for room. The addition of this room with only foundation, therefore, does not affect the distribution of the bees until they take possession of and occupy the super, while in the meantime conditions for swarming may develop rapidly. On the other hand, if a super of empty combs be given to a strong colony previous to the honey-flow, the younger bees in great numbers immediately take possession of the added super and begin to repair the comb and to prepare it for use. If the colony is strong these bees do not merely explore the super but actually occupy it, the brood-chamber, therefore, being relieved of many thousand young bees that are not yet old enough for field work.

In either comb-honey production or extracted-honey production, if the colonies are not strong when the first super is given they may refuse to expand into and occupy it or they may take possession of only a small portion of it. Such colonies usually store any honey they may accumulate at this time in the combs of the brood-chamber adjacent to the brood, and if in this way they surround themselves with honey and seal it they are not inclined to pass this finished work readily to expand into the supers beyond. In this way they may block off and occupy only a small portion of their hive and crowd this limited area even though empty combs are used in the supers above, whereas strong colonies readily expand beyond such barriers. For this reason it is sometimes more difficult to prevent swarming in colonies of medium strength than in strong ones. Any barrier of any kind between the brood-nest and the supers becomes especially objectionable in colonies of deficient strength. Some strains of bees are more inclined to limit their activities to a portion of the hive in this way than other strains, and may be more inclined to swarm for this reason.

The first super usually should be given before the bees need it, and especially in extracted-honey production it should be given as soon as the bees are strong enough to occupy it, in order to furnish a place outside of the brood-nest for the multitude of oncoming young bees. This first super for extracted-honey production should be supplied with empty combs, or at least half of its frames should contain empty combs. If no empty combs are available for this purpose, some of the combs of brood should be put into the super to start work there promptly and distribute the bees over greater surface. The first comb-honey supers are usually put on a little later than supers for extracted honey and should contain some sections in which the combs are already built, which were saved from the previous year. These combs usually induce the bees to occupy the super earlier than when only foundation is used in the sections.

As work progresses in the first super and the cells are being built out to full length, the room that can be occupied by bees decreases, making it necessary, if the super has been completely occupied, for some of the bees to go elsewhere. When the honey is finally ripened and sealed, few bees remain in the supers. Therefore, if a second super is not given until the first one is finished, most of the super workers are forced to go back into the brood-chamber. In the meantime there is no place for the oncoming young bees to take up inside work before they are old enough to begin to work in the fields. The super workers, forced out of the super back into the brood-chamber.

added to those emerging rapidly in the brood-chamber, give a large number of bees there which must remain unemployed until they are old enough for field work, thus causing a condition highly conducive to swarming. There is, therefore, a critical period not only just before the bees take possession of the first super of the season, but to a certain extent just previous to the giving of each additional super.

During the early part of the honey-flow when swarming is imminent additional supers should be supplied as the bees need them, before any of the workers are crowded back to the brood-chamber. If the honey-flow is good, the additional supers should be given as fast as the bees can be induced to occupy them, in order that the expansion of the work and the room in the supers shall keep pace with the oncoming of the young workers. Each newly added super should be so accessible, comfortable, attractive, and advantageously placed that young bees will come up and occupy it at once, which they may fail to do if newly added supers are too hot, too cold, too remote, difficult to ventilate, or otherwise unattractive. Supers should be snug and warm during cool weather and protected from too much heat during hot weather. During the latter part of the honey-flow, as the swarming season begins to wane, the bees may be crowded as to super room to induce them to finish the work well and concentrate the honey in fewer supers, but by this time there is less danger of swarming.

SPACE FOR THE EVAPORATION OF NECTAR.

Super room should be adequate not only for the storage of ripened honey but also for the distribution of the thin incoming nectar throughout a large surface of comb with but a small amount in each cell, to facilitate the evaporation of water from the nectar. A large amount of comb surface is needed for this purpose in regions where the nectar is especially thin when it is first brought in. In arid climates not so much extra room is needed for the evaporation of nectar as in humid climates. When all the cells available for ripening nectar are in use during a heavy honey-flow a slowing down of the work of the colony must follow, for the bees will not fill the cells full of raw nectar. When nectar is thin and abundant, the evaporating space may all be in use before much honey has actually been stored, which may result in a stagnation of the work of the colony, and in turn may increase the tendency to swarm. For this reason it is usually necessary to give more supers during the honey-flow than are actually filled with ripened honey.

TIERING UP SUPERS.

In producing comb-honey if the honey-flow is good and swarming is imminent each newly added super may be placed immediately above the brood-chamber; that is, between the brood-chamber and the supers in which work has already been started. This induces the bees to begin new work promptly and takes additional thousands of young bees out of the brood-chamber into the supers. (See Farmers' Bulletin 1039.) In extracted-honey production when empty combs are used in the supers it is not so essential to place the newly added ones below those already on the hive, but to do so undoubtedly entices more bees out of the brood-chamber than when they are placed on top of the other supers. Shallow extracting supers are usually tiered up in the same manner as comb-honey supers, each newly added one being placed below the supers already on the hive during the time that swarming is imminent. If full-depth extracting supers are used, half of the combs may be removed from the middle of the partly filled super and empty combs or frames of foundation taken from the new super may be put in their place. The partly filled combs that were removed are then placed in the middle of the new super, after which it is placed on top. This process may be repeated if necessary as often as it is desirable to give additional room close to the brood-chamber.

Great care should be taken, especially in comb-honey production, to discontinue such a rapid expansion of super room in time to have the work well finished. During the latter part of the honey-flow empty supers may be added on top of those already on the hive in either comb-honey or extracted-honey production, to prevent too much incomplete work at the end of the honey-flow, for at this time there is less probability of swarming than earlier in the season.

In regions where the swarming season occurs during the honey-flow it is of great importance that every condition possible be provided that will entice the younger bees from the brood-chamber into the supers and the field bees from the brood-chamber to the fields. If the brood-nests can thus be kept free from too many unemployed bees during the swarming season there should be little inclination to swarm.

INFLUENCE OF IDLE FIELD BEES.

The brood-chamber may be congested with bees, however, and swarming may sometimes occur apparently through no fault in the distribution of young bees within the hive, since a crowded condition may be brought about or intensified by the field bees as a result of certain peculiarities of weather conditions and honey-flow.

The presence of a large number of field bees within the hive during the swarming season evidently greatly increases the tendency to swarm. When the field bees are out of the hive the colony is relieved of their presence during the heat of the day when they would add

26646°—21——3

most to its sensation of strength. If, however, because of some fault in the management, because of adverse weather conditions, or because the flowers yield nectar erratically, the field bees remain in the hive, they add greatly to the crowded condition of the brood-nest and, therefore, increase the tendency to swarm.

It is well known that the advent of a honey-flow and active work in the field greatly stimulates the activities of the bees within the hive. Thousands of younger bees or hive workers now begin the tasks of preparing empty combs for incoming nectar, or for brood-rearing, building new comb, transferring nectar or honey, and ripening the new nectar, but there is apparently a rather delicate balance between the work inside the hive and the work in the field, for if the work inside the hive is interrupted in any way the work of the field bees slows down accordingly. Therefore those factors already discussed which tend to produce congestion and idleness among the young workers within the brood-nest during a honey-flow quickly add greatly to the number of unemployed bees by causing the field bees to remain in the hive instead of going to the fields.

If for any reason the expansion of the activity of the hive workers is interrupted a stagnation of the activity within the hive must follow, which in turn causes more and more stagnation in the field work. Such a condition may arise if the young bees do not readily enter and occupy the first super that is given, if additional room is not given promptly to keep pace with the increasing number of oncoming young bees, if all the available space for evaporating nectar is in use, if the hive workers are driven out of the supers into the brood-chamber by heat or lack of ventilation, if the newly added supers are too remote or otherwise unattractive, or if so much of the work is being finished that the new and unfinished work is less than that needed to employ most of the hive workers. When the field workers stay within the hive in increasing numbers during a honey-flow, preparation for swarming is the usual result. In this way a slight interference with the activities of the hive workers may quickly develop into a serious condition which might easily have been avoided if taken in time.

When the field bees are confined to their hives by several days of rain just previous to or during the swarming season, the result may be a greatly increased tendency to swarm. Sometimes two weeks of rain at about the time of the normal swarming season is followed by intense swarming. When the field bees remain in their hives a part of the time during the honey-flow because the flowers yield nectar erratically the tendency to swarm may be greatly increased. The presence of the great mass of field bees within the hive during the heat of the day from any of these causes must add greatly to the tendency to swarm, especially when the bees crowd in great masses in the space below the frames and in the lower portion of the brood-chamber, as they usually do when they are in their hives temporarily during the honey-flow.

In extracted-honey production it is not difficult by good management to prevent a crowding of the brood-nest during the honey-flow by either young bees or field bees, except in the last two cases mentioned. Both of these conditions are frequently encountered, especially in the northeastern portion of the United States in the clover region. There is, of course, no way by which the field bees can be prevented from staying in their hives in either case, even if it were desirable to do so, but by providing a deep space below the frames and an abundance of ventilation, together with adequate protection from the direct rays of the sun, the discomfort of the colony brought about by the field bees within the hive during the day may be considerably relieved.

To prevent swarming to the greatest extent it is necessary to induce most of the hive workers to leave the brood-nest early in their lives to take up work in the supers, so that the bees of the hive are distributed over a large comb surface which in turn should stimulate the field bees to go to the field in greater numbers. During the heat of the day no more bees should remain within the brood-chamber than are needed for the work to be done there. Such a distribution and employment of the hive workers usually induces the field workers to put forth the greatest energy in gathering nectar.

NATURAL SWARMING.

After having used all the known preventive measures, there will still be some colonies that attempt to swarm in certain locations during some seasons even in extracted-honey production, and in comb-honey production a large percentage of colonies may attempt to swarm. In either case, but especially in extracted-honey production, some of these swarms are probably a result of the imperfect application of preventive measures in time to prevent the beginning of the series of events which lead up to the actual issuing of the swarm. Except in certain localities, the beekeeper whose equipment and management meet the requirements previously outlined in this bulletin as swarm preventive measures should be troubled little by swarming if extracted honey is being produced.

CORRECTION OF CONGESTION BY SWARMING.

The conditions within the brood-chamber are changed greatly by swarming, both in the swarm and in the parent colony. In the swarm there are no very young bees and, of course, no emerging bees during the first three weeks. The workers of the swarm that are not needed for the work inside the new hive are old enough for work in the fields, and when most of the bees of a colony can go to the fields for nectar during the heat of the day a surprisingly large number may be massed together in one hive without causing a stagnation of their activities. When the first young bees begin to emerge three weeks later the daily emergence of young is small in comparison with that of a colony during the spring brood-rearing period; therefore the swarms usually do not become greatly congested with young bees again during the same season. Swarms that are hived in an empty hive on a new location seldom swarm again the same season, especially where the season is short, but if they are hived on empty combs or combs containing honey or a little emerging brood they may do so. Even when most of the workers of both the parent colony and the swarm are reunited, or when two or more swarms are hived together in one hive, the bees are usually satisfied without further swarming if plenty of room is given in the supers.

The parent colony loses most of its field workers and the queen when a swarm issues, but it has a large amount of brood and several queencells usually sealed or nearly ready to be sealed at the time of the issuing of the swarm. When the young queens begin to emerge about a week later, if the beekeeper does not interfere, the colony may cast one or more afterswarms, each accompanied by one or more of the recently emerged virgin queens. When there are no longer sufficient bees left to divide up among the emerging queens, all but one of the young queens are killed, this surviving one in the normal course of events later becoming established as the new mother of the parent colony. The rapid emergence of young bees soon restores the parent colony to good strength, but when swarming takes place during the honey-flow the parent colony may not recover sufficient strength in field workers to take an important part in gathering the season's crop of honey. After the young queen becomes established a parent colony seldom swarms again the same season, even though it may become quite populous and the season may be prosperous.

Thus neither the swarm having the old queen and the older bees in establishing itself in a new home, nor the parent colony having the young queen in reestablishing itself in the old home, is inclined to swarm again the same season. In each case there is an interruption in the emergence of young bees. These are important facts in the control of swarming.

INFLUENCE OF YOUNG QUEENS.

The fact that parent colonies seldom swarm again the same season has led to the belief that colonies having young queens do not swarm the first summer of the queen's life, but while such colonies are less inclined to swarm the use of young queens can not be depended upon except under certain conditions. If a young queen is introduced into a colony previous to the swarming season after a period of queenlessness, so that there is a period of 10 days during which no eggs are laid, there is usually no attempt to swarm again during the same season, especially if this interval of no egg-laying occurs late enough so that the young queen is not able to reach her maximum of egg-laying before the close of the honey-flow. If, however, the old queen is removed from a colony previous to the swarming season and a young laying queen is introduced at once without an interval of no egg-laying, the tendency to swarm may be reduced little, if any. The condition of the colony brought about by a period of queenlessness is apparently a greater factor in reducing the tendency to swarm than the age of the queen, for if the old queen is removed or caged within the hive for 10 days and then reintroduced, no queencells being permitted to mature in the meantime, the bees give up swarming frequently for the remainder of the season. Colonies which have both a young queen and the interval of queenlessness usually may be considered safe from swarming again the same season, especially in the North. Such colonies are comparable to the parent colony in nature.

VARIATION IN TIME OF SWARMING SEASON IN RELATION TO THE HONEY-FLOW.

Since the time of the swarming season is apparently determined largely by the great expansion of spring brood-rearing, it does not necessarily coincide with the main honey-flow of the season, although the honey-flow may greatly modify the tendency to swarm (p. 14). The time of the swarming season with reference to the time of the main honey-flow is a factor of importance in choosing the proper management of colonies that swarm or prepare to swarm.

(1) In some localities, particularly in some of the Southern States, the main honey-flow may not occur until six or eight weeks after the swarming season. The colonies may reach their maximum strength during the spring brood-rearing period and swarming may be stimulated by a light honey-flow. There may be considerable swarming even when the colonies are securing no more than a living from the fields, and sometimes bees may swarm even when it is necessary to feed the newly hived swarms to prevent starvation. If there is a complete dearth of nectar at this time, however, the bees usually give up swarming and greatly reduce their brood-rearing activities. Such colonies after having reached their maximum strength in the spring are not inclined to rear brood extensively again until the honey-flow begins. Under these conditions the colonies arrive at the beginning of the honey-flow with a large proportion of old bees and usually do

not swarm during the honey-flow unless it is of sufficient duration for the bees to fill their hives again with brood and to become crowded with young bees before its close. Swarming is not difficult to control under these circumstances unless the bees are gathering a little more than a living at the time of the swarming season, and usually the addition of an abundance of room in the form of empty combs with the brood extending through two or more stories of the hive will practically prevent swarming under these conditions.

When swarming occurs six weeks or more previous to the beginning of the main honey-flow, both the parent colony and the swarm should be given every advantage to enable them to build up again to full strength, so that both may gather a full crop. In such a locality, if natural swarming is permitted, all afterswarming should be prevented (p. 25). It is better, however, to divide the colonies, some time before they have reached their maximum in spring brood-rearing, into two parts, supplying the queenless portion with a young queen, thus postponing the maximum egg-laying on the part of the old queen until later. This division prevents swarming during the normal swarming season, and, if adequate stores are supplied, should result later in two colonies in splendid condition for the honey-flow. Colonies should not be divided previous to the honey-flow, however, unless this can be done at least five or six weeks before the beginning of the main honey-flow, for this much time is needed for them to build up to full strength.

Another plan for controlling swarming so long previous to the main honey-flow is that of keeping the colonies below swarming strength by removing some of the bees, to be sold as package bees, where the beekeeper is so located that he can sell them profitably and does ·ot desire to make further increase.

Some beekeepers who are located where the honey-flow occurs some time after the swarming season are able to move their colonies to other locations which furnish a honey-flow at this time, thus bringing the honey-flow and the swarming season together.

(2) When the honey-flow occurs during the swarming season, as in the clover region of the Northern States, the tendency to swarm is usually strong, while the main honey-flow is usually short. Under these conditions the colonies should not be permitted to divide their working forces by swarming, but most of the bees should be massed during the honey-flow, either in the swarm or in the parent colony. In regions where the swarming season and the honey-flow coincide, swarming is more difficult to control, especially if the field bees are confined to their hives a part of the time during the day by showers or by erratic yielding of nectar (p. 18), and the greatest precaution as to preventive measures is necessary. Remedial measures applicable here are discussed later in this bulletin.

(3) When the main honey-flow of the season occurs previous to the time the bees are in condition to swarm, the full crop can not be harvested because the colonies must utilize the honey-flow for building up to full strength. This condition is found in many localities in which the main honey-flow occurs quite early, if the management is not directed toward the early development of the colonies. The obvious remedy for this condition is a change in the management which may enable the bees to become sufficiently strong in time for the honey-flow. (See Farmers' Bulletins Nos. 1012, 1014, and 1039.)

HIVING NATURAL SWARMS.

The beekeeper who is operating but one apiary and expects to be present during the swarming season usually prefers to take precautions to prevent swarming as much as practicable, then hive the swarms that issue, rather than to examine all the colonies each week to anticipate swarming. If out-apiaries are being operated, or if the beekeeper is away from home during the day, natural swarming should not be permitted.

When natural swarming is permitted, the work of hiving the swarms is easier if the queens' wings are clipped[1] previous to the swarming season. This does not prevent swarming but it does prevent the swarm from leaving and averts the necessity of taking swarms down from tall trees or other inaccessible places, since a clipped queen can not go with the swarm and the bees will return to the hive. If by chance another swarm having a queen that can fly happens to be out at the same time and unites with the queenless one, the swarm can not be expected to return. The best time to clip the wings of the queen is usually during some early honey-flow, like that from fruit bloom, before the colonies have become very popu-

[1] To find the queen, take out one or two of the outside combs from the side of the hive next to the operator. If the queen is not on these combs, set them aside in order that the remaining combs may be more readily examined. If robbers are troublesome these combs must be put into an empty hive or a light box that will hold two or three frames and kept covered while they are out of the hive. As each of the remaining combs is removed from the hive, glance quickly over the exposed side of the next comb in the hive to see if the queen is there. If she is not there, turn the comb just removed to examine the other side and proceed in this way until the queen is found. As the combs are examined they are placed back into the hive on the side nearest the operator in order to maintain an open space between the combs already examined and those yet to be examined. This work should be done rapidly and no more smoke should be used than is necessary for rapid work. If the bees are inclined to be nervous and run on the combs it is necessary to watch for the queen in the spaces between the lower edge of the comb and the bottom bar of the frames, and also on the bottom and sides of the hive, for if the queen becomes frightened she may run off of the combs into these spaces.

When the queen is found she may be picked up by taking hold of her wings with the thumb and forefinger of the right hand. She is then transferred to the left hand and held lightly either by the thorax or by her feet. The right hand is now free to pick up a pair of small sharp-pointed scissors and clip off the major portions of the wings on one side. The queen is now transferred back to the comb by taking hold of the remaining wing.

lous. In the production of extracted honey and when the best swarm-control measures are employed, the clipping of the queens' wings is unnecessary and the practice is becoming less common.

Swarms that issue during the honey-flow or just previous to the beginning of the honey-flow should not be placed in a new location separated from the parent colony, since to do so would divide the working force of the colony, but the parent colony should be moved a short distance to one side and the new hive for the swarm put in its place. In this way the field force is all given to the swarm which now becomes the producing colony.

The hive of the parent colony should be moved while the swarm is out, the new hive put in its place, and the partially filled supers transferred from the parent colony to the new hive, which is then ready to receive the swarm. The hive entrance of the parent colony should be turned away from its former position (fig. 3) in order that the swarm may be hived in the new hive without a part of the bees entering the hive of the parent colony. It is sometimes advisable to cover the old hive with a cloth while the swarm is being hived if bees attempt to enter it.

FIG. 3.—While the swarm is out, the hive of the parent colony is turned away, the new hive put in its place, and the supers transferred to the new hive, which is now ready to receive the swarm.

If the queen's wings have not been clipped, the swarm after having clustered may be shaken into a basket or a light box, which may be attached to the end of a pole, if need be. They should then be dumped immediately in front of the prepared hive, which should be arranged so they will not crawl under it, but can readily enter (fig. 4). A wide board, a cloth, or a newspaper may be used for a bridge to the entrance. If the bees do not begin to enter the hive at once, some of those nearest the entrance may be pushed in with a brush or a large feather. If some start to run away from the entrance they may be gently brushed toward it. The bees should not be permitted to crawl up the sides of the hive and cluster outside, but all should be induced to enter.

If the queen's wings are clipped, the operator should be ready to watch for and catch the queen while the swarm is issuing. When the queen is found she should be placed in a wire-cloth cage and put on the shady side of the hive until the swarm returns. The swarm may return and enter the new hive without clustering, in which case the cage containing the queen may be thrust part way into the entrance of the new hive, but the queen should not be released among the returning bees until after many of them have entered the hive, because the bees may again take wing if the queen is released too soon. If the bees cluster where they are readily accessible, it may not be advisable to wait for them to return of their own accord, since other swarms may issue and several of them join the cluster. They may be handled in hiving the same as though their queen were with them. A wire-cloth cage large enough to be set over a hive (fig. 5) is sometimes useful if many swarms issue at one time, for one of these may be placed over any colony just starting to swarm to catch the swarm as it issues, thus preventing the confusion usually brought about when several swarms unite.

Fig. 4.—Swarm entering new hive.

PREVENTION OF AFTERSWARMS AND DISPOSITION OF THE PARENT COLONY.

By this method of hiving swarms the bees are soon at work again with renewed energy in the same set of supers which a short time previously they were so eagerly deserting. The field force has not been reduced, the returning field bees from the parent colony all entering the new hive, since it is located where the old one stood. Frequently such colonies store even more honey than colonies that do not attempt to swarm. As soon as the swarm is established in the new hive the entrance of the parent colony should be turned back toward its former position (fig. 6), and a day or two later it should again be turned, so that the two hives now stand side by side, having their entrances close together (fig. 7).

If extracted honey is being produced the parent colony and the swarm can be reunited a day or two later by first destroying all the queencells in the parent colony, then placing the hive body containing it (without bottom or cover) on top of the supers on the new swarm in the same manner as an additional super. In this way the parent colony and the swarm are in the same hive forming a single colony, the queen and the new brood-chamber being below the supers and separated from them by a queen excluder while the parent colony is above the supers. Nine or ten days after the swarm has issued any queencells that the bees may have built in the parent colony during this interval should be destroyed. Under certain conditions, not yet fully explained, this has not been found necessary if the parent colony is separated from the swarm by at least two full-depth extracting supers, but with less than this distance between, such colonies may swarm when the young queens in the parent colony begin to emerge.

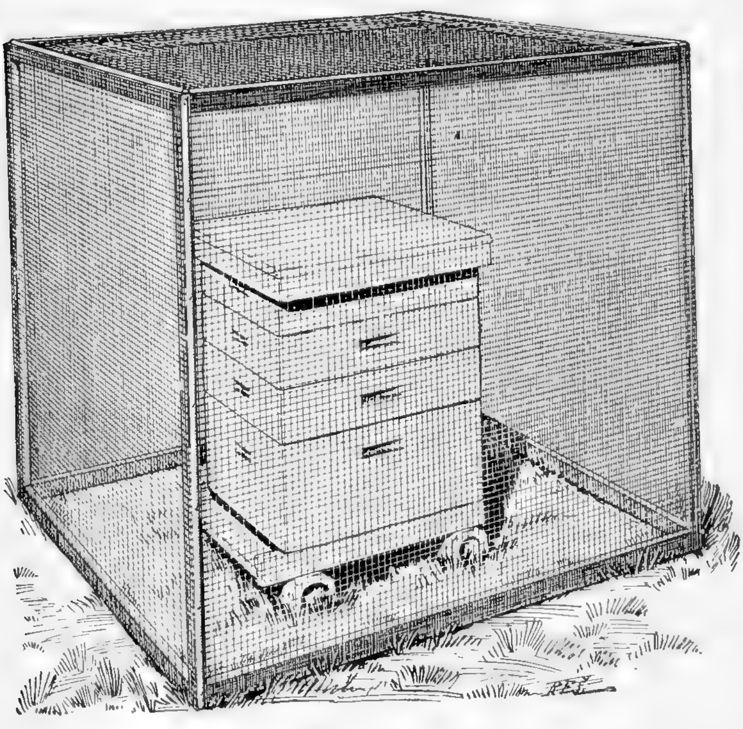


Fig. 5.—Cage arranged to catch issuing swarm. Especially useful when several swarms issue at about the same time.

If increase is desired, this brood-chamber may be taken away a week after the swarm has issued, to form a new colony. In this case the queencells should not be destroyed. If too many bees cling to the old brood-chamber the bees from all but three or four of the combs may be shaken into the supers in order to strengthen the swarm and also to make the parent colony too weak to cast an afterswarm. The combs containing the best queencells should not be shaken because of the danger of injuring the immature queens. If some combs having queencells are shaken the cells should be destroyed to prevent the emergence of any injured queens. If choice queencells from a breeding queen are available, all the cells on the combs from the parent colony should be destroyed and one of the choice cells should be given.

When comb-honey is being produced the parent colony can not well be united with the swarm directly in this way, but it should be left beside the swarm six or seven days, for on the eighth day the parent colony would normally cast its first afterswarm. It should then be moved away and given a new location well separated from other colonies in another part of the apiary. This should be done when the young bees that have learned to fly during the week are flying freely, preferably early in the afternoon, and the hive should be carried away and placed on its new stand so carefully that the bees are not disturbed, in order that they will go to the fields without noting the change in their surroundings. If this is done carefully, all of the field bees when returning from the field will return to their former location, where they must enter the other hive and unite with the swarm. This adds a large number of young workers to the swarm where they are of the greatest value at this time, and at the same time so reduces the number of bees in the parent colony that afterswarming is given up.

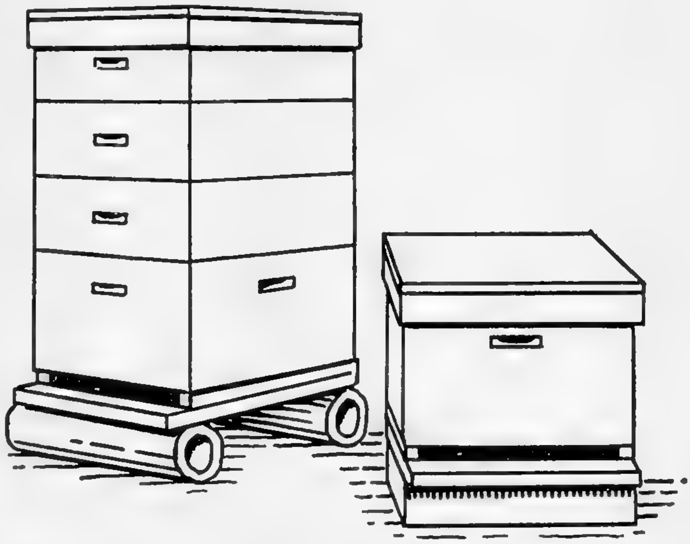


FIG. 6.—After the swarm has entered the new hive the hive of the parent colony is turned toward its former position.

The successful prevention of afterswarming by this method depends upon the completeness of the reduction of the population of the parent colony just before the time for the issuing of the first afterswarm. If anything should prevent this reduction at the right time, such as confinement of the bees to the hive for a day or two by bad weather at the time the parent hive is moved away, or the emergence of the young queens earlier or later than expected, colonies treated in this way may have enough bees when the first young queen emerges to send out an afterswarm. Under such conditions it may be necessary to shake the bees from several of the combs of the parent colony, uniting them with the swarm at the time the hive is moved away, to be sure of a depletion of the parent colony sufficient to prevent afterswarming. Usually, however, this method can be depended upon without opening the hives to note the advancement of the queencells or to shake out any of the bees.

If no increase is desired the parent colony may be moved to the opposite side of the swarm instead of to a more distant location, where it can be united with the swarm at the close of the honey-flow. In doing this it may be necessary to place the parent colony some distance beyond the swarm and turn its entrance away from that of the swarm temporarily to prevent the returning young bees finding their hive as they may do if it is placed on the opposite side with its entrance close to that of the swarm.

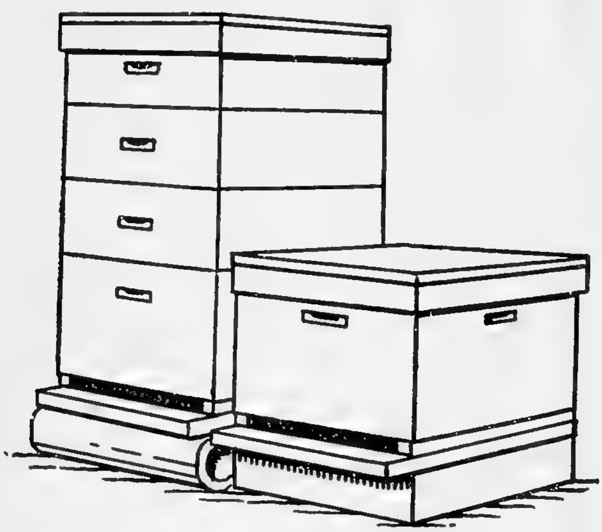


FIG. 7.—A day or two later the hive of the parent colony is placed close to that of the swarm. Seven days later it is removed.

INTERRUPTION OF WORK IN SUPERS UNDESIRABLE.

When swarms are hived during the honey-flow in the manner described above, it is important that conditions within the new hive be such that the energy of the newly hived swarm is directed from the beginning chiefly to the work in the supers instead of to work in the new brood-chamber. This is especially important during a short honey-flow, for the season may close before profitable work in the supers is resumed if the colony first fills the brood-chamber. Furthermore, a temporary cessation of work in the supers while the new brood-chamber is being filled may result later in a stagnation of the work of the colony brought about by a concentration of work in the brood-chamber. This applies particularly to comb-honey production, since in extracted-honey production there should be little if any interruption of the work in the supers after the swarm has been hived, unless the swarm is unusually small or unless the new brood-chamber is unusually large. The furniture used in the new brood-chamber, the size of the new brood-chamber, the number of bees in the swarm, the attractiveness of the supers (p. 14), and the character of the honey-flow all affect the continuity of the work in the supers when a swarm is hived.

INFLUENCE OF FURNITURE USED IN THE NEW HIVE.

The brood-chamber in which a swarm is to be hived may be furnished with (1) frames that are empty except a narrow strip of foundation about an inch in width to guide the bees in comb building, (2) frames containing full sheets of foundation, (3) frames containing full sheets of foundation, together with one or more frames filled with comb, (4) combs of unsealed or mostly unsealed honey, (5) combs of emerging brood in which no eggs have been laid for at least 10 days (usually taken from a parent colony 10 days after the swarm issued, first having all queencells destroyed), and (6) empty combs. There is a great difference in the work in the supers after the swarm is hived, depending upon which of these is used. The least interruption in the work in the supers usually occurs when only narrow strips of foundation are used in the frames in the new brood-chamber, and the greatest interruption in the work in the supers usually occurs when a full set of empty combs is used. As to the degree of interruption of the work in the supers, the other combinations of furniture occupy an intermediate position between these two extremes, usually in the order named. When either narrow strips of foundation or full sheets of foundation are used in the frames in the new brood-chamber and the supers are transferred to the swarm at the time of hiving, there being no vacant cells in the new brood-chamber and comb building being in progress in the supers, the incoming nectar is taken to the supers. Under these conditions there is practically no interruption in the work in the supers, the work in the brood-chamber usually being carried on slowly for some time, especially if only narrow strips of foundation are used. In sharp contrast with this, if a full set of empty combs is used in the new brood-chamber when the swarm is hived, the work in the supers is usually neglected, the energy of the colony being directed chiefly to filling the brood-chamber with honey and brood, but after these combs have been filled such colonies usually work indifferently in comb-honey supers.

A single empty comb together with frames of foundation affords such a limited number of empty cells immediately available within the brood-chamber that its use does not tend to reduce the work in the supers materially and it affords storage space for incoming pollen which might otherwise be carried to the supers. The use of a single empty comb also greatly reduces the tendency to swarm out (p. 31). When combs of honey which are mostly unsealed are used, the bees may begin to transfer this honey into the supers almost immediately after being hived. When combs containing only sealed and emerging brood together with honey and pollen are used, there are so few vacant cells that these are usually prepared to receive the eggs as the queen resumes egg-laying, so that most of the incoming nectar must be taken to the supers. As the remaining brood emerges the vacated cells are usually prepared for eggs until toward the close of the honey-flow.

The furniture used in the new brood-chamber also has an influence upon the tendency to swarm again the same season. When the bees build a set of new combs from narrow strips of foundation or full sheets of foundation they rarely swarm again, but when swarms are hived on combs of emerging brood, empty combs, or combs of honey, sometimes many of them may attempt to swarm again the same season if the honey-flow is of considerable duration. As to the effect upon this tendency, the various combinations of furniture for the new brood-chamber usually stand in the following order, increasing through the series: (1) Narrow strips of foundation, (2) full sheets of foundation, (3) full sheets of foundation together with one or more empty combs, (4) empty combs, (5) combs of honey, and (6) combs of emerging brood.

While narrow strips of foundation stand first, both as to forcing immediate work in the supers and as to reducing the tendency to swarm again the same season, their use is open to the serious objection that so much drone-comb is usually built that many of the combs built in this way are not suitable for subsequent use in the brood-chamber. Some comb-honey producers, however, use them, then at the close of the honey-flow unite the parent colony and the swarm, placing the brood-chamber of the parent colony above that of the swarm; then in the fall the lower brood-chamber may be removed and the now empty combs cut out to be rendered into wax. Many comb-honey producers prefer to use full sheets of foundation in all the frames or in all but one of the frames of the new brood-chamber for hiving swarms.

When either narrow strips of foundation or full sheets of foundation are used in the new brood-chamber, a queen excluder should be used when the supers are transferred from the parent colony to the swarm at the time of hiving, and precautions should be taken also against swarming out (p. 31).

CONTRACTION OF THE BROOD-CHAMBER.

If the new brood-chamber is contracted so that little work is required to fill it and so that most of the bees of the colony are crowded into the supers, the work in the supers should continue without interruption after a swarm has been hived. It was formerly a common practice to reduce the new brood-chamber to five or six Langstroth frames by inserting division boards at the sides of the hive to fill out the remaining space. This should not be done until two or three days after the swarm has been hived, for contracting the brood-chamber at the time of hiving the swarm may cause the bees to swarm out.

Contraction of the brood-chamber forces the bees to do most of their work in the supers; therefore a good crop of honey may be obtained in this way even during a short honey-flow, but after the honey has been removed from the hive at the close of the season such colonies are practically without stores and should either be reunited with the parent colony or supplied with a sufficient quantity of honey for fall and winter stores. This can be done easily by leaving for the bees a second hive body with combs which are practically filled with sealed honey.

Combs of honey and combs containing only sealed brood, together with honey and pollen in the new brood-chamber, have an effect similar to that of contraction of the brood-chamber. Combs with most of the honey sealed should not be used for this purpose unless they are placed at the sides, since such combs in the middle of the new brood-chamber may cause a stagnation of colony activity (pp. 13 and 15).

SWARMING OUT.

After a swarm has been hived it sometimes deserts the new hive or "swarms out." This may occur the day the swarm is hived, or the next day, and sometimes even on the third day after hiving. It may occur either with natural swarms or with artificial swarms. Swarming out apparently is often caused by a lack of room in the new hive or by discomfort from some other cause, though occasionally a newly hived swarm may leave the hive when no cause for their dissatisfaction is apparent. This trouble may be prevented or greatly reduced by placing an empty hive body, without frames, below the new brood-chamber for two or three days, by providing ample ventilation and shade for the new hive at the time of hiving the swarm, and by using one or more empty combs which have been used previously for brood-rearing in the new brood-chamber instead of frames of foundation exclusively. Combs of unsealed brood are not recommended for this purpose. Entrance guards or queentraps may be placed on the entrance of the new hive for a few days to prevent the queen escaping, if newly hived swarms are inclined to swarm out, but the trouble usually can be prevented by making provision for the comfort of the bees, especially for the first day or two.

When artificial swarming is practiced (p. 34) in comb-honey production, swarming out can be prevented by taking away the combs of brood in two installments, with an interval of three or four days between. In the first operation half or more of the brood should be taken away and frames of foundation given in their place, and three or four days later all the remaining combs of brood should be removed.

UTILIZING THE PARENT COLONY FOR PRODUCTION.

In the usual plan for hiving natural swarms, the swarm is used as the producing colony, the parent colony being deprived of most of its bees to give greater strength to the swarm. The massing of most of the bees of both the swarm and the parent colony into one hive is necessary for best results when swarming occurs during the honey-flow and especially so when the honey-flow is short. It is, however, sometimes desirable to mass the bees together in the parent colony instead of in the swarm. This may be accomplished by returning the swarm without the queen to the hive from which it came. Seven days later all but one of the queencells should be destroyed. the remaining cell being left to requeen the colony.

Great care must be taken in destroying the queencells to be sure that only one is left, for if more than one queencell is left the colony may be expected to swarm soon after the first young queen emerges. It is usually necessary to shake most of the bees from each comb as the combs are examined for queencells in order to be sure that no queencells are overlooked. The comb containing the queencell that is to be left should not be shaken, since if this is done the immature queen may be injured.

It sometimes happens that some colonies treated in this way will swarm soon after the young queen emerges from the one cell that was left, leaving the parent colony greatly depleted in bees and hopelessly queenless. Again, the queen may fail to emerge, in which case, unless a queen or another queencell is supplied promptly, the colony, being hopelessly queenless, works with reduced energy and later, of course, would become depleted. For these reasons some beekeepers prefer to destroy all the queencells five days after the swarm has issued, then again five days later, at which time a young laying queen is introduced by means of an ordinary introducing cage.

By hiving the swarm back into its own hive without the queen and permitting the colony to rear only one young queen, or leaving them queenless 10 days and then introducing a laying queen, the colony is left in a condition comparable to the parent colony in nature, except that it retains all of the workers instead of losing the bees of the swarm. Such colonies usually do not swarm again the same season. This method does not require extra hives and equipment, but it probably involves some loss in the less energetic work while the colonies are queenless.

TREATMENT TO ANTICIPATE SWARMING.

The emphasis given to the care of natural swarms on the preceding pages is largely for the purpose of bringing out the principles which underlie the successful methods used to anticipate swarming. Commercial honey producers who operate several apiaries can not afford to permit natural swarming but must use some system by which swarming can be controlled by visiting each apiary at certain intervals and applying remedial measures if preventive measures are not sufficient. Producers of extracted honey who have good combs, good equipment, and a good strain of bees usually can control swarming to a sufficient degree, in many locations at least, by ordinary preventive measures and good management, so that it is not necessary to examine every colony once a week to see if preparations for swarming are being made. In some locations, however, the swarming tendency is so strong (p. 12) that the greatest skill in the application of preventive measures is not sufficient to prevent loss, and some remedial measure must be applied.

Comb-honey producers in regions suitable for commercial comb-honey production (see Farmers' Bulletin 1039) find that while preventive measures may greatly reduce swarming it is usually necessary to treat many of the colonies for swarming during ordinary seasons, while during occasional seasons it may be necessary to treat most of them.

Swarming can be anticipated by creating conditions within the hive comparable either to those of a recently hived swarm or to those of the parent colony, and it is not necessary to wait until the swarm actually leaves the hive to do these things. In either case the necessary steps can be taken at the convenience of the beekeeper before the colony casts a swarm. To anticipate swarming, the beekeeper, therefore, as the first step, either takes away the combs of brood and arranges for the establishment of a new brood-nest, or he takes away the queen and destroys all queencells, if any are present. In some cases the removed brood is not taken entirely away from the colony but is separated from the queen and the new brood-chamber by means of a queen excluder, and in some cases the queen is not taken from the hive but is caged within the hive during the required interval, then released among the combs of brood. The subsequent behavior of the colony is practically the same as that of a natural swarm in the one case and that of the parent colony in the other.

In the operation of out-apiaries or of any apiary in which an attendant is not present the beekeeper should use every precaution to prevent swarming (pp. 6–19); then, as the swarming season approaches, it may be necessary for him to examine the strongest colonies to determine if queencells are being built. If any such are found, it now becomes necessary either to begin a systematic examination of each colony every week or ten days during the swarming season for indications of preparations for swarming and to treat those colonies which need treatment, or to treat all of the colonies, whether or not preparations are being made for swarming. Much will depend upon circumstances as to which of these plans is more desirable. The uncertainty of weather conditions during the early honey-flow in many parts of the country makes it difficult in comb-honey production to devise any system that will work out advantageously year after year by which all the colonies can be treated at the same time. In extracted-honey production, however, this may well be done.

If the plan of examining each colony for queencells once a week is to be carried out, the queencells in colonies which contain only eggs or small larvæ are destroyed, since some colonies will give up swarming when this is done. If the queencells are well advanced containing large larvæ, the colony should be treated at once, since the removal of such queencells can not be expected to deter swarming. When destroying newly started queencells in this way most of the bees should be shaken from the combs as they are examined, to be sure that none are missed, since if but one queencell is left the destruction of the remainder of the cells would have no effect upon the preparations for swarming.

The methods given in the following paragraphs are illustrative of different types of remedial measures. The various methods here outlined are by no means equally suitable for every locality or every season in a given locality. It is necessary for each beekeeper to work out a system for swarm control to meet the requirements of his particular locality and season. The underlying principles, however, are the same throughout the multitude of methods, and the following outlines are given to illustrate the principles involved, rather than to indicate definite systems to be followed.

CREATING CONDITIONS COMPARABLE TO THE SWARM.[2]

1. Shake the bees from their brood-combs back into the brood-chamber, placing the combs of brood in an extra hive body as the bees are shaken from them and putting in their places frames of foundation and one empty comb, or whatever is to be used in establishing the new brood-nest as in hiving swarms (p. 29). To avoid the necessity of finding the queen, the combs should be shaken or brushed sufficiently free of bees to insure that the queen is left in the hive when the brood is all taken away. If extracted honey is being produced, put a queen-excluder over the brood-chamber, replace the supers, and finally place the hive body now containing the removed brood on top as though it were an additional super,

[2] Colonies that are building queencells in preparation for supersedure should not be subjected to this treatment, but the failing queen should be removed, the queencells destroyed, and the colony treated as a parent colony (p. 39). Such colonies can be distinguished from normal colonies which are preparing to swarm by the imperfect work of the queen, the smaller number of queencells, and the general condition of the colony as to population and proportion of emerging bees.

first destroying all queencells if any have been started. Ten days later again destroy all queencells that are built on the combs of brood now above the supers.

To accomplish the same thing without shaking the bees from the combs, find the queen and place her, together with a comb of brood and adhering bees, in an extra hive body which is filled with frames of foundation or empty combs as described above. Lift the original brood-chamber from the bottom-board and put the extra hive body now containing the queen in its place. Put the queen-excluder and the supers in place and finally place the original brood-chamber above the supers, first destroying all queencells, if any have been built. Ten days later destroy all queencells in the original brood-chamber. When a comb of brood is placed in the new brood-chamber in this way, care must be taken that it does not contain any queen-cells, and if preparation for swarming is general in the apiary it is not advisable permanently to leave this comb in the new brood-chamber, because if preparation for swarming has already been in progress the bees sometimes start queencells on this comb of brood and later cast a swarm. When the bees are inclined to do this, the frame of brood should be removed a few days after the treatment.

As the brood emerges in the original brood-chamber the vacated cells are filled with honey during a good honey-flow and the former brood-chamber now becomes a super. If it contained some inferior honey when it was put above, which would reduce the quality of the crop, it may be better to reserve these combs of honey for winter stores. If increase is desired, this upper hive body of emerging brood may be removed from the hive a week or 10 days after it was put up and used to form a new colony. When this is done, the queencells should not be destroyed, unless it is desirable to give this new colony a queencell reared from better stock (see p. 7). If a queen-excluder has not been in use previously, it will be more difficult to find the queen as well as to destroy the queencells.

When comb-honey is being produced the procedure is practically the same, except in the disposition of the brood that is removed. This can not well be placed above the comb-honey supers and the emerging bees added to the colony as when producing extracted honey, but the emerging brood may be placed in a separate hive located by the side of the original hive (fig. 7), so that a large number of the emerging bees may be united later with the swarm when they are old enough for field work, simply by moving the hive to another location while these young bees are at work in the fields (see p. 27).

When the brood is removed in comb-honey production it is necessary, therefore, to leave enough bees with the brood to care for it. This can be done by placing the hive body which contains the brood back on the hive immediately after the shaking is complete, but placing it above a queen-excluder until enough bees return to these combs to care for the brood before it is established as a separate hive. Another way to do this is to find the queen before shaking any bees from the combs, then transfer two or three combs to the extra hive body without shaking off the adhering bees, in order to have bees enough in this hive to care for the brood, the queen, of course, being put back into the brood-chamber on the old stand. In either case, if increase is made from this removed brood, these new colonies should be supplied with good queencells, since when artificial swarms are

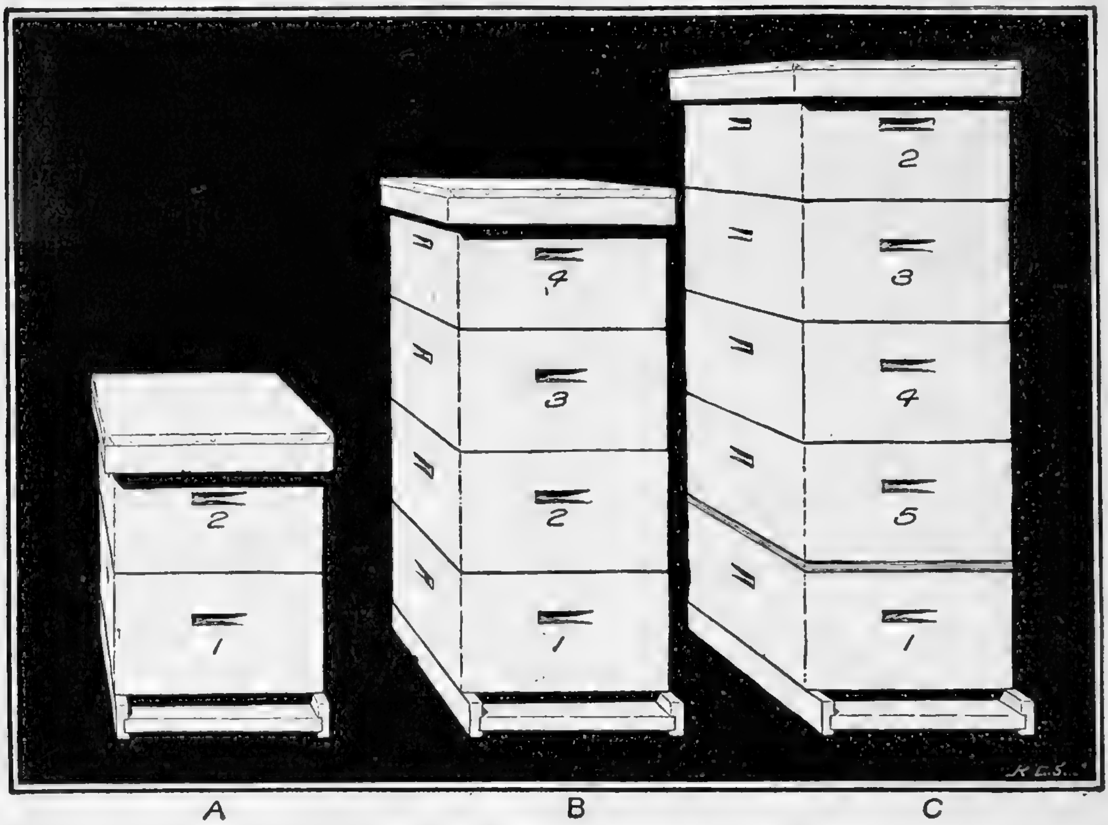


FIG. 8.—Creating conditions comparable to a swarm. Plan 2 for extracted honey. *A*, Brood in both hive bodies in the spring. *B*, Supers *3* and *4* are added as more room is needed, queen usually abandoning lower brood-chamber (*1*). *C*, Queen placed below excluder in lower hive body (*1*) after all brood in this chamber has been sealed. Empty super (*5*) is added and brood (*2*) is placed on top.

made in this way conditions often are not as favorable for the development of a good queen as in the case of the parent colony in natural swarming.

2. Use two hive bodies for brood-rearing previous to the swarming season. For extracted honey, add supers of empty combs above these two hive bodies as soon as more room is needed and do not use a queen-excluder. (Fig. 8, *A*.) Under these conditions the queen usually abandons the lower hive body as the season advances. (Fig. 8, *B*.) Ten days or more after she has abandoned it, when all the remaining brood in this hive body will have been sealed, find the queen, put her into the lower hive body, and confine her thereby means

of a queen-excluder. (Fig. 8, *C*.) Place the supers directly above the queen-excluder and finally place the hive bodies recently occupied by the queen on top of the supers. Conditions now are similar to those present when a swarm is hived on frames containing none but emerging brood together with pollen and honey and the parent colony is placed on top of the supers (p. 26). Ten days later the queencells that have been built in the meantime usually should be destroyed, though this is not always necessary (p. 26). This plan is useful in extracted-honey production provided the honey-flow is not greatly prolonged. It may not be sufficient completely to control swarming during a prolonged honey-flow, since the colonies may later

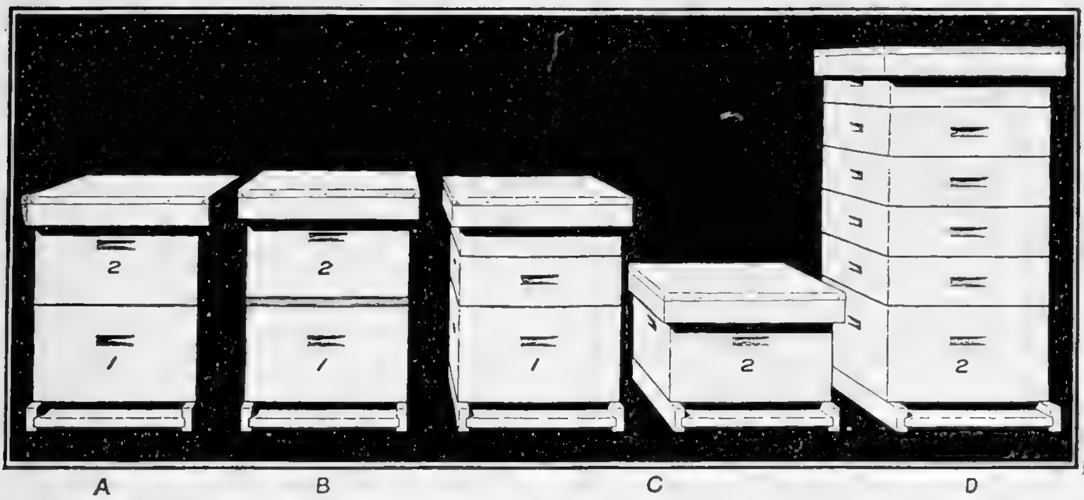


Fig. 9.—Creating conditions comparable to a swarm, but later comparable to a parent colony. Plan 2 modified for comb-honey. *A*, Brood in both stories in the spring. *B*, Queen-excluder inserted ten days previous to honey-flow. *C*, Queen transferred to brood-chamber from which she has been excluded at beginning of honey-flow. In the illustration it is assumed for convenience that the queen was confined to *2* when the excluder was inserted, which is here shown at the right as a separate hive supplied with a ripe queencell. The queen may have been confined to *1* instead, in which case she is transferred to *2*, which is left on the old stand, and the queencell is given to *1*, which is placed at one side. *D*, The brood-chamber containing the young queen (*2*) is substituted for the one containing the old queen (*1*) after the young queen has begun to lay.

again prepare to swarm. For a long honey-flow plan No. 3 may be preferable.

This plan does not lend itself readily to comb-honey production, because bees usually do not begin work well in comb-honey supers when two hive bodies are used for the brood (fig. 9, *A*), and the queen therefore may not abandon the lower hive body, as she does when extracting combs are used in the supers. For comb-honey production, however, a queen-excluder may be inserted between the two hive bodies 10 days previous to the time of putting on the comb-honey supers, the queen being in this way excluded from one of them. (Fig. 9, *B*.) After 10 days, by removing and examining a single comb for eggs and larvæ, it can be determined which hive body contains the queen. The queen should then be transferred to the hive body from which she has been excluded either by finding her or by shaking all of the bees, including the queen, from the combs. The hive body to which the queen has just been transferred is left on the old stand as the new brood-chamber and the hive body from which she was taken is now removed and managed as a parent colony. (Fig. 9, *C*.) This treatment may be sufficient when the honey-flow is short in duration, but if the honey-flow is long, swarming may be only delayed by this process. However, by giving a ripe queencell to the parent colony soon after the division is made, then after the young queen begins to lay substituting the brood-chamber containing the young queen for the brood-chamber containing the old queen,

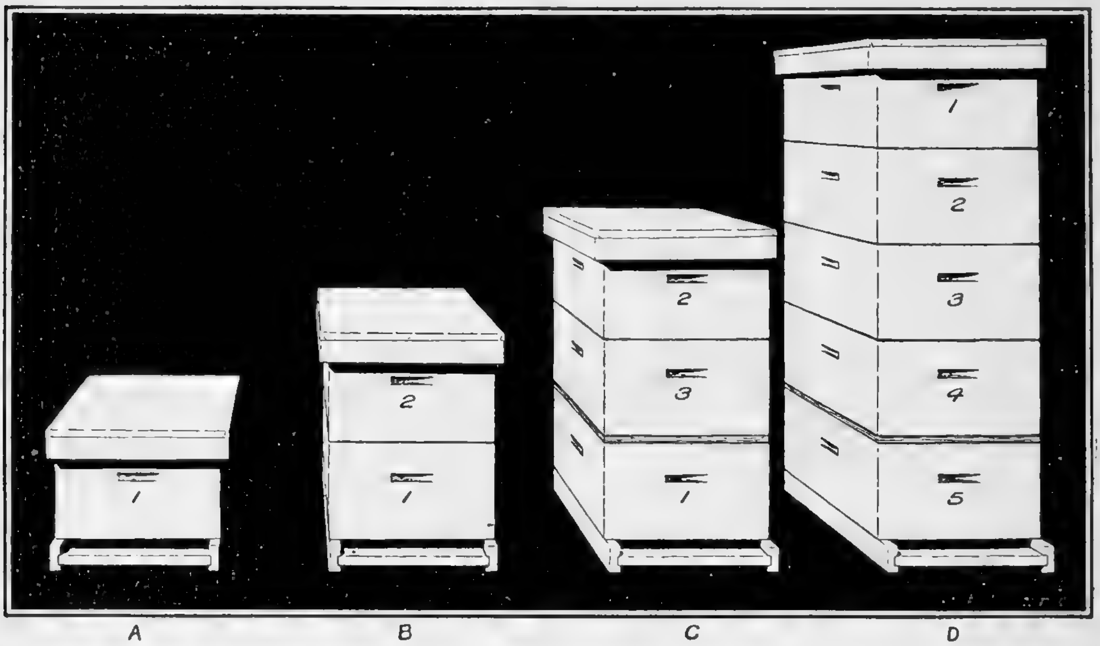


FIG. 10.—Creating conditions comparable to a swarm. Plan 3 for extracted honey. *A*, Colony in single story in early spring. *B*, Second brood-chamber (*2*) is added when more room for brood-rearing is needed. *C*, Ten days later the queen is placed below excluder (*1*), super (*3*) is added, and brood-chamber (*2*) is placed on top. *D*, Ten days later the queencells in brood-chamber (*2*) are destroyed, the queen is placed in lowest hive body (*5*) which contains empty combs or combs and foundation, the queen being confined to this chamber by a queen-excluder; empty super (*4*) is added and brood-chamber (*1*) is placed on top.

conditions comparable to the parent colony (p. 39) are created. (Fig. 9, *D*.) Such colonies, as a rule, do not attempt to swarm again the same season.

3. When the bees need more room for brood-rearing in the spring, give a set of brood combs (preferably old, dark combs), placing them on top of the original brood-chamber. (Fig. 10, *A*, *B*.) If the colony is strong at this time the queen will enter this added brood-chamber promptly, usually neglecting the lower hive body until the upper one is filled with brood, honey, and pollen. Ten days later, or at about the time of the beginning of the honey-flow, the brood in the lower story should all be sealed. At this time transfer the queen to the lower hive body, either by finding her or by

shaking the bees from the combs, from the upper into the lower hive body, and confine the queen below by means of a queen-excluder. (Fig. 10, *C*.) If the honey-flow is beginning, add a super of extracting combs (fig. 10, *C*), then place the recently used brood-chamber on top as a third story. Ten days later destroy all queen-cells in the queenless brood-chamber, then shake the bees together with the queen from the combs in the lower brood-chamber, placing the combs of brood into an empty hive body and giving back either empty combs or frames of foundation, together with one empty comb. Replace the queen-excluder and the supers, adding an additional one if needed, and finally place the brood-chamber containing the brood just removed on top of the supers. (Fig. 10, *D*.) To avoid shaking, the queen may be found, and together with a frame of brood, she may be placed in the extra hive body containing the empty combs or foundation, after which this extra hive body is put in place of the former brood-chamber, and the former brood-chamber is placed on top of the supers. This double treatment is not always necessary, but should completely control swarming in localities where the swarming tendency is strong.

This plan can be modified for comb-honey production if the colonies are strong by putting the queen down into the lower hive body after she has abandoned it long enough for all the brood to be sealed, removing the upper hive body entirely, the bees being shaken from the combs into the lower hive body, and one or two comb-honey supers being given. The brood that is taken away may be placed above queen-excluders on another colony not now being used for comb-honey. Six or seven of these brood-chambers may be given to each colony that is used for this purpose. Ten days later treat each colony as in plan No. 1 above, substituting for their brood-combs the combs of emerging brood that were removed before, first destroying all the queencells, if any are present. The combs of brood that are removed during this operation may be put into a separate hive and handled as a parent colony (fig. 7) or disposed of in some other way. Thus the bees are shaken twice, with an interval of 10 days between, on combs containing none but emerging brood (p. 29).

CREATING CONDITIONS COMPARABLE TO THE PARENT COLONY.

1. When the bees begin to make preparations for swarming, find and remove the queen. If it is desirable to keep her, she may be placed in another hive, together with the comb of brood on which she was found, to form a nucleus, or she may be killed if not needed. If queencells have already been started these should all be destroyed at the time the queen is removed. Ten days later again destroy all queencells, being careful to shake most of the bees from the combs

as they are examined to be sure that none are overlooked. Either at this time or a few days later introduce a young queen that has just recently begun to lay, by means of an ordinary introducing cage, which may simply be thrust into the entrance of the hive until the queen has been released.

Some beekeepers, instead of introducing a young laying queen, destroy all but one of the queencells and permit the colony to requeen itself from this remaining queencell, but in some cases such colonies will swarm soon after the young queen emerges from the cell, especially if the colony had made preparations for swarming before being treated (p. 32).

Instead of introducing a young queen, the original queen may be returned to her colony, the same care being used in introducing as with any other queen. It is not necessary to return the same queen, but a queen may be taken from any colony for this purpose. If the original queen is to be returned to the colony, she may simply be caged within the hive during the interval of 10 days instead of being taken from the hive, then a few days after the queencells have been destroyed she may be released among the bees. Practically the same result can be accomplished without finding the queen by shaking the bees together with the queen into the brood-chamber, which is now left empty except for one comb. The queen should be confined to this nearly empty hive body by means of a queen-excluder, the brood being placed above the excluder in another hive body. (Fig. 11, *A*, *B*.) After the queen has thus been separated from the brood for 10 days the queencells should all be destroyed and the extra hive body should be removed (fig. 11, *C*), the queen and the bees in this hive body being returned to the original brood-chamber. When the old queen is returned to the colony in this way, however, the tendency to prepare for swarming again is considerably stronger than when a young queen that has just begun to lay is given. A colony to which a young queen is given after an interval of queenlessness of at least 10 days is more nearly like a parent colony in nature and usually does not prepare to swarm again the same season.

When two hive bodies are used for brood-rearing previous to the honey-flow, these two-story hives may be divided at the beginning of the honey-flow, leaving most of the brood in the hive on the old stand, the queen and the remaining brood together with some adhering bees being placed in the other hive body, which is now supplied with a cover and bottom and set near the original hive. If any queencells are present at the time the division is made, these must be destroyed. The supers are given to the now queenless colony on the old stand. Ten days later the queencells should be destroyed and a young queen introduced, as described above. The two colonies may be reunited at the close of the honey-flow if comb-honey is being produced, or before the close of the honey-flow if extracted honey is being produced.

2. If the bees have been wintered in a single brood-chamber, give a second brood-chamber when the colonies need more room in the spring, placing this second brood-chamber on top. When old brood combs are used in this second brood-chamber, the queen usually goes into it within a few days. After a week or 10 days divide the colony by removing the upper hive body, which usually at this time contains the queen, and place supers on the hive body which remains on the old stand. If the nights are cool, such a division may result

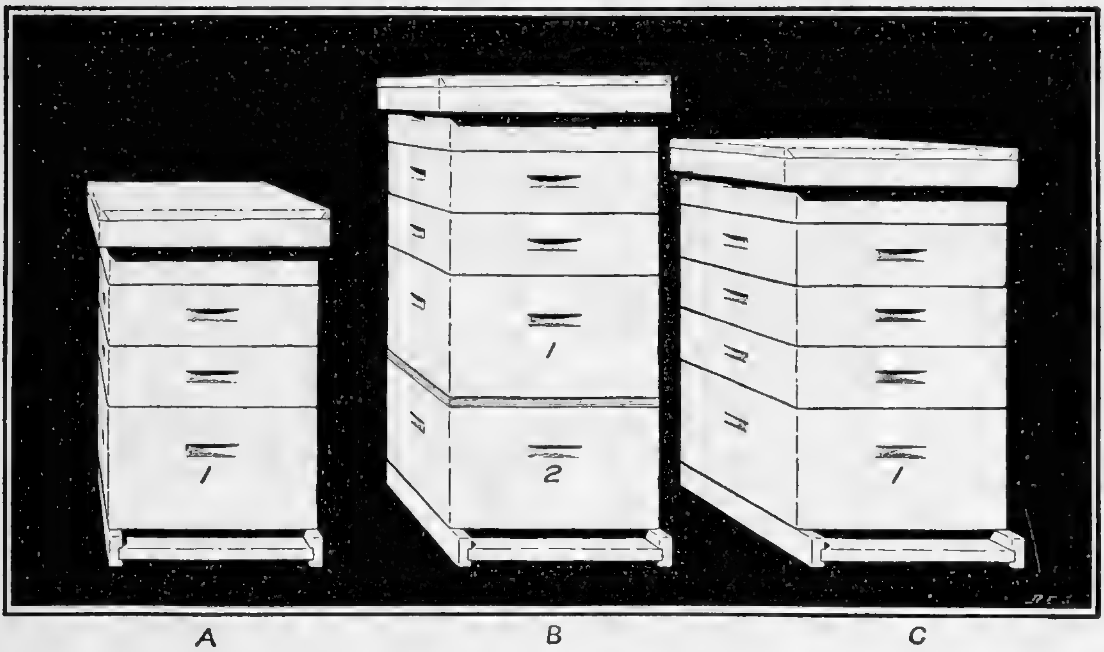


FIG. 11.—Creating conditions comparable to a parent colony. Plan 1 modified to return the original queen after her separation from the brood for ten days. *A*, Colony preparing to swarm. *B*, Bees together with queen shaken from all but one of combs of brood, these combs being placed in second story (*1*) above a queen-excluder, thus confining the queen in a nearly empty hive body (*2*) below the brood. *C*, Ten days later all queencells are destroyed and the queen is returned to the brood, the extra hive body being removed.

in the loss of some brood in the brood-chamber that is removed, for it is the youngest of the brood that is removed. After the brood is all sealed in the brood-chamber on the old stand destroy all queen-cells and introduce a young laying queen or permit this division to requeen itself by leaving one queencell (p. 40). The two divisions may be left standing side by side in order that they may be reunited later. If extra covers and bottoms are not available, the division may be made by using an escape board as a cover for the hive on the original stand, having the bee-escape removed and the hole for the bee-escape entirely closed, the brood-chamber containing the queen being on top of this escape board and the regular cover used over all. In this case an entrance should be provided for the upper hive body by pushing it forward on the escape board until an opening of sufficient size is formed. If extracted honey is being produced, this escape board may be removed before the close of the honey-flow to unite the two divisions, in which case the bees will kill the old queen later, if not at this time; thus the colony is requeened without the necessity of finding the queen.

3. Use two hive bodies for brood-rearing during the spring. Previous to the swarming season, insert a queen-excluder between the two hive bodies to confine the queen to one of them. Ten days later divide the colony by removing the brood-chamber which contains the queen, leaving the queenless portion on the old stand. To determine which hive body contains the queen, it is only necessary to remove one of the brood-combs from the middle of the brood-chamber to look for eggs or young larvæ, since in the brood-chamber from which the

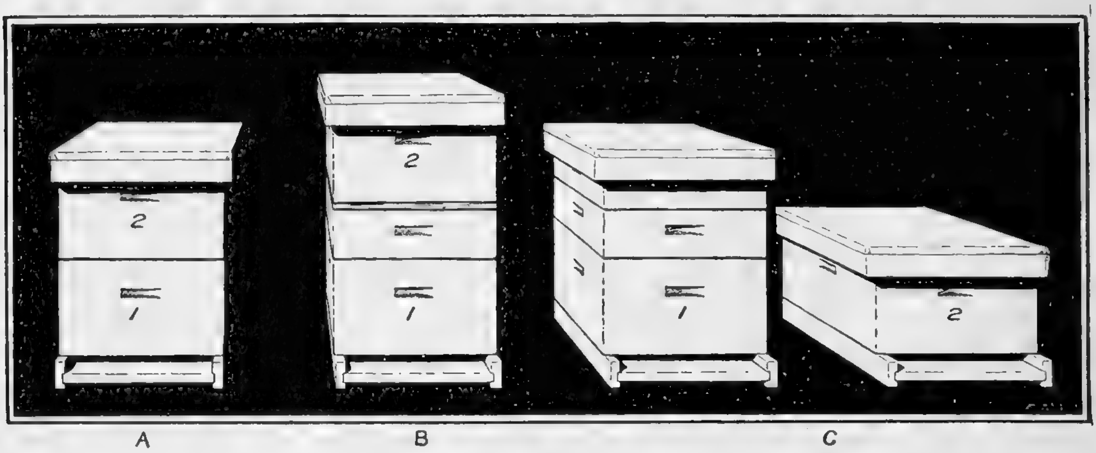


Fig. 12.—Creating conditions comparable to a parent colony. Plan 3 as modified for comb-honey. *A*, Brood in both stories previous to honey-flow. *B*, Comb-honey super and queen-excluder inserted between two hive bodies at beginning of honey-flow. It is not known at this time which hive body contains the queen. *C*, Hive body containing the queen (2) removed and established as separate hive. Queencell is placed in *1*. In the illustration it is assumed that the queen was in *2* when the queen-excluder was inserted in *B*. She may have been in *1* at that time, in which case, of course, this brood-chamber is removed.

queen has been excluded the brood is all sealed at this time. Supply the queenless portion with a young laying queen or a ripe queencell. The two divisions may be reunited later or that portion containing the old queen may be moved to a new location for increase (p. 27) a week or 10 days after the division, whereupon the field bees from the removed hive will return to the hive on the old stand, thus strengthening the colony that is working in the supers. If extracted honey is being produced the division containing the old queen may be reunited with the other division two weeks later by placing the brood-chamber above the supers, in which case the bees will probably kill the old queen later in the season if not at this time. By this plan it is not necessary to find the queen.

For comb-honey production this treatment may be applied at the time the first comb-honey super is given. This comb-honey super may be placed between the two hive bodies if preferred (fig. 12, *A*, *B*), to cause the bees to begin work in it more readily, the queen-excluder being placed above the comb-honey super. An escape board without the bee-escape should also be placed over the comb-honey supers to prevent the sections being soiled from the brood combs above and at the same time permitting communication between the two hive bodies through the hole in the escape board, or the queen-excluder can be dispensed with by tacking a piece of perforated metal over the hole in the escape board. In this case the upper hive body usually should not be left for the full 10 days but the division may be made earlier to prevent the sections being soiled and to cause the bees to store incoming nectar in the sections, instead of in the upper brood-chamber. After four or five days the presence of eggs and small larvæ indicates which brood-chamber contains the queen, after which the division may be made at any time up to 10 days, the queenless division being left on the old stand. Ten days after the queen has been excluded from the brood-chamber now left on the old stand, all queencells should be destroyed and a ripe queencell or a young laying queen should be given. (Fig. 12, *C*.)

RADICAL CHANGES UNNECESSARY NEAR CLOSE OF SEASON.

During the latter part of the honey-flow colonies that are preparing to swarm may be induced to give up swarming much more easily than earlier in the season. In fact as the season is drawing to a close colonies having sealed queencells preparatory to swarming sometimes tear down such cells of their own accord and give up swarming for the season.

Natural swarms that issue near the close of the honey-flow may be hived in an empty box, which is placed by the side of the parent colony for 24 to 48 hours, then hived back into their own hive. After the swarm enters the parent colony the queencells are usually destroyed and the bees apparently are satisfied. If this is done earlier in the season, however, further swarming usually results.

Colonies that are preparing to swarm near the close of the season may be induced to destroy their own queencells and give up swarming by moving the hive away and substituting another hive containing two combs of brood (some unsealed brood is necessary) without queencells, the remaining space in the brood-chamber being left vacant. The supers are then transferred to the prepared hive on the original stand, and the queen is left in the original hive which is set at one side or on top of the prepared hive. (Fig. 13, *A*, *B*.) If the bees are well at work in the fields when this is done and the original hive is so located that the returning bees do not enter it, but enter the prepared hive, the original hive becomes so depleted of bees that the queencells are destroyed and swarming is given up. The other division can not swarm because it has no queen. After four or five days the original hive may be restored to its former position (fig. 13, *C*) and the bees of the queenless portion shaken from their combs back into the original hive, thus reuniting the colony.

These cases may be useful near the close of the season or at any time if the tendency to swarm is not great, but neither of them can be depended upon during the height of the swarming season, for the conditions which were present previous to preparations for swarming are soon restored under this treatment.

THE CAUSE OF SWARMING.

While the cause of swarming has not been definitely determined, the one factor which is universally present in normal swarming is

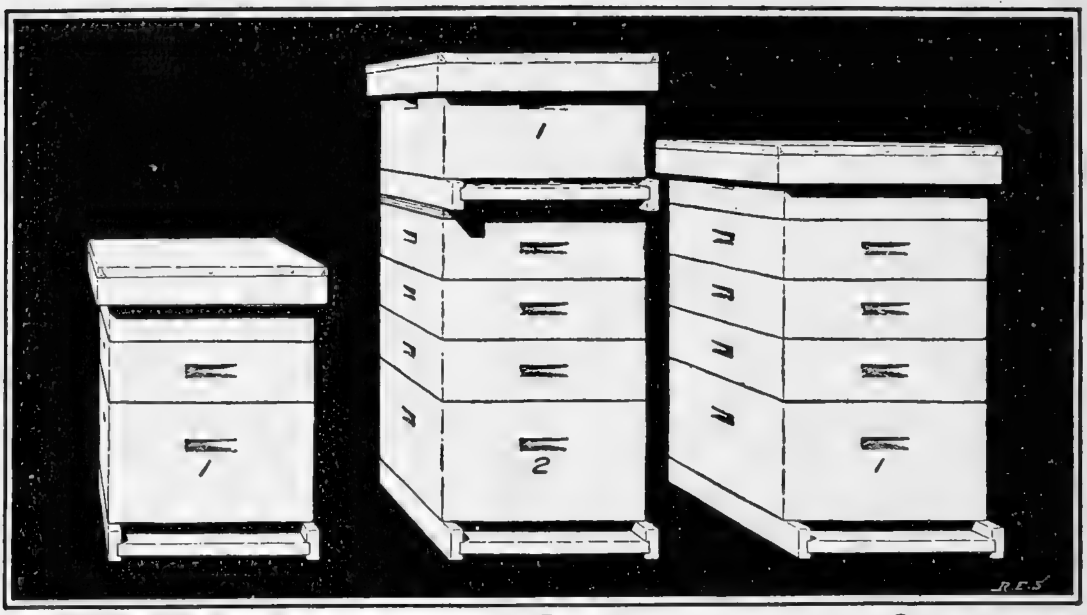


FIG. 13.—Method for inducing bees to destroy queencells and give up swarming. *A*, Colony preparing to swarm. *B*, Hive (*2*) containing two frames of brood (some of which is unsealed) is substituted for the original hive (*1*), which is now placed on top, no communication between hives *1* and *2* being permitted. *C*, Hive *2* is removed after a week or ten days and hive *1* is restored to its former position.

that of a congestion of bees within the brood-nest. Other factors often mentioned as causing swarming are not universally present. Such a congestion of bees within the brood-nest is usually brought about by a preponderance of recently emerged and emerging young bees, but the effect of such crowding may be greatly intensified by numerous factors in the environment, not universally present, which may be considered as contributing factors, but not causal. Whether a preponderance of bees too young for outside work or some other factor is responsible for swarming, this theory forms a good working hypothesis, since the successful preventive measures are those which reduce the congestion or alleviate its effects, and the successful corrective measures are those by which the balance in the proportion of hive bees and field bees is restored. In natural swarming as well as in the various methods that have been worked out to anticipate swarming, there is a break in the continuity of emergence of young bees within the hive, either at the time of the operation or a few weeks later. This reduction in the number of oncoming young bees is apparently an essential part of any successful treatment for swarming.

When a queen is being superseded during the swarming season the colony may swarm, even though it is lacking in a preponderance of young bees, which is present in normal swarming. In this case the presence of queencells begun in response to the supersedure impulse apparently brings on the issuing of the swarm. Such swarming differs in many respects from normal swarming (p. 34).

When a queen is removed or is lost by some accident several queen-cells are usually built, and when the young queens begin to emerge swarming may be expected even though the conditions conducive to normal swarming are absent. Such colonies apparently swarm because of a plurality of emerging queens, behaving in this respect like parent colonies in casting afterswarms and quite unlike the behavior in normal swarming.

SUMMARY.

Among the factors that contribute to the tendency to swarm are (1) those connected with inbred characteristics, (2) those connected with the size, shape, and arrangement of the hives and the character of the combs (immediate environment), and (3) those connected with the distribution of the bees as brought about by the peculiarities of the season, the locality, and the management (general environment).

Inbred characteristics.—Some strains of bees have a stronger tendency to swarm than others. To some extent, therefore, swarming may be reduced by careful selection in breeding.

The hive and combs.—Colonies of bees having large brood-chambers are less inclined to swarm than those having brood-chambers too small. Strong colonies having good queens may need 60,000 to 70,000 cells for the rearing of brood, during the period of extensive brood-rearing in the spring, in addition to the cells used for the storage of honey and pollen.

Colonies of bees having good combs throughout are less inclined to swarm than colonies having poor combs. Inferior combs may greatly increase the tendency to swarm, both by reducing the amount of available brood-rearing space and by acting as barriers in the way of a free expansion of the brood-nest.

Spaces for idle bees, especially within the brood-nest, may reduce the tendency to swarm. Such space may be provided by wide spacing of the combs or by a deep space below the frames.

Colonies in hives which are well ventilated and well protected from the direct rays of the sun are less inclined to swarm than those in poorly ventilated hives exposed to the sun. Ample ventilation should be provided, hives should be painted white, and if the weather is hot during the swarming season shade-boards should be used over the hives.

Distribution of bees within the hives.—Probably the greatest single factor in the cause of swarming is a congestion of unemployed bees within the brood-nest or discomfort in this part of the hive from overheating and lack of ventilation. Colonies which build a barrier of sealed honey around the brood-nest during the spring, thus confining their activities to this limited space, may be inclined to swarm even when there is an abundance of empty comb in other parts of the hive.

When the bees increase brood-rearing in the spring so rapidly that young bees accumulate faster than they are able to take up work in the hive outside of the brood-nest, the tendency to swarm is usually strong unless there is a dearth of nectar at this time. This condition brings on the normal swarming season, and great care is necessary to bring about a better distribution of the bees to prevent crowding the brood-nest.

If to this condition there is added any factor which in any way interferes with the young bees leaving the brood-nest to take up work in the supers, the congestion of bees within the brood-nest is increased, since this condition causes field bees to remain within the hives when they should be at work in the fields. The giving of super room of such character and in such a manner that the increasing number of hive workers may be enticed from the brood-nest and given work to do in the supers is of the greatest importance in the prevention of swarming.

If anything causes the field bees to stay in the hive during the day, the congestion and discomfort are greatly increased and these idle field bees may become a serious factor in increasing the tendency to swarm. In nature when a swarm issues, the overcrowding of the brood-nest is largely relieved, both within the swarm and within the parent colony.

Some important swarm-preventive measures, therefore, are:

(1) Careful selection of stock in breeding.

(2) The use of brood-chambers large enough during the spring brood-rearing period to hold the maximum amount of brood without crowding.

(3) The use of good worker combs in the brood-chamber to prevent a reduction of the available brood-rearing space.

(4) The arrangement of the brood combs to avoid barriers in the way of a free expansion of the brood-nest during the spring.

(5) Providing extra space for the bees within the brood-chamber by wider spacing of combs and a deep space below the frames.

(6) The use of large entrances during the swarming season, especially when the weather is hot, and in some cases additional openings for ventilation.

(7) Protection of the hives from the direct rays of the sun by the use of shade-boards or double covers.

(8) Painting the hives white, especially the cover, if a shade-board is not used.

(9) Management to prevent conditions favorable to the building of barriers of sealed honey around the brood-nest, or the breaking up of barriers of this kind if they already exist.

(10) Inducing the bees to expand into and occupy supers as rapidly as the honey-flow will justify during the first half of the honey-flow, or at the time the colony is rapidly expanding in numbers.

(11) Providing additional space in the form of empty combs for the ripening of incoming nectar, so that the field bees can immediately dispose of the nectar they bring into the hive, to prevent the beginning of any stagnation of the activities of the colony.

(12) Removing some of the emerging brood to reduce the number of emerging bees within the brood-chamber, thus producing a better distribution of the bees throughout the hive.

(13) The destruction of queencells, providing they have been started but recently. Frequently, however, other cells are immediately started after the queencells have been destroyed.

As a remedy for swarming the beekeeper relieves the congestion of bees within the brood-nest by creating conditions comparable either to the swarm or to the parent colony in nature.

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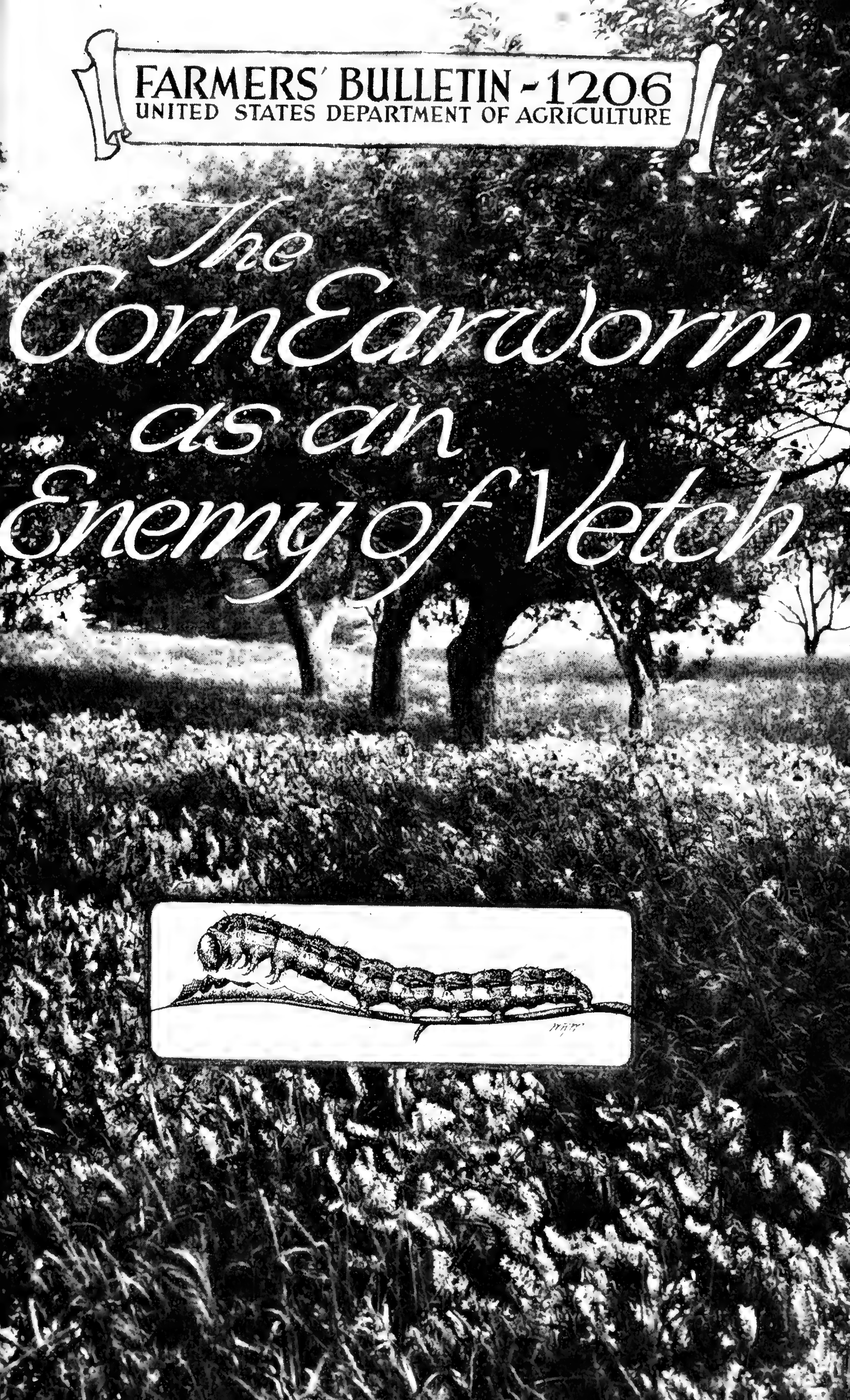
FARMERS' BULLETIN - 1206
UNITED STATES DEPARTMENT OF AGRICULTURE

The Corn Earworm as an Enemy of Vetch



VETCH, which has become an important forage crop throughout the Southeastern States, needs protection from the same insect that works such havoc on corn and cotton. This corn earworm, or cotton bollworm, is the most serious pest that growers of vetch have to combat. The caterpillars eat both the foliage and the seed pods, and, if the infestation is heavy, make the crop practically worthless.

Vetch intended for a hay crop generally escapes serious injury, as it is cut before the caterpillars are large enough to do much damage. It is recommended that a crop intended for seed be carefully watched and if the insects become numerous an insecticide be applied at once or the vetch cut for hay.

Spraying, dusting, the use of poisoned-bran bait, and other control measures are discussed and summarized in this bulletin.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. June, 1921

CORN EARWORM AS AN ENEMY OF VETCH.

PHILIP LUGINBILL, *Entomological Assistant,* and A. H. BEYER, *Scientific Assistant, Cereal and Forage Insect Investigations*

CONTENTS.

THE corn earworm is the worst insect enemy of vetch. It is one of the oldest known, most destructive, and most widely distributed insect pests and has many names descriptive of the injury it does to different cultivated plants. Of these names the most common are corn earworm, tomato worm, "tobacco budworm," and cotton bollworm, the last being used in the cotton belt.

The corn earworm occurs throughout the United States, where in the North it injures mainly green corn in field and garden, and in the South corn (figs. 1 and 3) and cotton, especially in the western portions of the cotton belt. Tomatoes and various other truck crops at times suffer severe injury. Recently the corn earworm has become a serious pest of alfalfa and especially of vetch in the South Atlantic States.

FIG. 1.—Corn earworm and its injury to ear of field corn. (Quaintance and Brues.)

The annual damage caused by the corn earworm to cultivated crops, exclusive of alfalfa, has been estimated at $27,000,000. The damage is done solely by the caterpillars, which are extremely ravenous and consume enormous quantities of food daily during the period from the time they issue from the egg until they are ready to transform into the pupa or resting stage. They feed all day long even during bright sunny weather, a habit not usual with other caterpillars.

Although considerable damage is done by the caterpillars eating the foliage of vetch, the greatest injury is done to the pods, which they enter in search of seed (fig. 4). When grown with oats for a hay crop, vetch may escape serious injury, as generally it is cut before the caterpillars are of sufficient size to do serious damage. When vetch is intended for a seed crop, however, or when part of the crop is left for seed, injury may be much more severe; for by the time the seed pods are well developed the caterpillars are about full grown and require a large amount of food. During a serious infestation the damage to the crop may be so great as to render it practically worthless for seed.

Pods which have been robbed of their seeds by the caterpillars often show no visible evidence of injury other than a small hole in the side made by the worm upon its entrance or exit. If such a pod be opened it will be found that all the seeds have been eaten. Sometimes, however, the sides of the pods are much damaged; in fact, often eaten half away.

WHAT THE CORN EARWORM EATS.

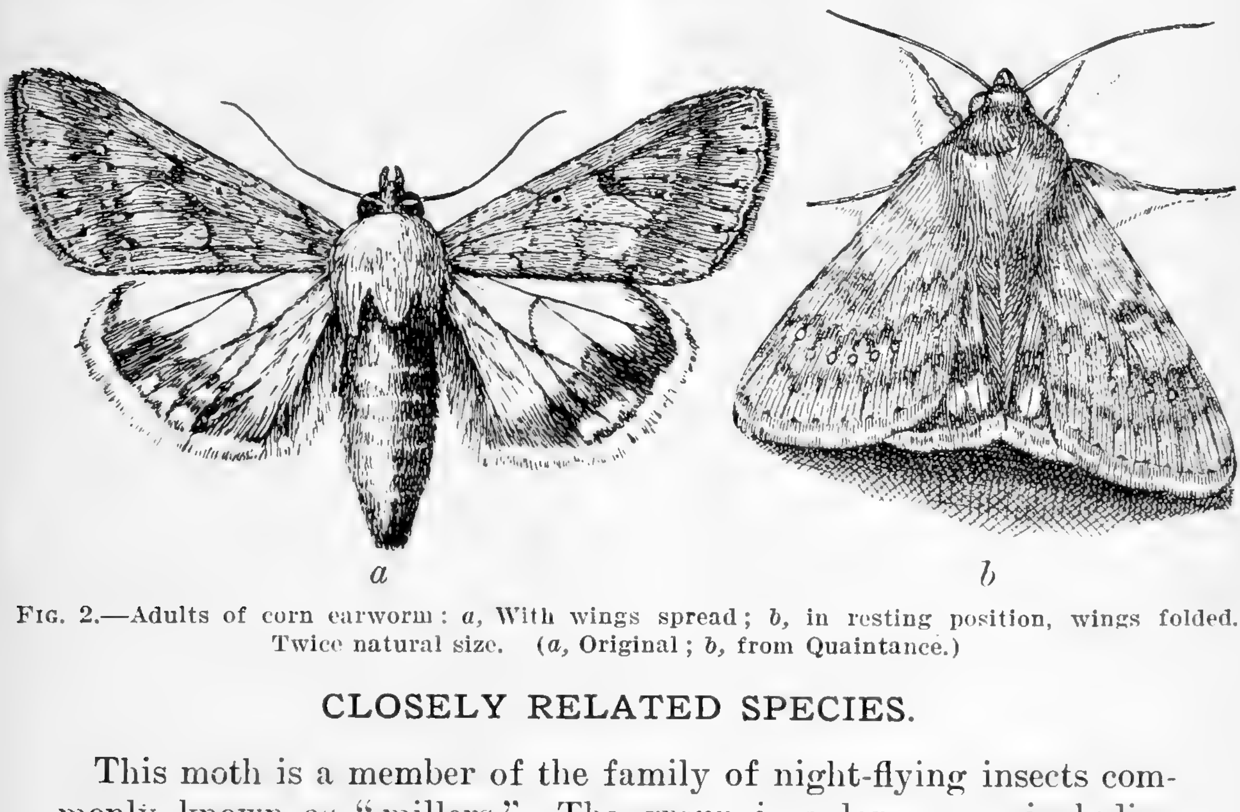
The corn earworm is practically omnivorous. Besides feeding on vetch, corn, cotton, tobacco, alfalfa, and tomatoes, it has a variety of food plants upon which it may subsist. Some of the more important are beans, pumpkins, peanuts, squash, cowpeas, pepper, asparagus, and sunflower. The caterpillars have also a cannibalistic habit, which is especially noticeable when a number of the caterpillars are closely confined. In such instances there is a battle to death, the victors devouring their antagonists. These caterpillars also feed upon other soft-bodied insects and are known to feed upon both the caterpillars and the pupæ of the alfalfa caterpillar, a most destructive insect pest of alfalfa in the southwestern United States.

WHEN A SERIOUS INFESTATION MAY BE EXPECTED.

Cool, moist weather favors an outbreak of the corn earworm on vetch, not only because this kind of weather is favorable for the development of the insect but also because it is conducive to a luxurious and dense growth of the vetch. Then, also, during such weather conditions the insect enemies of these caterpillars are hindered in their work. Cold weather has no apparent effect on the pupæ in regions where the insect is a pest of vetch because they are at that time underground and are not seriously affected by such freezes as occur in that latitude.

MOTH AND CATERPILLAR.

The adult of the corn earworm, or cotton bollworm (fig. 2), is a moth or miller which varies in color from a dull olive green in the male to a reddish brown in the female. It is to be seen flying about just before dusk in corn, cotton, and vetch fields, and at midday it may be found resting in the throat of young corn. Few growers recognize in this moth the parent of the corn earworm. The full-grown caterpillars attract more notice because they make their presence known by serious injury to crops.



a *b*

FIG. 2.—Adults of corn earworm: *a*, With wings spread; *b*, in resting position, wings folded. Twice natural size. (*a*, Original; *b*, from Quaintance.)

CLOSELY RELATED SPECIES.

This moth is a member of the family of night-flying insects commonly known as "millers." The group is a large one, including many of our most injurious caterpillar pests. Among them are the common cutworms of the garden and field, the true army worm, the fall army worm (or grass worm), and the true tobacco budworm, all of which show habits similar to those of the corn earworm.

The caterpillar of the corn earworm has been confused with the army worm, especially the fall army worm, because of the fact that when on vetch it feeds gregariously, or in colonies, and when the crop is cut moves or marches in "armies" to other fields.

SEASONAL HISTORY.

From South Carolina southward in May and June the first generation is destructive to vetch, alfalfa, young corn, and cotton. The second, which makes its appearance in the latter part of June and becomes abundant during the month of July, is injurious to corn as it comes into silk and tassel. The moths are attracted to the silk and leaves where the eggs are deposited. This is the most destructive generation to corn. The caterpillars feed on the silks, later

FIG. 3.—Corn earworm injury to bud (at left) and tassel (at right) of corn. Reduced nearly one-half. (Quaintance and Brues.)

on the kernels of the ear, and when full grown bore out through the husks, crawl down the plant, and enter the ground to pupate.

The third, or August, generation is attracted to cotton, attacking it at the time when most of the corn in southern fields is maturing

Fig. 4.—Work of corn earworm on vetch.

and, therefore, is no longer suitable as food for the caterpillars. Late corn, however, is damaged considerably by the larvæ of this generation, the percentage of infested ears sometimes running high. Tobacco is subject to injury about the same time. In cotton the

FIG. 5.—Tip of ear of corn, showing eggs of corn earworm on the silks. In upper right, a few eggs on silks, enlarged. (Quaintance and Brues.)

worms bore into the bolls. The fourth generation, which occurs only in the most southern portions of the country, is rarely important, since food is scarcer and weather conditions less favorable and their number usually has been reduced by parasitic enemies. The overlapping of the generations makes it possible to find all stages of the insect at any time during the summer and fall months.

LIFE CYCLE.

The corn earworm in its life history passes through four distinct stages: First, the egg (fig. 5); second, the larva or caterpillar (fig. 6); third, the pupa or resting stage (figs. 7 and 8); and, finally, the moth or mature insect (figs. 2 and 9).

THE EGG.

The egg (fig. 5) of the corn earworm moth is hemispherical in outline and somewhat smaller than a pinhead. It is a uniform light yellow when just deposited, but towards the end of the incubation period it becomes mottled with reddish brown. The duration of the incubation period varies from 3 days in summer to from 5 to 8 days in early spring or late fall. There is also a great variation in the number of eggs deposited. A moth deposits on an average about 800 eggs during her lifetime and about 300 during an evening. She may deposit as many as 500 eggs in one evening, however, and over 2,500 during her lifetime. The eggs are deposited singly, just before dusk, on various parts of plants upon which the caterpillars feed.

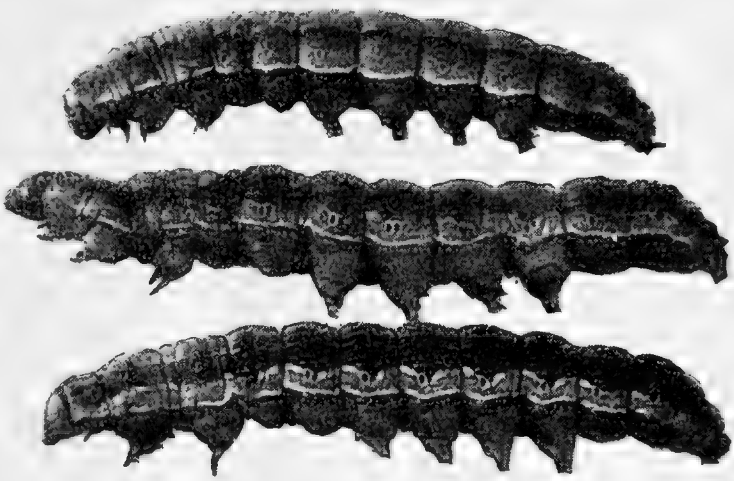


FIG. 6.—Three corn earworm larvæ, seen from the side, showing color types: Upper larva, green; middle one, rose colored; lower one, dark brown. Twice natural size. (Quaintance and Brues.)

THE LARVA OR CATERPILLAR.

The caterpillar or larva (fig. 6) is the stage in which the insect attacks and destroys the plant. The newly-hatched caterpillar is pale yellowish white with a pitch-black head. It walks with a looping motion somewhat similar to that of a "measuring worm." This is due to the second and third pairs of legs being shorter than the first in the young larvæ. In the full-grown individuals they are all equal in length.

The body of the caterpillar is covered with numerous wartlike humps of a dark color, each one of which bears a short hair. These humps are known as tubercles and give the caterpillar a spotted appearance even when young but more so when almost full grown. As the caterpillar grows the skin is shed periodically, usually every two to four days. This shedding of the skin is known as molting. The caterpillar molts at least five times, sometimes more. When full grown it is about 1½ inches long. After every molt the caterpillar takes on a new color pattern, quite different from the preced-

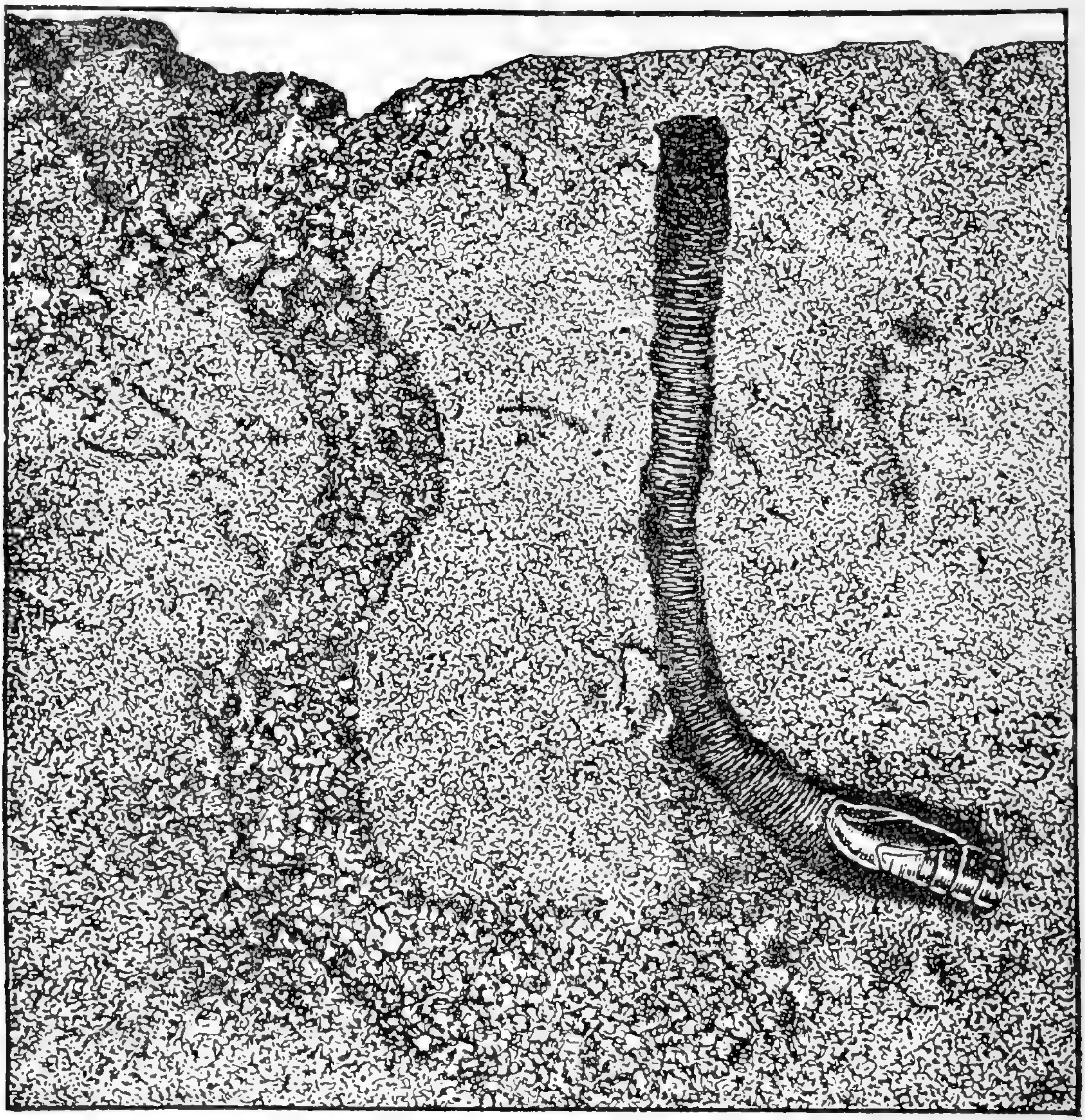


FIG. 7.—Pupa of corn earworm in its burrow in the soil. (Copied from Quaintance and Brues.)

ing one. Full-grown caterpillars vary greatly in color; in fact, if individuals showing extremes in color were selected, the average person would not recognize them as belonging to the same species. The color varies from a pale green to a very dark brown, almost black. Between these extremes are many shades and combinations of colors. Some have beautiful stripes or bands of yellow on the sides and almost black or olive on the back.

Caterpillars when feeding on foliage such as vetch show a somewhat darker color pattern than when feeding on corn ears or in cotton bolls. There are two common forms found in such places. One form has a dark amber head mottled with dark brown and a body that is almost black. Over the middle of the body are whitish lines running lengthwise. Along either side is a light-colored band. These bands usually are yellowish in color. The underside of the body is yellowish white and the feet are dark. The other form has a head of the same color as the preceding, but the body presents a marked difference in color pattern. The back is an olive gray with two narrow black lines close together running lengthwise over the middle. Along either side is a black band, and directly below it is a light one having the same color as in the other form. The under sides of the body and feet are as in the preceding form. Other forms are modifications of these.

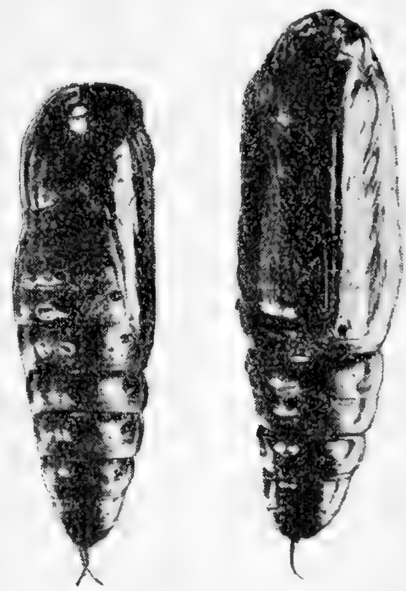


Fig. 8.—Pupæ of corn earworm. Twice natural size. (Quaintance and Brues.)

The skin of this caterpillar is finely granulated and somewhat greasy in appearance. That of the fall army worm or of the true army worm is smooth and shiny. This difference aids in identification of the caterpillar.

The length of life of the caterpillar depends upon the temperature of the period during which it lives. During the spring and early summer when the temperatures are not so high the length of this stage is from 22 to 28 days with an average of about 24 days. During the summer months this stage is somewhat shorter.

Coming from eggs that were deposited at short intervals, the caterpillars reach maturity at about the same time and consequently undergo the transformation stage together. This explains why caterpillars may be seen in countless numbers in the evening and by the next morning may have disappeared entirely, causing great astonishment to the planter.

THE PUPA OR RESTING STAGE.

Upon reaching maturity the caterpillar burrows into the soil to a depth of about 6 inches—the actual depth depending upon the texture of the soil. A burrow is then constructed which runs backward and upward to within a few inches of the surface of the soil so that the moth upon emergence will be able to come out of the ground without any difficulty. (Fig. 7.) The caterpillar changes to a pupa at the bottom of the burrow. The shape and general appearance of the pupa may be seen in figure 8. The pupa is reddish or light brown, and highly polished. It is rather stout, about three-fourths inch long, and its last abdominal segment is supplied with two slender spines known as the cremaster. The time spent in this stage varies from 8 to 14 days during summer, and is much longer in early spring and in the late fall. The insect passes the winter in the pupa stage, and the moth emerges early the following spring—earlier in the southern regions than in more northerly ones.

Fig. 9.—Moths of corn earworm resting on corn ear.

THE MOTH OR ADULT.

The moth of the corn earworm (fig. 9) is about three-fourths of an inch long with a wing expanse of about one and three-fifths inches. The moths are of different colors, the variation being sexual. Because this appears not to have been noticed heretofore, a brief description of the color of the two sexes follows:

The males are a light to a dull olive with dusky spots on the forewings and a circular spot with a black center about midway between the apex and base on the costal angle of either wing. The hindwings have dusky bands near their outer angles. Veins of the hindwings are prominent and dark.

The females are fawn-colored with irregular spots of black on the forewings, often having dark bands near the outer angles of these wings. The circular ring so conspicuous in the forewing of the male is almost wanting or if present is merely a solid dark spot. The hindwings have broader and darker bands near their apical angles than those of the males.

The moths conceal themselves among the foliage during the day and come out at dusk to lay eggs and to feed upon the nectar and sweet juices of various plants. They live about 10 days or two weeks and during this time they mate and deposit their quota of eggs for the next generation.

INSECT ENEMIES.

The corn earworm when feeding on roasting ears or in cotton bolls is afforded much protection from its natural enemies. When feeding in the open on vetch and other crops it is attacked by numerous parasitic enemies. Chief among these are parasitic flies (fig. 10). These flies can be seen flying about in the field and depositing their eggs on the backs of the caterpillars. The eggs are whitish, somewhat oval, and about the size of a small pinhead; they can be seen quite readily with the unaided eye. A number of eggs may be deposited on the back of one caterpillar. The maggots hatching from these eggs enter the caterpillar's body, feed upon its tissues and organs, and gradually kill it. When mature the maggots leave the body of the caterpillar, which often has been eaten completely with the exception of its skin, and enter the ground to transform. The skin of the maggot hardens into a leathery case, dark red in color, termed a puparium, within which the transformation to adult takes place. The insect remains in the pupa stage about 10 days and at the end of the period the fly emerges.

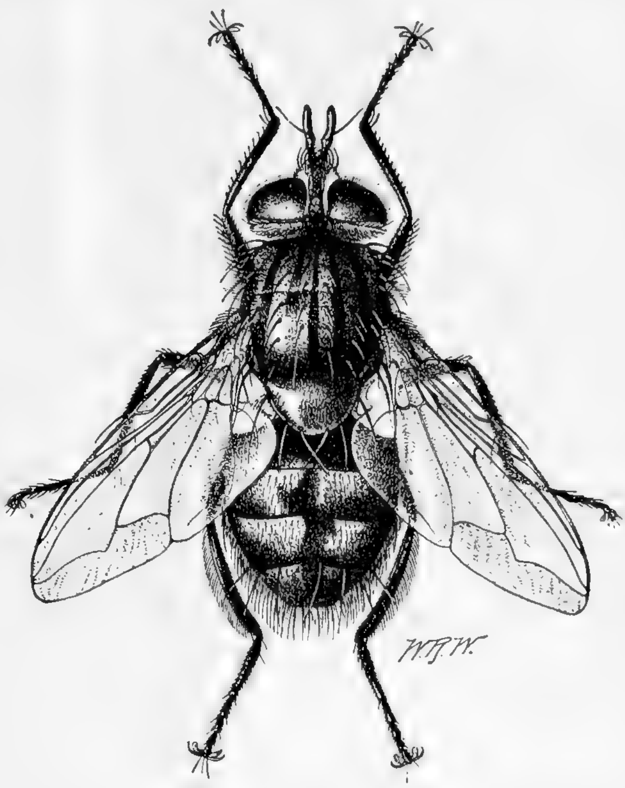


FIG. 10.—*Winthemia quadripustulata*, a fly parasitic on the corn earworm: Adult. Much enlarged. (Walton.)

These flies make known their presence by their high-pitched, humming sound when flying about fields in search of caterpillars upon which to place eggs. Among the more important bird enemies of the corn earworm are blackbirds, crows, sparrows, bluebirds, and meadowlarks. Domestic fowls are useful in reducing the numbers of the caterpillars. Toads also devour large numbers and have been found very commonly in vetch fields infested with these caterpillars.

CONTROL MEASURES.

In many cases during recent invasions of the corn earworm, the infestation started in hairy vetch and spread thence to young corn, cotton, and alfalfa. Growers who have suffered from invasions of this pest have hesitated about continuing to plant vetch. However, it is not necessary to reduce the acreage of vetch as this pest can be controlled by a little effort. As has previously been mentioned, vetch intended for a hay crop generally escapes serious injury because it usually is cut before the caterpillars are of sufficient size to do much damage. That part of the crop, however, which is intended for seed and which is left uncut for several weeks longer, that the seed may ripen, is subject to more serious injury; for during this period the caterpillars do their most destructive work. The seed crop of vetch, therefore, should be carefully examined from time to time; and if the caterpillars are found to be abundant, an insecticide should be applied at once, or if it is not possible to do this, the crop should be cut for hay. The quality of hay will not be as good as that from earlier-cut vetch, but the hay will be worth more than the small quantity of seed that the crop will yield.

During favorable seasons vetch and oats, planted together in rich soil, generally make a very dense growth. Therefore it is not advisable to use a large sprayer to apply an insecticide, for not only is it difficult to apply a spray so that it will reach the lower parts of the plants but the trampling of the dense growth of the crop results in much damage to the plants by their being broken off, bent over, or mashed down. The area to be treated is generally small and may be easily treated with portable machines, either sprayers or dusters. Every farmer should possess such an outfit. They are not necessarily expensive and may be purchased in almost any town. Often such an implement will more than pay for itself with a single usage. Every farmer should keep in touch with a concern that supplies standard insecticides, such as arsenate of lead, Paris green, or calcium arsenate. He should also keep in touch with an entomologist who can supply the necessary advice immediately. Nearly every State in the Union has such an official. It would be advisable also to have on hand a copy of Farmers' Bulletin 908 on "Information for fruit growers about insecticides, spraying apparatus, and important insect pests."

SPRAYING FOR THE CATERPILLARS.

When the caterpillars are feeding on the foliage of plants, such as vetch or alfalfa, they may be killed by applying a poison spray (fig. 11). This spray should be applied with as much force as possible so as to reach the foliage at all depths. A mixture of 1 pound of arsenate of lead (powder) or 2 pounds of arsenate of lead (paste form) to 50 gallons of water may be used. Paris green may be used in place of arsenate of lead, but is less desirable on account of the greater danger of burning the foliage. When Paris green is used it should be mixed with lime in the following proportions: Paris green, 10 ounces; freshly slaked lime, 2 pounds; water, 50 gallons. Zinc arsenate also may be used safely as a spray in the proportion of 1 pound to 50 gallons of water. Care should be taken when spraying young corn to see that the spray reaches well down into the bud.

FIG. 11.—An inexpensive type of outfit which may be used for spraying vetch or alfalfa.

DUSTING.

Since the advent of dusting as a means of controlling the cotton-boll weevil in the South, this method (fig. 12) of applying a poison for other insects is gaining in popularity. New and better dusters are now made and are almost as easily obtainable in the South as are spraying machines. Calcium arsenate or lead arsenate (powder form) may be used in any one of these dusters with satisfactory results. During a recent outbreak of the fall army worm in a certain district in the South splendid results were obtained with the use of a hand duster and calcium arsenate.

Dusting should be done early in the morning when the dew is still on the plants, or late in the evening. A little slaked lime may be added as a carrier but these insecticides are more effective when used in the pure form. There is no danger of burning the plants when lead arsenate is used in this way or when calcium arsenate is used, provided this arsenate shows not over three-fourths of one per cent of water-soluble arsenic. However, calcium arsenate having water-soluble arsenic in excess of three-fourths of one per cent should not be applied in the pure form but should be mixed with lime. If Paris green is used as a dust, freshly slaked lime should be added at the rate of 1 pound of Paris green to 3 pounds of lime.

POISONED-BRAN BAIT.

The poisoned-bran bait, used under some conditions, is a valuable means of controlling the corn earworm on vetch and on alfalfa. It is made as follows: Wheat bran 50 pounds, Paris green or white arsenic

1 pound, or powdered lead arsenate 2 pounds, low grade molasses 2 gallons, water 3 to 4 gallons. The bran and insecticide are first mixed together dry, the molasses is then added, and the whole mass is thoroughly combined. Five pounds of salt may be added to the mixture to keep it from drying out. The addition of six finely chopped lemons or oranges to the mixture to give flavor has been found to be advantageous in some cases, and water may be added when necessary.

Fig. 12.—Hand duster which may be used in applying calcium arsenate or lead arsenate to forage plants infested with corn earworms.

When scattered over the fields thinly it is effective with caterpillars moving to an uninfested field.

MECHANICAL METHODS OF CONTROL.

Before cutting the vetch in a seriously infested field a deep furrow should be made around it, because the caterpillars begin to leave a field while it is being cut, spread in all directions, assume the army worm habit, and, if nothing is done to prevent their onward march, will pass to other fields and destroy crops growing there. Cotton and corn growing next to vetch have been completely overrun by caterpillars acting in this manner. If a deep furrow is made with a turn plow (fig 13) in the path of advance the caterpillars, in their endeavors to cross the ditch, will fall into it and become entrapped. They may then be sprayed with kerosene or crude oil, or a log may be dragged through the furrow to crush them. Holes may be sunk at frequent intervals in the bottom of the furrow for entrapping the worms. Where the worms attempt to cross a smooth, hard road in

FIG. 13.—Plowing a furrow around a field to be protected from corn earworms on the march. The man in the foreground is digging post holes at intervals to entrap the worms.

going from an infested field to a new field, a field roller run up and down the road gives excellent results in destroying them.

SUMMARY OF CONTROL MEASURES.

(1) A practical spraying outfit or duster should be kept on hand: also standard insecticides.

(2) In the spring watch carefully the vetch crop, and at the first sign of caterpillars apply the control measures recommended in this bulletin.

(3) In case the infestation is beyond control the crop should be cut for hay immediately. The ground should then be well cultivated so as to expose the pupæ to the hot sun and to their natural enemies.

(4) When the caterpillars are on the march, or are starting in one corner of a new field, stop their onward march by plowing a deep furrow around the infested area. Care should also be taken to see that the furrow is kept free from rubbish.

(5) As a spray for vetch and other forage crops use any one of the following mixtures:

(*a*) Arsenate of lead (powder form)	pound	1
Water	gallons	50
(*b*) Arsenate of lead (paste form)	pounds	2
Water	gallons	50

As a spray for corn use a stronger solution:

(*a*) Arsenate of lead (powder form)	pounds	2
Water	gallons	50
(*b*) Arsenate of lead (paste form)	pounds	4
Water	gallons	50

(6) In dusting use one of the following insecticides:

(*a*) Calcium arsenate. Undiluted if analysis shows not over three-fourths of one per cent water-soluble arsenic, and diluted with lime if analysis shows over three-fourths of one per cent water-soluble arsenic.
(*b*) Arsenate of lead (powder form).
(*c*) Paris green 1 pound; lime, freshly slaked, 4 pounds.

(7) Poisoned bait is scattered broadcast over the infested fields. Make this up according to the following formula: Wheat bran 50 pounds, Paris green or white arsenic 1 pound, cheap molasses 2 gallons, water 3 to 4 gallons, and add 6 finely chopped oranges or lemons to the mixture.

CAUTION: *Care should be taken not to pasture stock on crops that have been sprayed or dusted with poison mixtures until rains have removed all traces of the poisons.*

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO CEREAL AND FORAGE CROPS.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Chalcis-Fly in Alfalfa Seed. (Farmers' Bulletin 636.)
Wireworms Destructive to Cereal and Forage Crops. (Farmers' Bulletin 725.)
True Army Worm and Its Control. (Farmers' Bulletin 731.)
Corn and Cotton Wireworm in Its Relation to Cereal and Forage Crops, with Control Measures. (Farmers' Bulletin 733.)
Cutworms and Their Control in Corn and Other Cereal Crops. (Farmers' Bulletin 739.)
Alfalfa Weevil and Methods of Controlling It. (Farmers' Bulletin 741.)
Grasshopper Control in Relation to Cereal and Forage Crops. (Farmers' Bulletin 747.)
Fall Army Worm, or Grass Worm, and Its Control. (Farmers' Bulletin 752.)
Bollworm or Corn Earworm. (Farmers' Bulletin 872.)
Rough-Headed Corn Stalk-Beetle in Southern States and Its Control. (Farmers' Bulletin 875.)
Common White Grubs. (Farmers' Bulletin 940.)
Controlling the Garden Webworm in Alfalfa Fields. (Farmers' Bulletin 944.)
Southern Corn Rootworm and Farm Practices to Control It. (Farmers' Bulletin 950.)
Controlling the Clover-Flower Midge. (Farmers' Bulletin 971.)
Control of the Green Clover Worm in Alfalfa Fields. (Farmers' Bulletin 982.)
How to Control Billbugs Destructive to Cereal and Forage Crops. (Farmers' Bulletin 1003.)
Wheat Jointworm and Its Control. (Farmers' Bulletin 1006.)
Larger Corn Stalk-Borer. (Farmers' Bulletin 1025.)
European Corn Borer: A Menace to the Country's Corn Crop. (Farmers' Bulletin 1046.)
Hessian Fly and How to Prevent Losses from It. (Farmers' Bulletin 1083.)
Grasshopper Control in the Pacific States. (Farmers' Bulletin 1140.)
Studies on the Life History and Habits of the Jointworm Flies of the Genus Harmolita, with Recommendations for Control. (Department Bulletin 808.)
Clover and Alfalfa Seed Chalcis-Fly. (Department Bulletin 812.)
Western Grass-Stem Sawfly. (Department Bulletin 841.)

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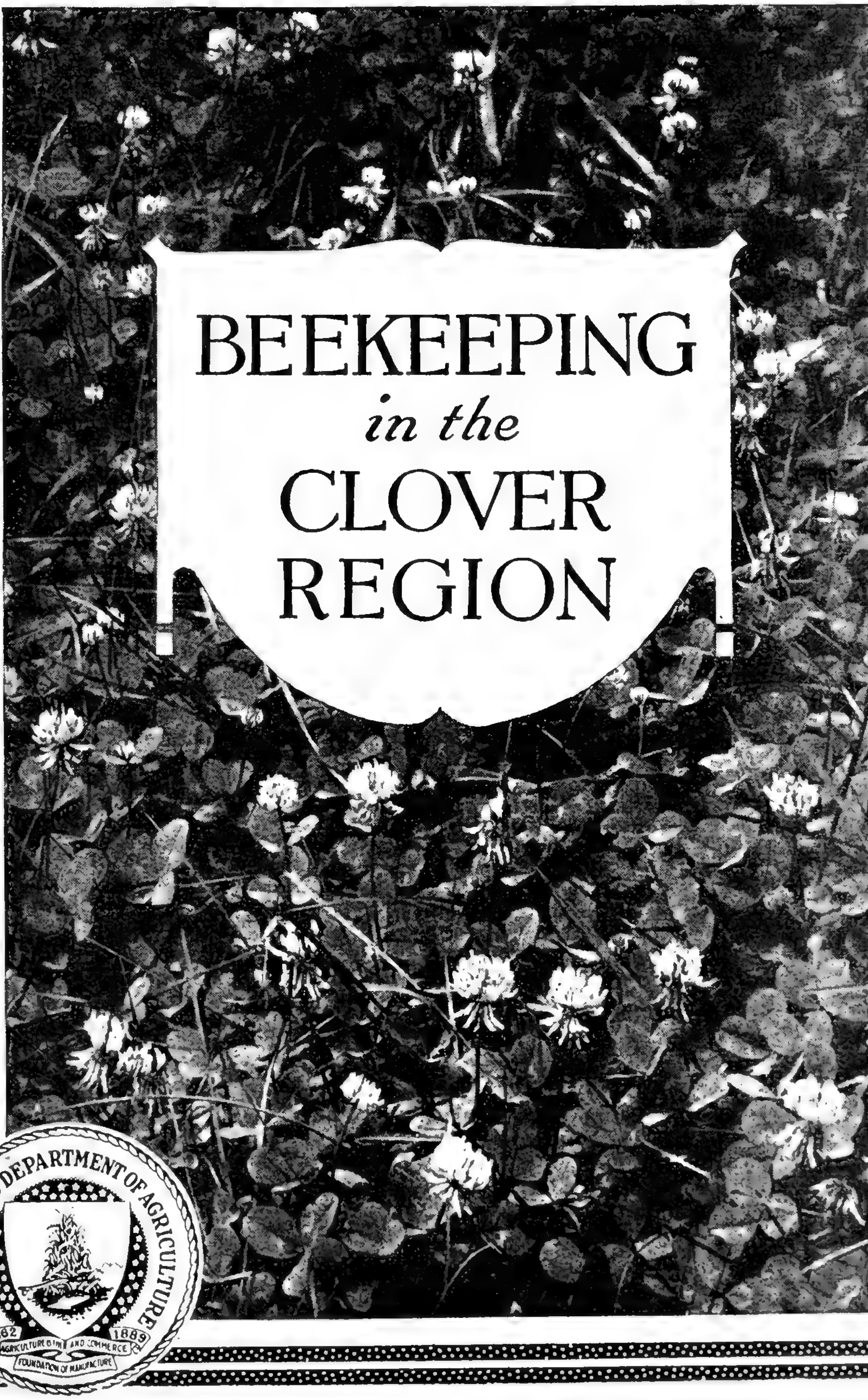
UNITED STATES DEPARTMENT OF AGRICULTURE

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1215



BEEKEEPING *in the* CLOVER REGION

BEEKEEPING METHODS suitable for the clover region are well developed but many beekeepers of this region are failing to obtain the full available honey crop because of deficiencies in their practice. A system of management is here given which will result in a full crop from these sources.

The variation in the value of the clovers to the beekeeper is also discussed and the methods to be followed in bringing the clover region back to its former prominence in honey production are outlined.

Washington, D. C. Issued February, 1922; revised August, 1922

BEEKEEPING IN THE CLOVER REGION.

E. F. PHILLIPS, *Apiculturist in Charge*, and GEORGE S. DEMUTH, *Apicultural Assistant, Bee-Culture Investigations, Bureau of Entomology.*

CONTENTS.

BEEKEEPING practices in the United States have been developed largely in the clover region and because of this the literature of the subject deals chiefly with methods applicable to this territory. Nevertheless the clover region is failing to produce the honey it should; chiefly, no doubt, because the methods that give the best results for the region are not clearly analyzed, and there are so many to choose from that the beekeeper can with difficulty decide which are best. Clover is now the source of a vast amount of honey, doubtless furnishing more than any other nectar-secreting plant. Since the honey from this source is not surpassed in quality by any other, it is important to the beekeeping industry that the clovers be utilized more completely. This bulletin endeavors to simplify the problem of the beekeeper of this region by describing those practices which have been proved most effective. A single system is here outlined, rather than several methods for each phase of the work, the plans given being those which will give the best results in most clover locations.

The clovers included in this discussion are *white clover*,[1] *alsike clover*,[2] and *red clover*.[3] These plants bloom at nearly the same time, the honeys are almost identical, and the same methods may be used for the gathering of their honey-crops. Their geographical distribution in the United States may be considered, for the purposes of this bulletin, as identical. These clovers belong to the family Leguminosae, to which belong many other important honey-plants, such as alfalfa[4] and sweet clover.[5]

[1] *Trifolium repens.* [2] *T. hybridum.* [3] *T. pratense.* [4] *Medicago sativa.* [5] *Melilotus alba.*

GEOGRAPHICAL BOUNDARIES OF THE CLOVER REGION.

The typical clover region occupies the northeastern part of the United States, extending west into Minnesota and south approximately to the Ohio River and Mason and Dixon's Line. It appears on the west coast in Washington and Oregon. In both east and west the region extends into Canada, some of the best portions being located north of the national boundary. Limited areas of less value are found outside the boundaries indicated.

It must not be assumed, however, that these plants are equally valuable to the beekeeper throughout the area indicated; for, as

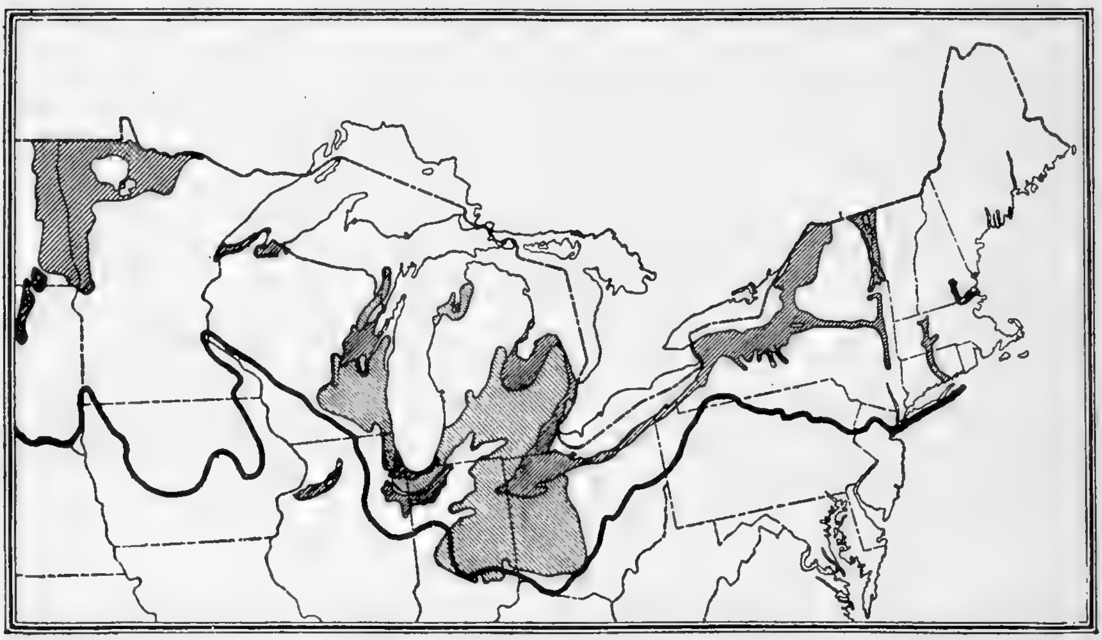


Fig. 1.—Map of clover region showing boundary (heavy black line) of area covered by the last glacier. The best areas for nectar secretion from the clovers are those formerly covered by glacial lakes (shaded from right to left), when properly drained and those of the Middle West (shaded from left to right), where the soils are derived by glacial action from rocks containing limestone. Undrained swamps are useless as clover areas.

will be pointed out later, nectar secretion of these species is influenced by many factors, and as a result there are many places in the area here indicated in which the plants are almost valueless for nectar secretion. In general, the farther north one goes the better the secretion becomes from these species. Most of the best clover territory lies in the area covered by the last glacier (fig. 1) and the best of the clover region lies in western Vermont, northern and central New York, northwestern Ohio, northern Indiana, and Illinois, Michigan, Wisconsin, Minnesota, and northeastern Iowa. While these clovers are found in all parts of the United States, except in the arid regions, the beekeeper outside the best areas may not look to them as sources of nectar, except possibly as minor contributing sources. The discussion in this bulletin is applicable only to those places where they are major sources of honey.

VARIATIONS WITHIN THE REGION.

As has been indicated, there is great variation in the frequency of occurrence of the plants in the region included in the geographical boundaries of these clovers. There is also, as is well known to beekeepers, an enormous variation in the amount of nectar secreted by these plants according to soils, climatic conditions, and other environmental factors, to be discussed briefly further on. The color of the nectar, and of the resulting honey, varies considerably, the honey being darker where the secretion is less rapid. In general it may be stated that secretion is most abundant, and the honey of the best

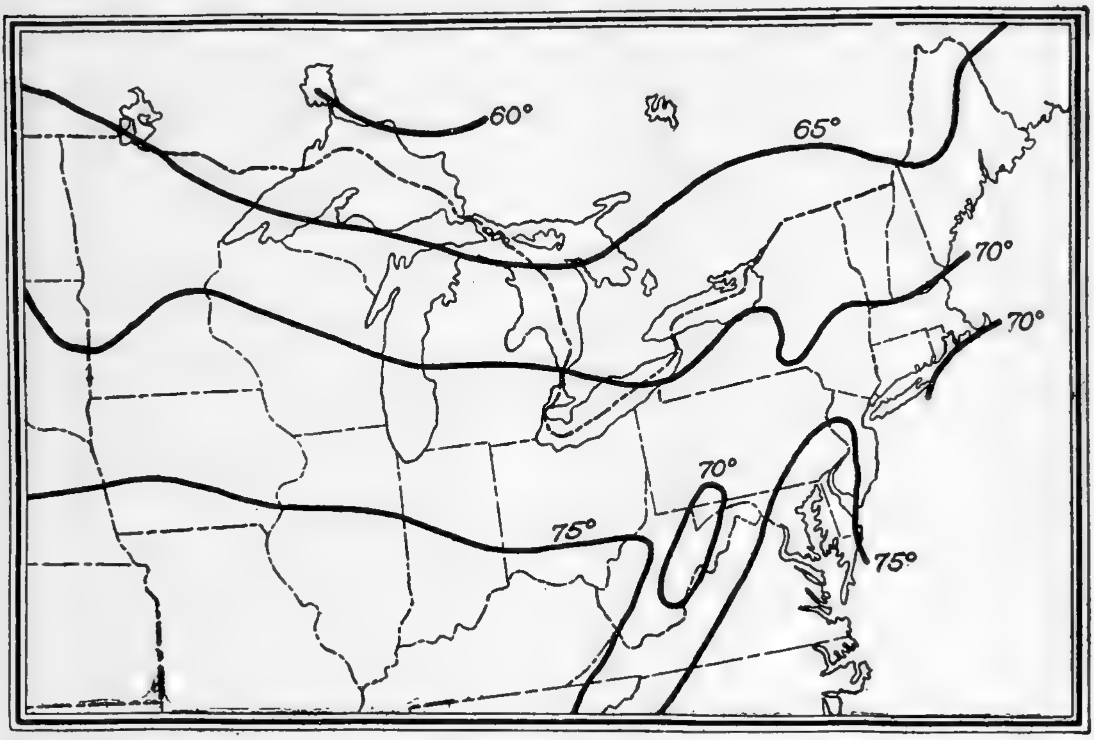


FIG. 2.—Normal July temperatures in clover region. Because of variation in the time of blooming of the clovers this map may not indicate the normal temperature at the blooming season for the southern part of the region. The optimum normal temperature for nectar secretion from the clovers is about 70° F. or less.

quality, where the soils are not acid (fig. 1) and where the summer temperatures are relatively low (fig. 2).

Unfortunately, the statistics of beekeeping are not sufficiently accurate to enable one to mark definitely the boundaries of the best of the clover region, nor are data available from other sources which may be used without reservation as indicative of the optimum conditions for nectar secretion of these plants within the region. In general, any region suitable for a high development of dairying is one where heavy nectar secretion from the clovers may be expected.

RELATION TO OTHER BEEKEEPING REGIONS.

Within the broad boundary of the clover region are included many other beekeeping regions of lesser extent, such as the buckwheat region. The presence of other plants on which the beekeeper depends for surplus honey naturally modifies materially the methods of beekeeping practiced; but, since there are within this region no other important nectar-secreting species which bloom earlier than do the clovers, the beekeeper must plan his work so as to get the greatest possible amount of honey from this source. Where buckwheat is a major source of honey the clovers are not at their best. Where tulip tree is a major source of honey the clovers are usually insignificant. The clover region does not extend westward into the territory where alfalfa becomes a major honey source. While there is considerable sweet clover within the clover region, this species is more important to the beekeeper outside the area where the other clovers are important.

It should be emphasized that, since the clovers do not secrete nectar freely everywhere within the area indicated, there are minor areas within the clover region where other species are the main dependence of the beekeeper, and these areas are not to be considered as part of the clover region in a strict sense. Examples of this are to be found in the willowherb and wild red-raspberry regions of the North and, especially, the swamp regions, such as those in which Spanish needle is a major source.

CHARACTERISTICS OF THE CLOVERS.

WHITE CLOVER.

White clover is a native of the Old World and is not thought to be native to North America. It is a perennial, low-growing, creeping plant, propagated by seed and also taking root on the creeping stems. The roots are shallow and do not arise from a crown. The stems are recumbent. The flowers are white, with a slight pink tint on the tips of the corolla at times. To the northward this pink tint increases in extent and intensity, and at high altitudes the flowers of this species are decidedly reddish. As the flowers of the head wither the petioles are no longer erect and the individual flowers turn reddish-brown and bend backward around the stem. The leaflets are smaller and more rounded than those of alsike clover and have light markings, similar to those of red clover.

The chief blooming period, and the only one which may be counted upon to furnish nectar, begins about five to six weeks after the average date of the last killing frost in the spring (fig. 3), and lasts about three to five weeks. Some blossoms appear before the date indicated and it usually happens that nectar secretion does not begin until 10 days after the first blossoms appear. Under favorable weather conditions the blooming period may be greatly prolonged, and sometimes the period of nectar secretion is also lengthened, although usually flowers blooming in the later part of the summer furnish little or no nectar. The chief agent for pollination of this species is the honeybee.

As has been indicated, nectar secretion is not uniform throughout the range of this species. The plants thrive best when there are good rains in July, August, and September. Winterkilling is less noticeable for white clover than for red clover. If there are abundant rains in May the plants are put into a condition of great vigor, and this adds greatly to the probability of a heavy secretion for the season. Rains while the plants are in bloom serve to prolong the period of blooming and of nectar secretion. White clover is seem-

FIG. 3.—Map showing average date of last killing frost in spring. From these data the beekeeper determines the time to unpack colonies of bees wintered outdoors.

ingly most valuable as a honey-source in the northern part of its range, and this is probably due to the fact that the plants are most vigorous and secrete nectar most freely where the temperatures at blooming time are relatively low (fig. 2). The species is able to reseed itself in central Alaska, where the growing season is exceedingly short. It is recorded that secretion occurs in the north at temperatures too low for bees to fly. It rarely may be counted upon as a major honey-source where the average summer temperature exceeds 75° F. A more important consideration, however, is that secretion is most rapid where there is a considerable daily range of temperature, the best results being observed when the night temperature is below 65° F. and the day temperature above that point.

While proper climatic conditions are necessary for nectar secretion from this species, it is only where soil conditions are favorable for the growth of the plants that the beekeeper can expect to get a heavy secretion of nectar. (Fig. 1.) Soils having an abundance of lime are found wherever white clover is a major source of honey. While white clover plants are observed growing in soils that are deficient in lime, under such conditions these plants secrete nectar only under the most favorable climatic conditions, and failures in the clover-honey crop are frequent in such regions.

ALSIKE CLOVER.

Alsike clover also is a native of the Old World and is not native to America. In ordinary farm practice it is grown as a biennial, although a few plants may survive after seed production. It is propagated by seed and not from creeping stems. The roots are shallow and branching. The stem is erect and rarely exceeds a height of 2 feet, except on low, rich land or in the far north. The flowers are white to pinkish-rose, the color being deeper to the northern part of the range. The flowers of this species turn back on maturing, as do those of white clover. The leaflets are shorter and relatively broader than are those of red clover. The heavy blooming period may begin slightly before that of white clover and is often curtailed by cutting. When the plants are pastured the blooming period may be prolonged if the climatic conditions are favorable. The chief agent for pollination is the honeybee.

In general, the conditions favorable for nectar secretion for alsike clover are the same as those for white clover. This species differs from white clover, however, in the fact that it is a regular farm crop in some places, and such locations are unusually favorable for the beekeeper. It is increasing as a farm crop, especially in locations where, because of increasing soil acidity, red clover is no longer so profitable. Alsike clover is grown alone and with timothy for hay, and in some limited localities it is grown for seed, thus giving the maximum time for nectar secretion. It does not yield nectar equally well in all places where it is grown for hay, since the best yields are possible only where the soil and climatic conditions are most favorable. In the northern part of the range of this species the nectar secretion is greatest.

RED CLOVER.

Red clover is a native of the Old World, having been cultivated as a farm crop for many centuries. It is a biennial, rarely perennial, propagated by seed. It has a branching taproot extending deep into the ground, the depth varying with the character of the soil. The stems are erect and vary in height, being higher than those of alsike clover. The flowers are bright red or purple, remaining erect after withering. The leaflets are larger than those of either of the other two clovers mentioned and have V-shaped lighter markings. In ordinary farm practice there are two separate blooming seasons, the first coinciding in time with that of alsike clover. When grazed the blooming season is extended until fall under favorable weather conditions. Unlike alsike clover, the usual farm practice is to cut the first crop for hay and then permit the plants to mature seed in the second crop. While because of the length of the corolla tube this species is best adapted for cross-pollination by bumblebees, no insect is of more importance in the setting of the seed than is the honeybee. When the mammoth red clover is grown the blooming season is prolonged, as this variety comes into bloom from one to two weeks later than the common red clover.

Because of the fact that the honeybee can not always reach the nectar in red clover, accurate data are unavailable as to the conditions best suited for nectar secretion in this species. In general, conditions favorable for nectar secretion in white and alsike clovers are also those under which red clover produces the most nectar. It is well known that the amount of nectar produced by the red-clover flowers is greater than that in the flowers of the other two clovers, and it is indeed unfortunate that the honeybee can not take full advantage of this abundant source. The beekeeper usually does not credit red clover with the production of much nectar available to the honeybees, but it is doubtless true that where this species is grown it forms at least an important minor source of nectar, and probably much of the clover honey produced in the United States is partly derived from red clover. Usually the benefit from red clover is more noticeable from the second crop, it being believed that the shorter corolla tubes enable the honeybees to gather a larger proportion of the nectar. This is especially valuable to the beekeeper because at this time the secretion from white and alsike clovers has usually ceased.

Red clover does not thrive in wet or cold soils, to which alsike clover is better adapted. It is losing ground as a farm crop, probably because of an increasing deficiency of lime in the soils of the regions in which it was formerly more abundant. This is fortunate for the beekeeper, in that its place is being taken more and more by alsike clover, which is better adapted to visits of honeybees.

While there is a gradual shifting in agricultural importance of the various clovers, the beekeper of the typical clover region has no cause for alarm, because more and more the farmers of this region are recognizing the necessity of growing crops which are capable of fixing nitrogen from the air, and so far no such crop has been found for this region which does not furnish abundant nectar.

112365°—22——2

PRESENT DEVELOPMENT OF BEEKEEPING IN THE REGION.

As has been indicated in an earlier section, beekeeping as a business first developed in the United States in the clover region. Because of the peculiarities of the problems of this region, and the difficulty of getting the maximum honey-crop from the clovers, the most skilled beekeepers of the country are found in the clover districts. It does not necessarily follow, however, that the clover region is as well developed as it should be, for it is unfortunately true that too few of the beekeepers of this region are sufficiently skilled to make beekeeping a vocation. This region is the most densely populated part of the United States, and this leads to a larger number of amateur beekeepers.

There is not so much honey produced in the clover region to-day as formerly, and this decline is not due to any change in the value of the clovers as honey-plants. Formerly basswood[6] was abundant throughout most of this region. It begins to bloom much later than the clovers, and when it was abundant the beekeeper could utilize part or most of the clover season to prepare his colonies for the basswood honey-flow to follow. The loss of the basswood made it necessary that the care of the colonies be improved if a surplus crop was to be obtained, and since many beekeepers were not able to do this, they suffered a decline of their business, while many abandoned beekeeping. The development of more intensive agriculture in much of this region reduced the abundance of the flowers which furnished the honey-flows of the fall, making it more difficult to devise a system of beekeeping which would insure good colonies for winter. The most important factor leading to the decline of beekeeping in this region was the methods which came into vogue during the days when comb-honey was produced almost exclusively. At that time it was the aim of most beekeepers to have every possible drop of early honey stored in the supers, and this resulted in a shortage of honey for fall and winter, which in turn resulted in the death of many colonies or a great reduction in colony population the following year. It thus became common for beekeepers at that time to have exceedingly small colonies, and this reduced the profits of beekeeping so greatly that many persons no longer found it profitable to keep bees. It seems strange now that the cause of this decline was not then recognized, but with a return to more rational beekeeping methods it is found that the clover region has not lost its capabilities for profitable beekeeping, and it is now becoming again an important area for honey production. There is no part of the country where the industry may be carried on with greater profit

[6] Linden, *Tilia americana*.

than this, but if the most is to be made of the region highly skilled beekeeping is necessary.

Throughout much of this region there is no major honey-flow other than that from the clovers, and the beekeeper's entire return must be from this one source. This makes it necessary that every colony be in the best condition at the beginning of the clover honey-flow, and this is impossible for any but the best beekeepers. This region is therefore one especially well adapted to the development of beekeeping on a commercial scale, since only the skilled beekeeper can expect to succeed under these conditions.

PECULIARITIES OF THE REGION.

The uncertainty of a honey-flow in the fall in much of this region increases the difficulty of having the bees in proper condition for winter, and to an unusual degree increases the difficulty of having adequate stores in the hive for the winter, and especially for the brood-rearing period of the following spring. As the clover region is located in the north, the wintering problem is more intense here than in any other beekeeping section of the United States. This part of the work of the beekeeper has not received the attention which it demands, which largely explains the small colonies so frequently observed at the beginning of the clover honey-flow.

Coming as it does so soon after the average date of the last killing frost in the spring, the clover honey-flow is one which it is difficult for the beekeeper to utilize to the full extent. Furthermore, the secretion of nectar is quite rapid, making it necessary for the beekeeper to provide supers at just the right time and in sufficient number. Then, too, the honey-flow is frequently short in duration, so that the bees must be ready at the very beginning if a full crop is to be obtained.

Because of the character of the honey-flow and its time relation to the period of spring brood-rearing, swarming is more intense and more difficult to control than in any other region in the United States. While much work has been done on methods of swarm control applicable to this region, these methods are not understood by the majority of beekeepers and in good years it happens frequently that half the crop is lost through failure in this regard.

TYPE OF HONEY TO BE PRODUCED.

Since the passage of the Federal food and drugs act in 1906 the tendency in beekeeping has been more and more to produce extracted honey. Because of the rapidity of the clover honey-flow, and especially because of the superior quality of clover honey, this region is perhaps better adapted to the production of comb-honey than any other main region of the United States. Not all of the clover region is equally good for comb-honey production, however, for the production of good comb-honey necessitates rapid secretion of nectar. Where this occurs in the clover region, the honey is of the highest quality and the color is lighter than in other parts of the region. Clover honey is also favorable as a comb-honey type because it does not quickly granulate in the comb as do some of the other light-colored honeys of the country.

An additional reason for the production of comb-honey in the clover region is that the largest consuming population is in this region. The comb-honey producer of the clover region does not, therefore, have so far to ship his product—an advantage of importance in the shipping of so delicate a product. While the West and South can and will produce extracted honey in abundance in the future, it may happen that the future of the clover region lies in the development of still greater production of comb-honey. It should be pointed out, however, that comb-honey can not be produced successfully and profitably by careless beekeepers, and if this region is to increase in importance in the production of comb-honey it must be through the development of a larger number of skilled beekeepers within the region. Because of the difficulty of swarm control in out-apiaries run for comb-honey, extracted-honey production is more attractive to the specialist beekeeper so long as the returns per man are as great and so long as the sale of pure extracted honey is facilitated by the protection of pure-food laws.

OTHER PLANTS IN THE REGION WHICH FURNISH NECTAR.

Throughout the clover region there are other plants to which the beekeeper may look for additional honey, and within its boundaries are more restricted areas, usually marked off by soil or moisture differences, where other important major honey sources are found. Among these major honey sources may be mentioned wild red raspberry[7] and some of the members of the heath family, which bloom early in the summer, and willowherb,[8] milkweed,[9] Spanish needle,[10] sumac,[11] and buckwheat,[12] which bloom later. In some localities these plants are found quite near to good clover territory, but as a rule the places where these plants furnish considerable nectar are not those in which secretion from the clovers is good. They can be utilized by the beekeeper of the clover region best by the practice of migratory beekeeping.

[7] *Rubus strigosus.*
[8] *Chamaenerion angustifolium.*
[9] *Asclepias* spp.
[10] *Bidens* spp.
[11] *Rhus* spp.
[12] *Fagopyrum esculentum.*

There are still other plants which grow in the same type of locations in which the clovers thrive, and among these may be mentioned fruit bloom, dandelion,[13] the maples,[14] tulip-tree,[15] and black locust[16] which bloom early, and basswood,[17] sweet clover,[18] and heartsease[19] which bloom later.

The wild red-raspberry, various members of the heath family, and willowherb thrive on acid soils of the North. The willowherb is common in northern Canada extending southward in burned-over areas on sandy and acid soils into Maine, New York, Michigan, and States westward, and appearing again in the United States on the west coast. Milkweed honey is produced in certain parts of Michigan. The species of Spanish needle valuable for nectar thrives in swampy locations, being most important in northwestern Indiana and in adjacent territory in Illinois, and it is found in other places outside the typical clover region. While buckwheat is grown in many parts of the clover region, it is most abundant and most beneficial to the beekeeper in the plateau region of New York and Pennsylvania, where the clovers are not at their best.

Basswood was formerly an important source of honey in the clover region, but it has been so largely removed that it is now less important, although in some seasons good yields are still obtained from this source. In fruit-growing regions nectar from fruit trees is an important source of early honey, but usually is not sufficient in amount to provide surplus honey. Tulip-tree is more southern in its main distribution, but in some parts of the clover region may furnish some early honey, provided the bees are in condition to get it. Sweet clover is found almost throughout the clover region in limited quantities. It is increasing in importance, but is more valuable as a honey-plant outside the typical clover territory. Heartsease thrives in the moist soils of river bottoms in the clover region, but is more important as a honey-source outside this region.

Since adequate preparation for the clover honey-flow brings the colonies to their full strength as soon as is practicable in the spring, no special modifications are called for in taking advantage of earlier sources. Within this region the later honey-flows usually follow almost immediately after the clover, and as a rule there is no late summer honey-flow. The later honey-flows are usually so irregular in this region that they do not constitute part of the beekeeper's regular program, and if he gets honey from them he considers it as something additional for which he has not had to plan. As one goes farther north in the clover region the probability of a continuous honey-flow during the summer becomes greater.

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[13] *Leontodon* spp.
[14] *Acer* spp.
[15] *Liriodendron tulipifera.*
[16] *Robinia pseudacacia.*
[17] *Tilia americana.*
[18] *Melilotus alba.*
[19] Smartweed, knotweed (*Persicaria spp.; Polygonum spp.*)

112365°—22——3

EQUIPMENT RECOMMENDED.

The hive generally used in the clover region is the 10-frame Langstroth, and all the practices described in this bulletin are based on the use of this hive, which is the standard for the United States. Hives having deeper frames or a larger brood-chamber may be used without great difference in the methods here described, but no hive smaller than the 10-frame Langstroth should be used in this region. This hive is not patented and is now sold by all the dealers in beekeeping supplies. Care should be exercised to get accurately made hives and frames. The spacing of the frames should be accurate and the parts of all the hives should be interchangeable.

The combs of the brood-chamber should be all of worker-sized cells. This may be obtained best by the use of full sheets of comb-foundation, and no beekeeper of this region can afford to use merely starters of foundation. The frames should be carefully wired to strengthen the combs. Detailed directions for arranging the sheets of foundation in the frames and for wiring are given in Farmers' Bulletin 447 and also in still greater detail in the books on beekeeping. Even when full sheets of worker foundation are used, there will be a tendency for the foundation or the combs to sag, leaving several rows of imperfectly formed cells at the top of the frames. The beekeeper should constantly sort out imperfect combs and use them for the supers. Extra care should be exercised to see that only perfect combs are placed in the lower one of the two hive-bodies during the winter in order that the queen may pass easily from the second to the first story during the period of brood-rearing previous to the time of unpacking.

Because of the presence of European foulbrood in some parts of the clover region, and especially because of the superior quality of the Italian race of bees, the beekeeper of this region will find it greatly to his advantage to keep bees of this race. These bees are able, under good management, to clean out the larvæ dead of European foulbrood. Not all strains of this race are equally good for this purpose and the beekeeper should take pains to get those which are best. No one strain of Italian bees can be recommended as the best, and the proper plan for the beekeeper is to buy several untested queens from several reputable queen breeders who have been engaged in breeding queens for sufficient time to establish their reliability and ability to breed good stock. The names of breeders may be obtained from advertisements in the bee-journals. From queens thus purchased there may be chosen the one or ones suitable for breeding purposes, and the beekeeper should then plan to raise his own queens from this stock. The time and methods of queen-rearing will be discussed further on.

ADAPTATIONS OF BEEKEEPING PRACTICE FOR THIS REGION.

Because of the peculiarities of the clover region, which have already been outlined, it is of the highest importance that every step in preparation for the honey-flow be taken in time. This necessitates especial attention to conditions in the fall, for during this period the bees that are to live over winter are reared. It will not do to wait until the clover begins to secrete nectar, or even until spring opens, and then make the most of what the bees are able to do, for this frequently results in a total failure to secure a crop of honey.

OUTLINE OF THE ANNUAL CYCLE FOR THIS REGION.

To have a good colony of bees at the beginning of the active season it is necessary that the beekeeper begin his preparation about August 1 of the previous year. From this time on he should have constantly in mind the prosperity of the colony for the coming winter period, giving them during the ensuing 6 or 8 weeks conditions favorable for the rearing of bees for the winter colony. During the winter he should in every way assist the bees in conserving their energy, so that they will not begin brood-rearing too early, and so that they may also be able to do the work of brood-rearing to the fullest extent in the spring. During the spring they must be provided with abundant stores or brood-rearing will be curtailed at this critical time. These things will bring the colonies to full or approximately full strength at the time when the clovers begin to bloom. The work from this point on will be largely that incident to the production of the honey-crop, to be discussed in detail further on, but some time previous to the first of August, when another beekeeping year is to begin, the beekeeper should see that every colony has a vigorous young queen.

FALL PREPARATION.

Because of the absence of a late honey-flow in much of this region, brood-rearing is uncertain in late summer and the colonies may have too few young bees for winter. In much of this region brood-rearing normally ceases about the 1st of October, and during the period of 6 or 8 weeks previous to this date are reared the bees which live through the winter. If brood-rearing is not adequate during this time the old bees can not be expected to live until spring. Only those bees which are reared in late summer are able to rear brood sufficient for a full colony the following spring. Brood-rearing naturally decreases in late summer and it is necessary that favorable conditions for brood-rearing be provided or the bees may almost cease brood-rearing and thus endanger the very life of the colony. In the absence of a fall honey-flow this danger is acute.

In addition to seeing that each colony has a vigorous queen previous to August 1, the most important requirement is the leaving of abundant stores for the bees during this critical brood-rearing period. This is more necessary in the clover region than in many other places in the country, and it is an especially important consideration in apiaries where extracted honey is produced, as in this case the brood-chamber is usually short of adequate stores.

If the bees are to be wintered outside, the best plan is to leave with each colony a second hive-body and plan to winter it in the two hive-bodies, as will be discussed later. The upper hive-body should be practically full of honey, and this will usually be the case if this food chamber has been on the hive all summer. This provides a sufficient amount of stores, not only for fall and winter, but also for the period of the spring brood-rearing when the bees must have large quantities of honey.

If the bees are to be wintered in the cellar, as in the far north, it is often not convenient to winter them in two-hive bodies, but in this event the beekeeper must save this amount of honey to be given to the bees as soon as needed in the spring if a full colony is to be reared in time for clover.

When comb-honey is produced the beekeeper should have for each colony a second hive-body to be used as here indicated. Too many comb-honey producers fail to have this, and as a result their bees are often not ready for the clover honey-flow.

The requirements of the colonies for late summer are, therefore, a young queen and two stories for each hive, the upper one practically full of honey. Nothing else that the beekeeper may do at this time will materially contribute to the welfare of the colony.

WINTER CARE.

Because the honey-flow in the clover region comes so soon after the beginning of brood-rearing in the spring, wintering is the most important problem confronting the beekeeper. Throughout the region the winters are severe, making necessary considerable protection of the colonies. In most seasons the bees are confined to the hives without opportunity for flight for a considerable period, sometimes as much as 20 weeks. Bees must have stores of high quality during such confinement or they will suffer from dysentery. It is especially important that the honey immediately adjacent to the cluster be good, since this is the part used in the winter. If in the fall the beekeeper finds that these stores are of poor quality, he can correct this by feeding each colony about 10 pounds of either a heavy sugar sirup or honey of fine quality, after brood-rearing has ceased. (Fig. 4.) This feeding should be done rapidly. It is not so important that the stores used in the spring be of such good quality, as there are usually opportunities for flight.

In the colder parts of the clover region, where the average winter temperature is below 25° F., many beekeepers prefer to winter their bees in cellars. If this is done, the beekeeper should see that the cellar is properly constructed, so as to maintain during the period of confinement a uniform temperature, not too low or too high. This usually can best be done by constructing the cellar so that the ceiling is below the frost line (fig. 5), in order that the cellar may

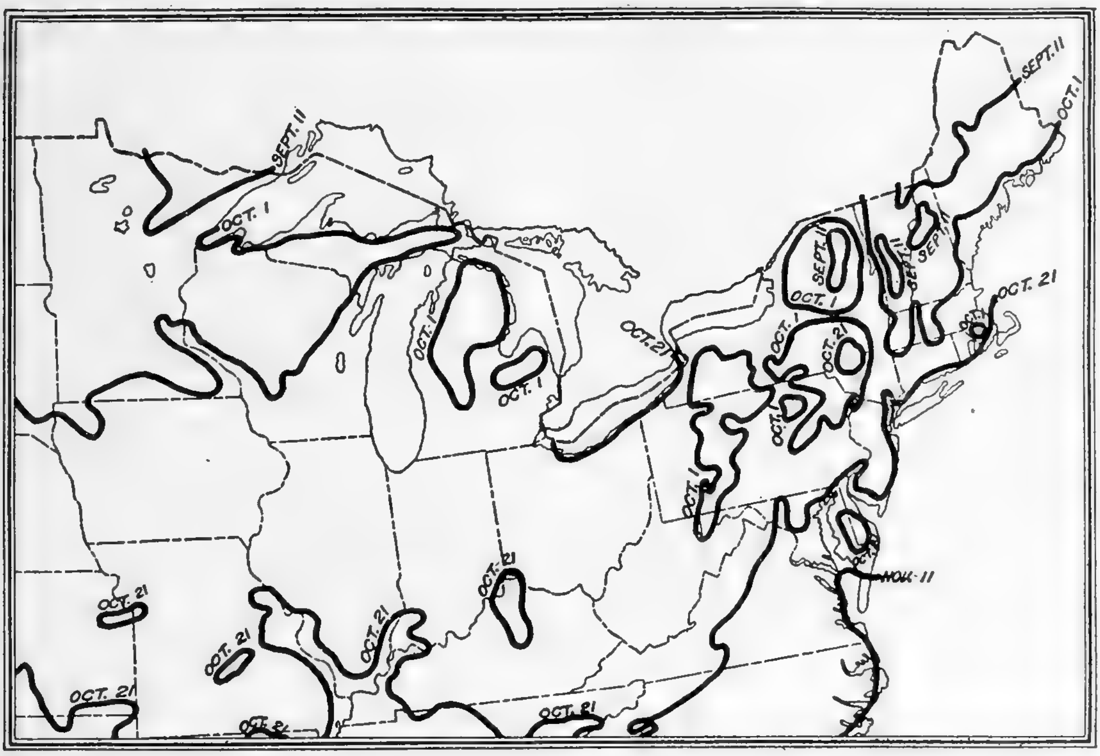

FIG. 4.—Map showing average date of first killing frost in fall. From these data the beekeeper determines the time to pack colonies outdoors. Feeding for the improvement in winter stores is done after the first killing frost.

not undergo rapid changes in temperature. Detailed directions for the construction and maintenance of the winter cellar are given in Farmers' Bulletin 1014, to which the reader is referred. When bees are wintered in the cellar they will perhaps be kept in one hive-body, but in this event a second hive-body with plenty of honey should be stored, to be given to each colony during the period of heavy brood-rearing of spring. The hive-body with the bees should contain about 25 pounds of honey. A failure to provide this extra room and stores is the cause of great loss in many parts of the clover region. There is no better place to store the extra hive-body containing honey, or any better way to winter bees in the cellar, than to leave all the honey with the bees, if one can arrange to handle the heavy hives as they are put into and removed from the cellar.

Outdoor wintering is preferable in the southern part of the clover region. For detailed methods of this work the reader is referred to Farmers' Bulletin 1012. The quadruple packing case (fig. 6), described in this bulletin, is one of the best for this region. The time for packing (fig. 4) and unpacking the bees and the amount of packing material necessary for good results vary considerably throughout the region, definite directions being found in the bulletin just referred to. Early packing is important in conserving the vitality of the bees that are to start the work of brood-rearing the following spring. It is especially necessary that the hives be protected from wind and that the entrances to the packed hives be reduced during cold weather as described in the bulletin on outdoor wintering.

The bees should be wintered in two hive-bodies, just as was described for the late summer (p. 16). It is not safe in this region to

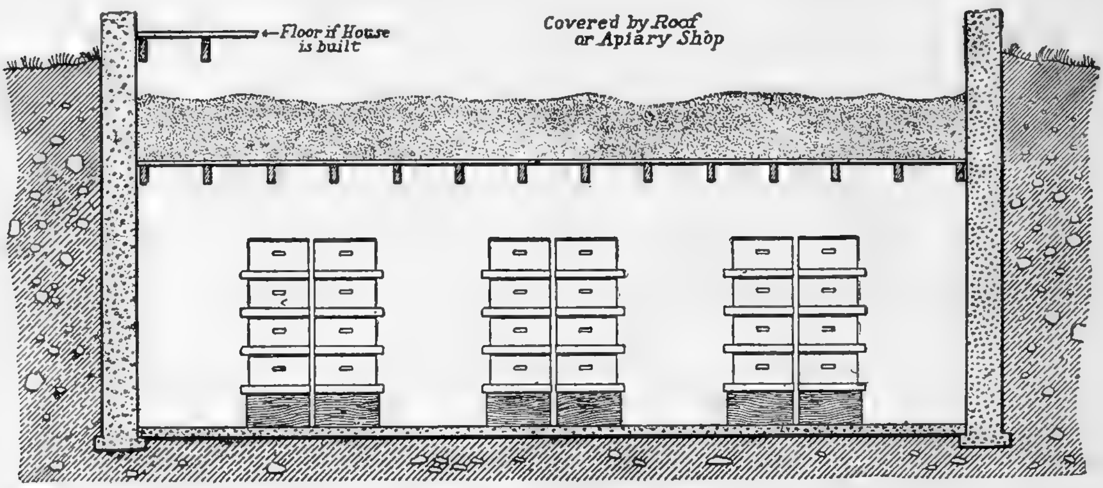

FIG. 5.—Diagram of bee cellar. Clearance 6½ feet, ceiling 2½ feet below ground level, packed with about 1½ feet of sawdust.

put bees into winter quarters outdoors on less than 45 pounds of stores, for while considerable nectar may come in during the early spring, occasionally this does not happen in this region, and it is necessary that the beekeper leave the amount specified in order to insure the proper building up of the colony after March 1. It is much safer to leave the entire amount all winter than it is to give more before the time of unpacking in May.

SPRING CARE.

If the bees have been wintered in a cellar in single hive-bodies, as is customary, they should be given the second hive-body containing the additional honey not more than four weeks after their removal from the cellar. If the lower hive-body has scant stores the supply of honey should be given as soon as they are put out of the cellar. Unless stores are needed the cover should not be removed until the second hive-body is added, since the bees will not at this time be able to seal the cover of the hive. Entrances should be contracted on removal from the cellar, and no further spring manipulation is needed or desirable until about the beginning of the clover honey-flow. If it is thought necessary to examine any of the colonies, this should be done from below, but if the proper care has been given the beekeeper knows the condition of each colony without examination, and the bees are better off without disturbance.

If the bees were wintered in packing cases outdoors in two hive-bodies the packing should not be removed until it is necessary to permit some essential spring manipulation. If there is any evidence of

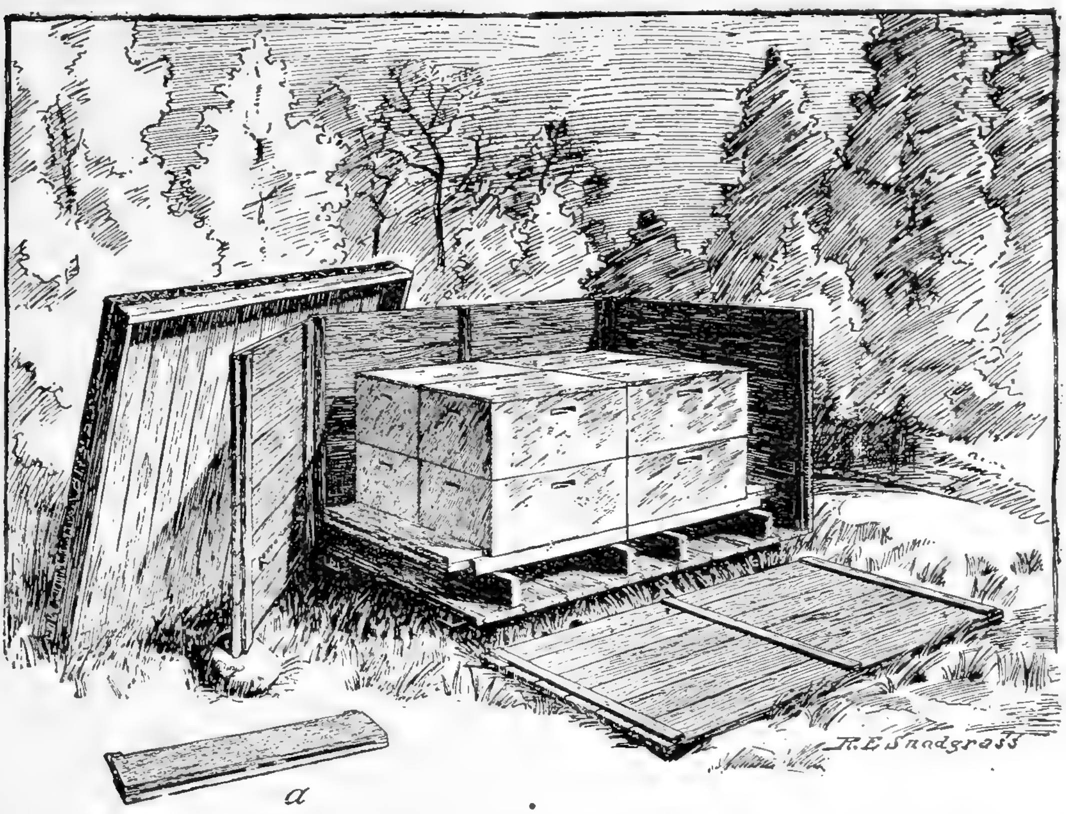

FIG. 6.—The quadruple winter packing case; *a*, detail of tunnel to hive. Any type of packing case which gives equivalent insulation on bottom, sides, and top may be used.

preparation for swarming, or if there is an unexpected early spring honey-flow, the bees may need either more room or some different arrangement of the parts of the hive. Ordinarily the only spring manipulation necessary up to the time of unpacking is that of enlarging the entrances to the hives as the population of the colonies seems to require.

Some beekeepers practice the clipping of the wings of their queens in the spring to prevent swarms from leaving, and this is most easily done before the colony population is so greatly increased. If queens are clipped this should be delayed at least until the time of unpacking outdoor colonies, as the bees need protection until the time specified. With the methods of swarm control applicable in extracted-honey production in the clover region the clipping of queens is superfluous.

In comb-honey production it is more important, but is decreasing among the best beekeepers, since swarm control is being more carefully practiced.

In some seasons there may be a tendency for the bees to make preparations for swarming before the usual time of unpacking. When this occurs it is best to unpack all colonies at once and to proceed with swarm-control measures, as increase before or early in the clover honey-flow is undesirable.

ADDITIONAL ROOM FOR HONEY.

In the production of extracted honey the giving of room for surplus honey is not so complicated as in comb-honey production. The honey-flow from the clovers is usually rapid and short, and this makes it necessary that the extra room be given promptly and in sufficient quantity, or some of the honey will be lost. The first super should be given before the honey-flow begins, at the time of unpacking if the bees have been wintered outdoors. Additional supers should be given before the bees are at all crowded for room, usually when the super previously given is about half full and when there is some honey in all of the combs, except that at the close of the honey-flow the bees should be allowed to fill out their supers. Because of the amount of water in nectar from the clovers considerable room is needed for ripening honey, as well as for storage, and a failure to provide this often greatly reduces the crop. Unless honey is to be extracted during the clover honey-flow, as is usually not desirable, the beekeeper of this region will find it desirable to have at least six full-depth hive-bodies for each colony, and sometimes more are needed in good seasons under good management. The measures advised for swarm control influence the arrangement of the supers, as will be described later.

In the production of comb-honey each colony should be reduced to a single hive-body when the first comb-honey super is given, this hive-body being filled with brood. The removed hive-bodies containing some brood should be given to colonies not used for comb-honey production, each colony being given about six such hive-bodies as supers to be filled with honey and later returned after the comb-honey supers have been removed. The first super should contain some bait sections and should be given soon after the appearance of the first white clover blossoms. Additional supers should be added as needed, each being given about the time that the one previously given is about half full, and each should be placed immediately above the brood-chamber, except toward the close of the season. For detailed directions regarding the placing of comb-honey supers the reader is referred to Farmers' Bulletin 1039. The comb-honey producer of this region will find it desirable to have six or seven supers prepared for each colony previous to the honey-flow, for this many will be needed under good management in good seasons.

SWARM CONTROL IN EXTRACTED-HONEY PRODUCTION.

Before the beginning of the honey-flow there will be brood in both hive-bodies, unless the queen has been prevented from going from the second to the first hive-body by imperfections of the combs. As soon as additional hive-bodies are given the queen will almost invariably desert the lower hive-body. After the brood in the lower hive-body has all been sealed, but before any colonies have swarmed, the queen in each colony is placed in the lowest hive-body and a queen excluder

FIG. 7.—Diagram of the swarm-control method for extracted-honey production. *A*, Brood in both hive-bodies in the spring. *B*, Supers 3 and 4 are added as more room is needed, queen usually abandoning lower brood-chamber. *C*, Queen placed below queen-excluder in (1) after all brood in this hive-body is sealed. Empty super (5) is added and brood-chamber (2) is placed on top.

placed above it (fig. 7). This may be done either by finding the queen or by shaking the bees together with the queen from the brood-combs into the lower hive-body. Immediately above the queen-excluder are placed whatever supers are needed at that time and above these are placed the hive-bodies containing brood. Ten days later it may be necessary to remove the queencells from the brood on top of the hives, although this is not always necessary even if queens are reared so far above the new brood-chamber. The hive-body which was formerly the second story will contain 10 frames, and not eight as in the supers, and this is the hive-body which should be left with the bees after the removal of the supers.

If the season is such that swarming is bad, it may be necessary to repeat this operation 10 days or two weeks after the first treatment, this time by shaking the queen and bees of the brood-chamber into a hive-body containing empty combs and placing the brood again on top. Toward the end of the honey-flow the removed brood may be used for making increase, the brood being removed from the hive at the end of a week after the second treatment for swarming.

SWARM CONTROL IN COMB-HONEY PRODUCTION.

In the production of comb honey the control of swarming is more difficult than when extracted honey is produced. In this case also there will normally be brood in both hive-bodies, and, as has been stated, most of the brood should be placed in the hive-body that is left with the colony when the supers are put on. Strong colonies so reduced should be given two comb-honey supers at once. From this time on until swarming is over it is necessary to examine every untreated colony every seven days to look for queencells. If queencells are found which contain only eggs or very young larvæ, all of these queencells should be destroyed, and this will almost always defer swarming until the next examination. To find all the queencells it is necessary to shake most of the bees from the combs, in order that none of the queencells may be overlooked. If on examination queencells are found containing older larvæ, or if the larvæ are unusually well provided with royal jelly, the colony can not be kept from swarming by the removal of queencells and must be treated immediately. The queen and the bees are now shaken from the brood-combs into the same hive, which is now filled with frames of foundation as the old combs are removed. One empty comb should be placed in the center of the new brood-chamber to prevent the colony from deserting. The supers are now replaced. Since the removed brood must have some adhering bees, it is customary to find the queen and then to refrain from shaking two or three of the brood-combs, being sure that the queen is not taken away with the brood. The removed brood is now transferred to another hive, which is placed close beside the original hive. Seven days later, when the bees are flying freely, this hive of brood is removed for increase to a new location, great care being taken to do this gently, so that the bees at work in the field will not find the new location, but will join the original colony. This usually prevents the issuing of an afterswarm and adds the field bees to the producing colony. Since if queencells are shaken the developing queens are often injured, the comb containing the finest of the queencells should be removed without shaking. If no permanent increase is desired, this new colony may be united with the producing colony or elsewhere at the close of the honey-flow.

For other methods of swarm control the reader is referred to Farmers' Bulletin 1198.

REMOVAL OF THE HONEY CROP.

The removal of either extracted honey or comb-honey is greatly facilitated by the use of bee-escapes, especially at the close of the season. If robbing is imminent, care should be taken to keep the honey well covered while it is being taken to the honey-house.

When extracted honey is produced, it should be left on the hives until it is well ripened. The outfit needed for extracting and the methods used will depend on the size of the apiaries maintained. Since this phase of the beekeeper's work has been so adequately discussed in the current beekeeping literature, and since the needs of each beekeeper will be in some degree unlike those of others, it seems best in this bulletin to lay stress on those phases of the work which are more important, namely, the production of the crop.

When comb-honey is produced, it must be removed as soon as it is finished, and this sometimes necessitates the removal of supers in which there are still unfinished sections. These are assembled in supers and returned to be finished. Previous to shipment to market, comb-honey should be kept in a dry place. Cleaning the sections, grading, and otherwise preparing the sections for market are phases of the work outside the bounds of this bulletin.

PREPARATION FOR LATER HONEY CROP.

When there is reason to expect a honey-flow following that from the clovers, with an interval of dearth between, care must be taken to leave the bees with an abundance of honey, so that brood-rearing may go on with as little interruption as possible. If the fall honey-flow is assured, as is rarely the case, the beekeeper might remove some of the fine-quality clover honey from the hive-body that is to serve as the upper story after the supers are removed. The usual mistake is to leave too little honey at the end of the clover honey-flow.

If the later honey-flow is one which necessitates migratory beekeeping, then the beekeeper is almost compelled to remove the honey so as to move only the bees and empty supers. This is safer because the wise beekeeper does not move his bees unless he is well assured of the value of the new honey-source. Migratory beekeeping is not extensively practiced in the clover region, although there is excellent opportunity for this where there are honey-plants of limited distribution near enough so that they may be reached by a night's run by automobile truck.

In case of a later honey-flow the time of requeening will probably be earlier than is usually best for the clover region. In order that the young queens may have time for the building up of a good colony for a late honey-flow, requeening may be done in connection with swarm control. This procedure will be found discussed in detail in Farmers' Bulletin 1198.

DISEASE CONTROL.

It is unfortunately true that both of the serious diseases of the brood of bees, American foulbrood and European foulbrood, are present in most parts of the clover region. The beekeeper must plan his work so as to have the control of these diseases constantly in mind. There seems to be no hope of the eradication of these diseases from the region.

European foulbrood is a disease of weak colonies in spring and early summer, being especially destructive in colonies of black bees. It has long been known to beekeepers of this region that when there is a failure of the clover honey-flow this disease is much worse. If the practices of beekeeping herein given are followed carefully, the beekeeper will have his colonies in such condition that they can successfully combat this disease, and no further precautions will be necessary aside from providing the right kind of queens. If the disease continues to be troublesome this is proof that the methods of beekeeping are not such as to insure the best honey-crop from the clovers. For fuller details regarding the prevention and control of this disease the reader is referred to Farmers' Bulletin 975.

American foulbrood is not, unfortunately, a disease which can be prevented by the practice of good beekeeping methods, and the shaking treatment is necessary if this disease appears. This is described fully in Farmers' Bulletin 1084. If there is much American foulbrood in the neighborhood, each colony should be examined for disease early in the season, soon after unpacking if they are wintered outdoors, so that every colony found to have the disease may be treated early in the clover honey-flow. If the disease is discovered after the clover honey-flow, its eradication is more difficult. If the case is mild it is safer to contract the entrance and wait for the fall honey-flow before treating, but in the absence of a fall honey-flow the bees may be treated after brood-rearing ceases by the fall treatment. Details of this treatment are given in Farmers' Bulletin 1084. If a bad case of the disease is found after the clover honey-flow, it is not safe to postpone treatment. No colony should ever be packed for outdoor wintering in which the disease is known to be present.

TIME AND FREQUENCY OF REQUEENING.

There must be no interruption of brood-rearing during the period when bees are being reared for the winter colony, and nothing should be done which will stop egg-laying for even a day during the time between the beginning of brood-rearing in the spring and the beginning of the clover honey-flow. During the spring it is difficult to rear queens. Clearly, then, requeening must be done between the beginning of the clover honey-flow and August 1. The exact time will depend on the method of swarm control employed and on whether there is a honey-flow later than that from the clovers. In most cases the best time to introduce new queens is just in time for them to mate and begin laying early in August. If the beekeeper rears his own queens, as he should if he is heavily engaged in beekeeping, he will usually find it desirable to start his queencells about the middle of July. They may be introduced by means of a cell protector after the removal of the queens about two days before the young queens are ready to emerge. In due time they will emerge, mate, and begin laying eggs, and the interval of no egg-laying at this season will do no harm. For methods of rearing queens the reader must be referred to the books on beekeeping, but it may be stated that this is a branch of the work with which every beekeeper should make himself familiar, since it is not wise to depend on the purchase of all one's queens.

If the methods of beekeeping herein described are followed it will be more necessary to requeen annually than has been the case with the usual practices of beekeepers of the clover region. If extracted honey is being produced, the queens wear out faster than in the average comb-honey apiary. As we go southward in the clover region the necessity of annual requeening is greater than where the seasons are shorter. If there is no regular fall honey-flow, annual requeening to insure the establishment of the winter colony is desirable. If requeening is left to the bees through supersedure, too often it happens that the spring brood-rearing period is broken, resulting in the loss of the crop. Taking all of these things into consideration, annual requeening is advisable throughout most of the clover region, and this practice is increasing.

INCREASE.

In ordinary practice increase in the number of colonies by division before or during the honey-flow from clover results in a decrease in the honey-crop, except when such increase is made from brood which will emerge too late to take part in gathering the crop (p. 22). It is also detrimental to make increase after early August, when bees for winter are being reared. Increase is therefore limited in time just as is requeening.

When permanent increase in the number of colonies is desired, the large colonies may be divided at the time of requeening, thus utilizing the workers that would not live through winter and that will not be serviceable in gathering a honey-crop. No new colony should be started with less than enough bees to care for four or five frames of emerging brood. The brood should be placed chiefly in those colonies which are moved away from the old stand. Queencells should be furnished within two days to all queenless colonies and under no circumstances should the beekeeper allow these small colonies to rear their own queens, as such queens are almost always inferior.

A simple way to make increase at this time, when each colony is to be divided into two, and when the beekeeper has but one apiary, is to remove the lower hive-body containing the queen and brood to a new location. On the old stand is placed a hive containing empty combs, and a queencell is placed between the combs in a cell-protector, the second story being put in place. A hive-body containing full combs of honey is placed on the removed hive containing the queen, for their winter food supply. To prevent the return of too many of the bees of the new colony to their old location, the entrance of the new hive should be closed with green grass. As this dries the bees are released. When out-apiaries are maintained the original hive can be divided into two equal parts, the queenless portion given a queencell, and one part moved to another apiary to prevent its return to the old stand.

MARKET FACILITIES AND METHODS OF MARKETING.

Most of the clover region lies in the part of the United States having the most dense population, and this makes it possible for the beekeeper to sell his honey near the point of production, a thing impossible for beekeepers of many other regions. This at once suggests the desirability of developing either a local market or one not far away, especially for comb-honey. Beekeepers of this region do this by means of selling from the home to those who call for the honey, by sales to local grocers, or by conducting a mail-order business. Where these plans are not practical, the honey should be so prepared as to enter the general honey markets of the country, in which clover honey brings the highest price.

Because of the possibility of local marketing in the clover region few carlots of this honey reach the general honey markets of the country, but this fact should not be interpreted as indicating a small production in this region, which in reality produces nearly half of the Nation's honey supply.

OPPORTUNITIES FOR DEVELOPMENT OF THIS REGION.

While not all parts of the clover region are equally good, there are few places in which it is not possible to keep bees with profit under proper management. It is unfortunate, however, that the opportunities for beekeeping in this region are not being utilized as completely as in some other beekeeping regions of the country. There are vast areas of the clover region not adequately covered by bees, and also many places where, because of the methods of beekeeping practiced, the beekeepers are failing to produce the best possible crops. Beekeeping to be profitable in this region must be conducted with all possible skill, and there are not sufficient beekeepers with the right amount of skill to cover this territory. A drawback to the adequate development of the clover region lies in the fact that there are thousands of persons owning a few colonies who give their bees little or no attention and who get practically no honey, and these bees serve to occupy territory, while if they were in the hands of a good beekeeper they might be adding to the Nation's honey supply. The spread of the brood diseases is serving to change this condition, for the number of persons owning bees in the clover region is decreasing.

With the education of the beekeepers of this region in better methods of beekeeping, there is reason to look for a great development in the industry in the near future. This is already under way and great progress is being made, so that never was the outlook in the clover region brighter than at present.

Since it is impossible, within the scope of this bulletin, to give all the details of beekeeping practice which will be needed by commercial beekeepers in the clover region, it is necessary to refer to certain other bulletins of the Department of Agriculture in which these practices are discussed in greater detail. These may be obtained without charge on application to the Department of Agriculture, Washington, D. C. Some of these bulletins have already been mentioned. Those most applicable to the clover region are:

Bees. (Farmers' Bulletin 447.)
Honey and its Uses in the Home. (Farmers' Bulletin 653.)
Outdoor Wintering of Bees. Farmers' Bulletin 695.)
Sweet Clover, Utilization. (Farmers' Bulletin 820.)
Transferring Bees to Modern Hives. (Farmers' Bulletin 961.)
Control of European Foulbrood. (Farmers' Bulletin 975.)
Preparation of Bees for Outdoor Wintering. (Farmers' Bulletin 1012.)
Wintering Bees in Cellars. (Farmers' Bulletin 1014.)
Commercial Comb Honey Production. (Farmers' Bulletin 1039.)
Control of American Foulbrood. (Farmers' Bulletin 1084.)
Swarm Control. (Farmers' Bulletin 1198.)

Semimonthly reports of commercial honey markets may be had free on request from the Chief, Bureau of Markets and Crop Estimates, Department of Agriculture, Washington, D. C.

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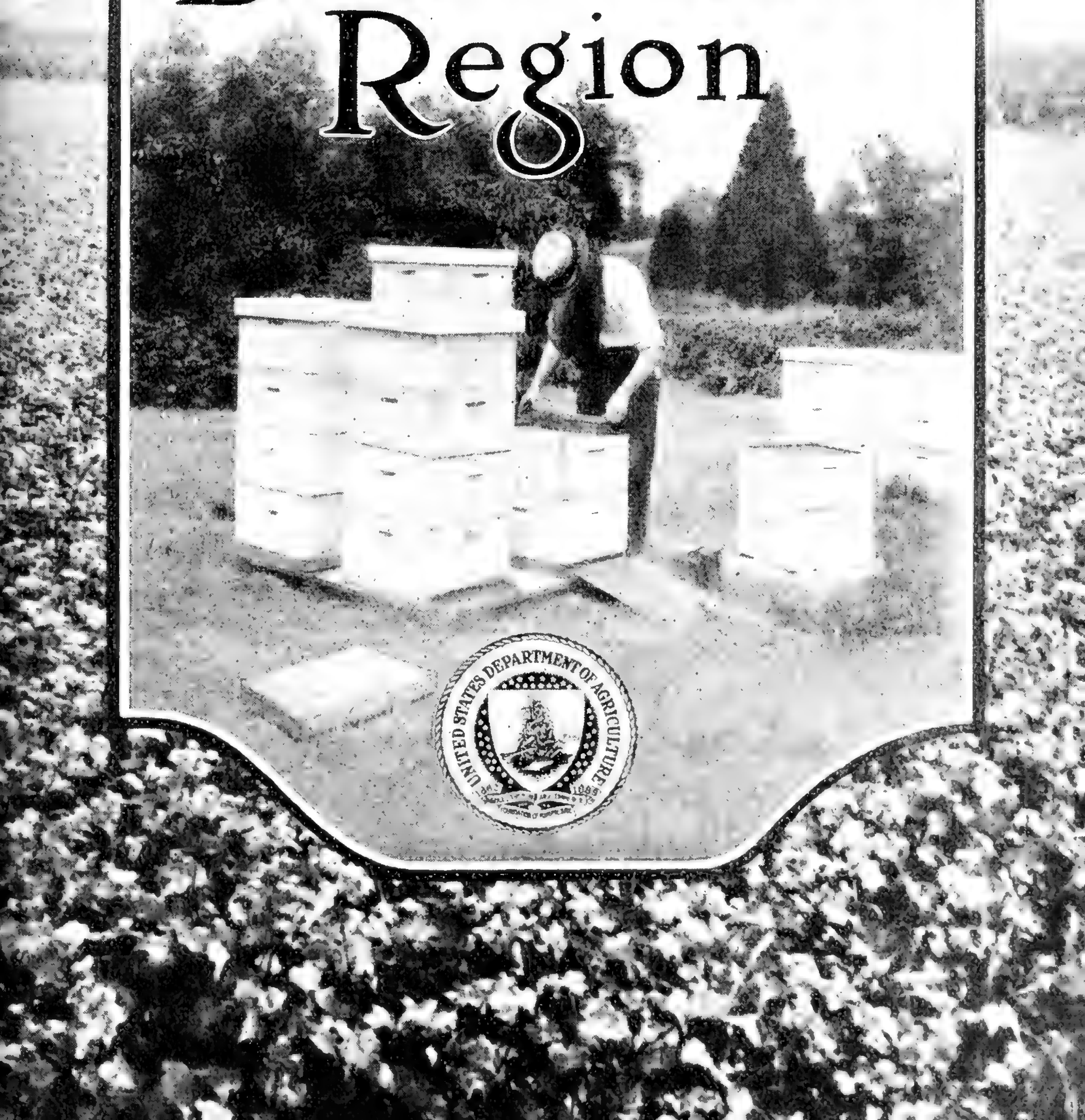
Farmers' Bulletin 1216

United States Department of Agriculture

Beekeeping in the Buckwheat Region



THE production of the full honey crop from buckwheat requires a plan of apiary management quite different from that of most other beekeeping regions. A system of management is here given which will result in a full honey crop and at the same time control European foulbrood, which is so prevalent in the buckwheat region.

Methods are also given which may be used in case the clovers are valuable as sources of nectar.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. January, 1922

BEEKEEPING IN THE BUCKWHEAT REGION.

E. F. Phillips, *Apiculturist in Charge*, and George S. Demuth, *Apicultural Assistant, Bee-Culture Investigations.*

CONTENTS.

THE successful production of honey from buckwheat requires special and quite different methods from those applicable to a typical clover territory, since buckwheat comes into flower long after the blooming period of white clover. Although buckwheat is now the source of a large amount of honey, estimated by Jones[1] as 2.9 per cent of the total for the United States, and although some parts of the buckwheat region are at present fully stocked with bees under good management, in other parts much nectar remains ungathered. Many beekeepers fail to take full advantage of this source of honey because of the lateness of the honey-flow and especially perhaps because of the fact that European foulbrood is endemic in this region. This bulletin undertakes to outline the methods which will enable the beekeepers of the buckwheat region to utilize fully this important source of honey. Wherever possible a single system is described rather than several methods for each phase of the work.

Buckwheat[2] belongs to the same plant family as the knotweeds or smartweeds, commonly called heartsease in beekeeping literature,

[1] Jones, S. A., 1918. Honeybees and honey production in the United States. U. S. Dept. of Agric. Bul. 685, 61 p.

[2] *Fagopyrum esculentum*, family Polygonaceae. To this species belong the three varieties commonly grown in the United States, the Japanese, the Silverhull, and the Common Gray. *Fagopyrum tataricum*, the Tartary buckwheat, is grown in a few localities in the country, to a limited extent. Of the three common varieties the Silverhull is most valuable to the beekeeper, the Japanese being commonly reported as of little value for nectar secretion. *Fagopyrum emarginatum*, the notched-seed buckwheat, is not known to be grown pure in this country.

and as the wild buckwheat which constitutes an important source of nectar in California. It is an introduced plant, probably native to China.

GEOGRAPHICAL BOUNDARIES OF THE BUCKWHEAT REGION.

The buckwheat region lies in the Northeastern States and extends into Canada. Two-thirds of the entire buckwheat acreage in the United States is in New York and Pennsylvania. Buckwheat grows westward as far as Minnesota and southward in higher elevations in the Appalachian Mountains as far as North Carolina. From the

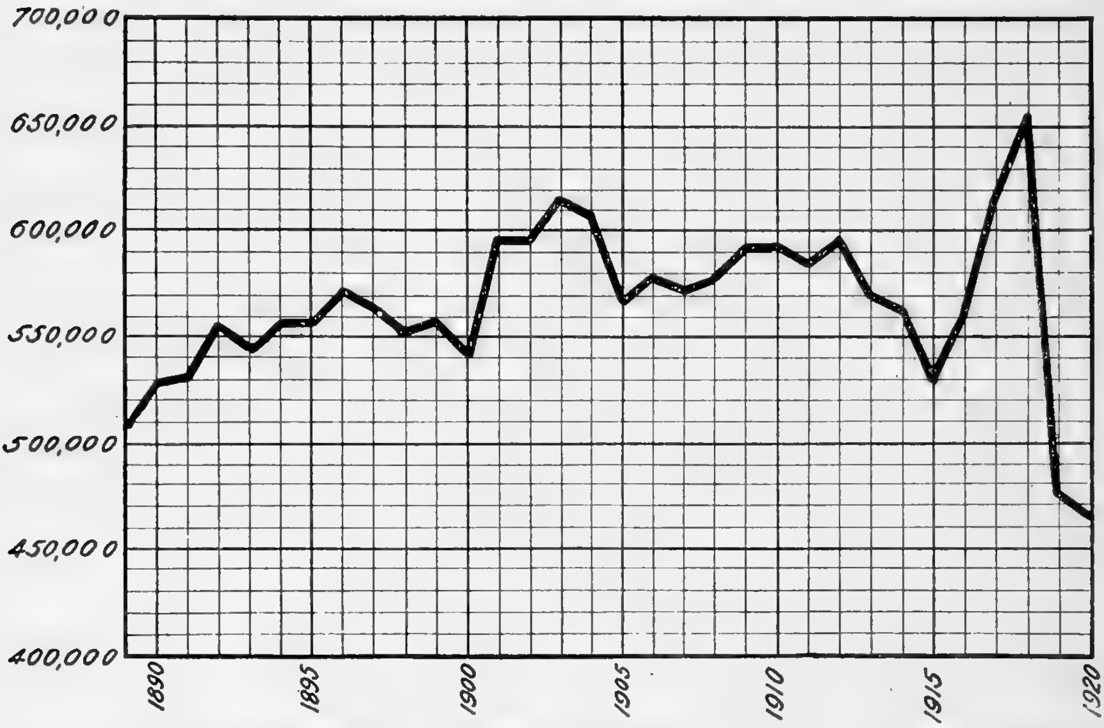


FIG. 1.—Chart showing variation in acreage of buckwheat in New York, New Jersey, and Pennsylvania. The total honey crop is closely related to the acreage. (Data supplied by Bureau of Crop Estimates.)

beekeeping standpoint the buckwheat region is limited to those places where this species is regularly grown as a farm crop in sufficient abundance to furnish nectar for a surplus honey-crop. This beekeeping region, therefore, lies in New York, Pennsylvania, northeastern Ohio, western Maryland, and West Virginia. (Fig. 1.) While this plant is grown in other States to the west of the region indicated, it is frequently a catch crop. It has little influence on the honey-crop under these circumstances and does not materially modify the plans of the beekeeper in preparing for the honey-flow. The abundance of this species in the various sections is shown on the accompanying map (fig. 2). Zavitz [3] states that the average number of

[3] ZAVITZ, C. A., 1919. Farm crops. Bul. 268, Ontario Agricultural College.

acres of buckwheat in Ontario for the past 36 years has been 118,648 per annum. In 1918 the acreage of buckwheat in the United States was 1,027,000, an increase of 27 per cent over the average for 1912–1916. In 1919 the acreage was 739,000.

VARIATIONS WITHIN THE REGION.

As indicated previously, this species is less valuable from the standpoint of nectar secretion in its western range because of less acreage. It appears also not to secrete nectar so freely when grown outside its optimum distribution, probably because of the special requirements of temperature, soil, and moisture in the abundant

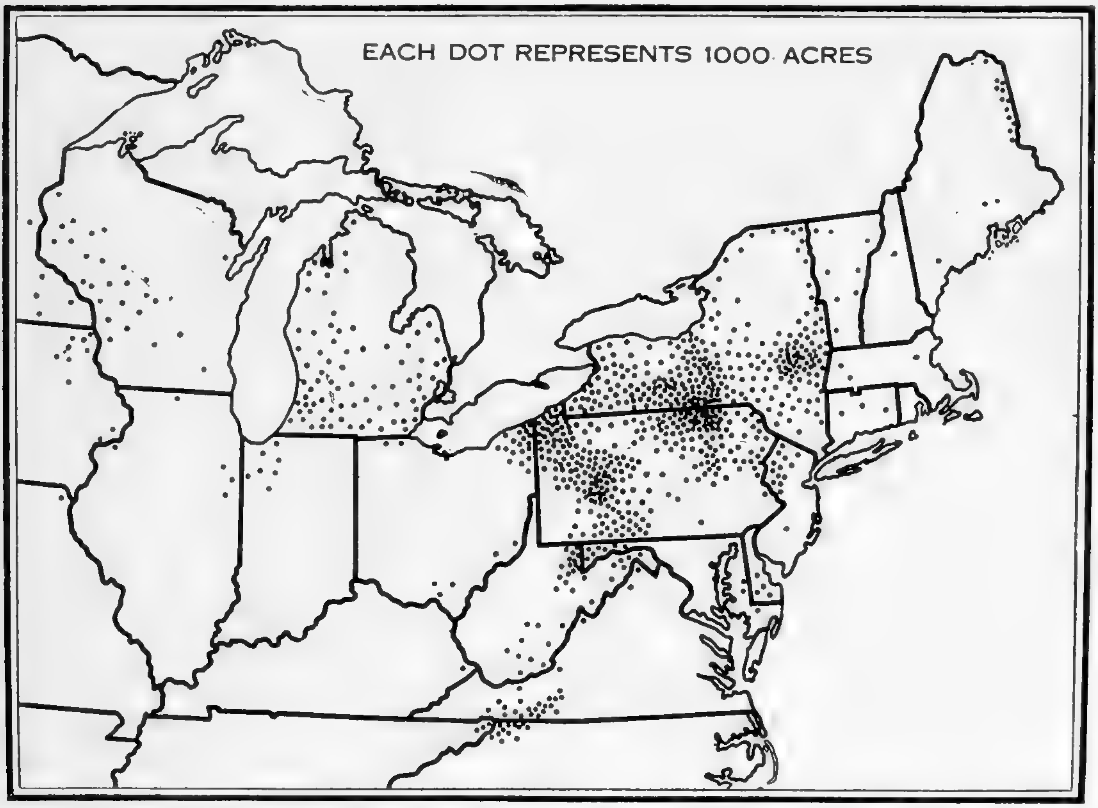


FIG. 2.—Map showing the principal buckwheat-producing region of the United States.

secretion of nectar in this species. It secretes best on the Volusia and DeKalb soils, which are formed by the disintegration of shale and sandstone, especially in the glaciated plateau region of New York and Pennsylvania. It secretes best in regions where the nights are cool and the mean temperature during the blooming period does not exceed 70° F. So far as known, the nectar is always dark in color and the resulting honey is strong in flavor. The color variation observed in the nectar of other honey plants is not observed in this species.

RELATION TO OTHER BEEKEEPING REGIONS.

The buckwheat region lies within the boundaries usually given for the clover region, but buckwheat is found most abundant in parts of the country where white and alsike clovers are less reliable sources of nectar. Beekeeping practices of the region are often materially modified by the presence of alsike clover, which grows on soils more acid than are suitable for the vigorous growth of red clover. The region extends southward into the tulip-tree region, although in the southern part of the buckwheat range the area devoted to the growth of the plant often lies too high for the best development of the tulip-tree. Where buckwheat is grown there is usually much waste land, permitting the growth of many species of plants which furnish nectar in the fall. These, however, do not materially modify the beekeeping practices. Buckwheat chiefly covers an area not dominated by any other valuable source of honey, and the region is therefore one in which the beekeeper will wish to choose those methods of beekeeping that will give the maximum amount of honey from this source.

CHARACTERISTICS OF BUCKWHEAT.

Buckwheat is a quick-growing annual herbaceous plant growing erect to a height of 2 or 3 feet. The root development is vigorous and extensive, although the roots have a rather delicate structure. They are able to utilize relatively unavailable mineral foodstuffs in the soil and in this respect the plant has an advantage over other grain crops. The stems vary from one-fourth to five-eighths inch in diameter and from green to purplish red in color while fresh. Only one stem is produced from each seed and it branches more or less freely, permitting the plants to adapt themselves to the thickness of planting. The leaves are heart-shaped and alternate on the stems, being usually sessile. The flowers are small, white to pink in color, and are borne in racemes or panicles on flower stems arising from the bases of the leaves. Flowers are produced in two forms in about equal numbers: In one form the stamens are long and the style short and in the other form the ratio is reversed. This increases the probability of cross-pollination by insect visits, and it is usually believed that insect pollination is the frequent method. Only one kind of flower is produced on an individual plant, but seeds of either form give rise to plants of both types. The ratio of these types is seemingly not influenced by differences in soil. The blooming period depends on the time of planting, the flowers first opening about five or six weeks after seeding. After blooming has once begun it usually continues until frost or harvest, although, as will be pointed out later, the secretion of nectar is not equal throughout this period of blooming. The seeds of the common varieties are smooth and shining, with three acute angles.

Buckwheat usually grows free from the interference of weeds, as it grows too rapidly for most weeds to make headway against it. There is no serious plant disease or insect enemy of a destructive nature.

Buckwheat is less exacting as to soil requirements than other grain crops and grows on soils that fail to support the clovers and other valuable honey-plants. It is, however, exacting as to climatic conditions, requiring cool, moist weather, especially at blooming time. Since the setting of seed is dependent on proper condition of the flowers at the time of pollination, the flowering period is a critical one for the species. Buckwheat does well on thin, poor lands and on acid soils, provided the climatic conditions are favorable. As pointed out earlier, it is grown most abundantly in the United States on the Volusia and DeKalb soils of New York and Pennsylvania, which are not adapted to many other agricultural crops because of the lack of lime and general poverty of the soils. Dry soils are required for germination, and considerable heat is advantageous in the early stages of growth. During the period of blooming and seed formation high temperatures are injurious, especially when hot sunshine follows showers, causing blasting of the flowers. It is adapted especially to high altitudes and regions where the growing season is short, but any frost during the growing season will kill the plants. They can not stand a temperature of more than three or four degrees below freezing.

The secretion of nectar from buckwheat is quickly influenced by various factors. It is commonly observed that buckwheat secretes best in the early part of the day; but in some localities, especially those where the temperature is lower, secretion may continue throughout the day. Secretion is more abundant following cool nights, especially if the sun comes out bright the following day and if there is little or no wind. Secretion is reduced or stopped when the temperature drops below 70° F. While buckwheat is usually planted so that the blooming period comes in August, earlier plantings are sometimes made, especially for orchard cover crops. It is often observed that the earlier bloom is almost if not entirely devoid of nectar. The last bloom of the year, after about September 1 until frost, secretes little or not at all. The flowers are quickly blasted by unfavorable weather conditions, thus stopping nectar secretion. Leighty, in Farmers' Bulletin 1062, calls attention to the fact that "many buckwheat growers believe that the weight per bushel of the seed is heavier where the crop has been worked largely by bees." [4]

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[4] For further information regarding the cultivation and uses of this species, the reader is referred to Farmers' Bulletin 1062, Buckwheat, by Clyde E. Leighty, issued in 1919.

PRESENT DEVELOPMENT OF BEEKEEPING IN THE REGION.

Beekeeping has long been extensively practiced in the buckwheat region, especially in New York, but there are vast areas in New York, Pennsylvania, and West Virginia where there is little commercial beekeeping and where there are not enough small beekeepers to utilize much of the nectar from this species. It has long been recognized that this region is especially adapted to commercial beekeeping. This is so because of the large acreage of this plant, but especially because of the widespread distribution of European foulbrood, which makes side-line beekeeping well-nigh impossible. Even in parts of the region where there was formerly an extensive development of the industry there is now great opportunity for the growth of the business of beekeeping. The presence of disease has had a serious retarding effect on honey production in this region, because of a failure even on the part of many of the better beekeepers to control it properly. Not only has European foulbrood retarded the industry but a failure on the part of the beekeepers to practice the best methods of beekeeping has resulted in a great reduction in the crop per colony. The number of colonies of bees to the square mile in this area, except in localities where the bees have been eradicated by disease and because of poor management, is almost as great as in any other part of the United States. In spite of this condition, the honey production of the region is inadequate. Especially where the honey resources are augmented by nectar from the clovers or some other plant which furnishes nectar earlier in the season than does buckwheat, there is opportunity for the development of extensive beekeeping operations. Buckwheat might easily be the source of far more honey than is now produced in this region.

PECULIARITIES OF THE REGION.

One of the difficulties in the development of the buckwheat honey region has been the lack of specific literature dealing with this important area. The practices of the clover region, which have formed so large a part of the beekeeping literature, are not suitable for the gathering of the full crop from buckwheat, although the basic principles of beekeeping practice are everywhere the same. Beekeepers who depend on sets of rules have failed to succeed in the buckwheat region when they have followed rules laid down by beekeepers operating in the clover region. This lack of specific literature concerning buckwheat as a honey-plant is a serious one, and the chief object of this bulletin is partially to make up this deficiency.

As buckwheat secretes nectar so late in the summer, the colonies of bees properly cared for reach the peak of their prosperity too long before surplus honey is available. On the other hand, colonies that are retarded in their development early in the season, by bad wintering, by the presence of European foulbrood, or by lack of stores, may not reach complete development even in time for the late honey-flow from this source. It is therefore necessary for best results that the beekeeper of the buckwheat region practice those methods which will produce full-strength colonies early in the season to combat European foulbrood, and then that he so modify his system as to cause the colonies to have the greatest possible population of young vigorous bees at the beginning of the secretion of nectar from buckwheat. A failure to have the colonies strong and at the same time composed of young, vigorous bees at the beginning of the buckwheat honey harvest is the cause of the loss of tons of honey from this source annually.

It will thus be seen that the proper care of bees during winter is a serious problem throughout the buckwheat region; in fact, there is no place where this is more important. This has not been fully recognized, because of the lateness of the secretion period. It is also evident that after brood-rearing has begun it must progress rapidly in order that the colonies may be able to combat European foulbrood successfully, and only young, vigorous queens can lay the eggs necessary for such a development of the colony. Abundant stores are needed in the early part of the year, but beekeepers frequently neglect to provide these, although usually there are fall sources of honey which are stored in the brood-nest, making it less necessary to give additional stores in the spring than is usual for strictly clover areas. It is also unfortunately true that many of the bees of the region are of the inferior German or black variety, and this race is especially susceptible to European foulbrood. The scrub queens of this variety may begin egg-laying at a good rate, but too frequently fail before the colonies are up to full strength, thus making them still more prone to contract disease. Methods for remedying these defects will be discussed later, but it is evident that the production of a crop of honey from buckwheat requires a high degree of skill on the part of the beekeeper. The chief causes of failure in this region are, therefore, poor wintering, inferior stock, and a failure to adapt the beekeeping practices to the peculiarities of the time of blooming of this source.

TYPE OF HONEY TO BE PRODUCED.

The honey from buckwheat is darker than any other honey produced in large quantities in the United States and the flavor is strong. Such honey should never be put on the general honey markets of the country in the form of comb-honey. There is always a small local

70584°—22——2

demand for comb-honey from buckwheat, however, and where a beekeeper is sure that he is in touch with such a market, he may safely produce some comb-honey. Fortunately little bulk comb-honey (chunk honey) is produced in the buckwheat region. For the general markets, and also for general use within the buckwheat region itself, extracted honey is the only type of buckwheat honey which should be produced. Furthermore, the daily gain on colonies from buckwheat is less rapid than from many other sources of nectar, and this results in less well filled and sealed sections of comb-honey. Unfortunately most beekeepers, when taking up modern methods of beekeeping, get equipment suitable for comb-honey production. The production of extracted honey is well adapted to commercial honey production, and the characteristics of the buckwheat region make it especially desirable that beekeeping be practiced on an extensive scale. Even when clover honey is produced extensively in the buckwheat region, it is desirable that it also be extracted to avoid the necessity of two sets of equipment.

OTHER PLANTS IN THE REGION WHICH FURNISH NECTAR.

Throughout the buckwheat region many other plants add to the beekeeper's profit. Fruit bloom, dandelion, maples, and other early spring sources are useful in helping the bees to build up in the spring, but do not furnish surplus honey. White clover[5] and alsike clover,[6] which bloom in June and early July, are found in almost all parts of the region, but the soil conditions usually are not the best for the secretion of nectar from these species. Alsike clover is coming into more general use as a forage crop in this region because of its adaptability to soils that are deficient in lime and which are cold. It is more often found in the valleys with buckwheat on the adjacent hills. Basswood,[7] which blooms in the middle of July, was formerly abundant in the region, but has been largely removed. Sweet clover[8] is sometimes found blooming in July, but is rarely of much value in the region. Asters[9] and goldenrods[10] usually furnish considerable nectar in the fall. Many minor sources of nectar also occur locally, but these do not modify the beekeeping practices.

The chief modifications in beekeeping practice arise from the effort to obtain a surplus crop from the clovers. These plants furnish nectar several weeks before buckwheat blooms, and it is therefore necessary that the colonies be at full strength at this earlier date if the fullest advantage is to be taken of these sources. Since European

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[5] *Trifolium repens.*
[6] *Trifolium hybridum.*
[7] *Tilia americana.*
[8] *Melilotus alba.*
[9] *Aster* spp.
[10] *Solidago* spp.

foulbrood is found throughout the buckwheat region, however, this also necessitates the possession of strong colonies much earlier than would be necessary simply to get the buckwheat honey harvest. It therefore is unnecessary for the beekeeper to do anything other than prevent the ravages of this disease in order to get all the nectar available from the clovers. The practices herein given are such as to yield the fullest return from the clover crop.

EQUIPMENT RECOMMENDED.

The hive generally used in the buckwheat region is the 10-frame Langstroth, and all the practices described in this bulletin are based on the use of this hive, which is the standard for the United States. Hives having deeper frames or a larger brood chamber may be used without great difference in the methods here described, but no hive smaller than the 10-frame Langstroth should be used in this region. This hive is not patented and is now sold by all the dealers in beekeeping supplies. Care should be exercised to get accurately made hives and frames. The spacing of the frames should be accurate and the parts of all the hives should be interchangeable.

The combs of the brood chamber should be all of worker-sized cells. This may be obtained by the use of full sheets of comb-foundation, and no beekeeper of this region can afford to use merely starters of foundation. The frames should be carefully wired to strengthen the combs. Detailed directions for arranging the sheets of foundation in the frames and for wiring are given in Farmers' Bulletin 447 and in still greater detail in the books on beekeeping. Even when full sheets of worker foundation are used there will be a tendency for the foundation or the combs to sag, leaving several rows of imperfectly formed cells at the top of the frames. The beekeeper should constantly sort out imperfect combs and use them for the supers. Extra care should be exercised to see that only perfect combs are placed in the lower one of the two hive-bodies during the winter, in order that the queen may pass easily from the second to the first story during the period of brood-rearing previous to the time of unpacking.

Because of the presence of European foulbrood throughout the buckwheat region, no race of bees may be used with safety except the Italian. This race has the ability to clean house so well developed that the bees can clean out the remains of the larvæ dead of this disease, provided other conditions are right. Not all strains of Italian bees are equally good for this purpose, however, and the beekeeper of this region should take pains to get those which are best. No one strain can be recommended as the best, and the proper plan for the beekeeper is to buy several untested queens from several reputable queen-breeders who have been engaged in breeding queens for sufficient time to establish their reliability and ability to breed good stock. The names of breeders may be obtained from advertisements in the bee-journals. From queens thus purchased there may be chosen the one or ones suitable for breeding purposes, and the beekeeper should then plan to raise his own queens from this stock. The time and methods of queen-rearing will be discussed on later pages.

ADAPTATIONS OF BEEKEEPING PRACTICE FOR THIS REGION.

To obtain a crop of honey from buckwheat and at the same time have the colonies in such shape that they can overcome European foulbrood during the period of its prevalence in the spring and early summer, it is of the highest importance that the beekeeper begin the work of preparation early. It will not do to wait until the buckwheat is in bloom and then make the most of what the bees are able to do. This always results in a reduction of the crop, sometimes to the point where no surplus honey is obtained. The beekeeper of this region is extremely fortunate in that the late honey-flow practically insures sufficient brood-rearing to make a winter colony.

OUTLINE OF THE ANNUAL CYCLE FOR THIS REGION.

To have a good colony of bees at the beginning of the active season it is necessary that the beekeeper begin his preparation about August 15 of the previous year. This is during the period of nectar secretion from buckwheat, and he will still have honey to remove from the hives, but from this time on he should have constantly in mind the prosperity of the colony for the coming winter period, giving them during the ensuing six or eight weeks conditions favorable for the rearing of brood for the winter colony. During the winter he should in every way conserve the energy of the bees so that they will not begin brood-rearing too early and so that they may also be able to do the work of brood-rearing to the fullest extent in the spring. During the spring they must be provided with abundant stores or brood-rearing will be curtailed at this critical time. These things will bring the colonies to full or approximately full strength at the time when alsike clover comes into bloom, enabling the beekeeper to get the available crop from this source, which has been somewhat neglected in this region. The plan from the beginning of the alsike clover bloom until the beginning of the buckwheat bloom will depend on whether the beekeeper desires to make increase in the number of his colonies before the buckwheat honey-flow. His decision in this matter will be determined by the importance of clover as a source of honey.

FALL PREPARATION.

The exact procedure in fall management will depend on the prevalence of clovers or basswood in the locality, which will in turn determine the methods of getting the bees ready for the buckwheat harvest, as outlined later in this bulletin. In any case, each colony that is to go through the winter should have, by August 15, the queen which is to head it the following spring. It should also have, regardless of the prevalence of buckwheat in any particular season, two 10-frame hive-bodies, one of which is devoted to brood-rearing and the other one well filled with honey for the use of the bees during the winter and spring. If there is in any year a failure of buckwheat and the upper hive-body is short of stores, the beekeeper should see to it that each colony has at least 20 pounds of honey at all times from August 15 to October 1 in order that the bees for the winter colony may be reared. This amount will, however, not be adequate for the winter and spring. The matter of fall and winter stores rarely needs special attention in the buckwheat region, if the beekeeper leaves enough with the bees.

WINTER CARE.

The problem of caring for bees during the winter season is the most important that the beekeeper of the buckwheat region has to face, chiefly because of the fact that European foulbrood is so prevalent throughout the region. The stores to be used during the period of confinement, whether outdoors or in a cellar, must be of good quality to reduce the danger from dysentery. These stores will be those next to the winter cluster which will be used first; and if there is any question as to the quality of the stores, the beekeeper may insure good stores by feeding at least 10 pounds of granulated sugar in the form of a thick sirup or honey of good quality from healthy colonies after all brood-rearing has ceased. (Fig. 3.) Fortunately, buckwheat honey is good for the winter period, and unless inferior honey is stored after the close of the buckwheat honey-flow the beekeeper need give no further attention to the quality of the honey.

In the colder parts of the region many beekeepers winter their bees in cellars. If this is practiced, great care must be exercised to see that the cellar is so constructed that the temperature will be maintained uniformly, not too high or too low. Detailed directions for the construction and maintenance of cellars are given in Farmers' Bulletin 1014 of the Department of Agriculture, to which the reader is referred. In a properly constructed bee-cellar (fig. 4) the ceiling and every other part of the wall surface must be below the frost line, to prevent fluctuations in temperature due to outside changes and to maintain a temperature sufficiently high to prevent the wasting of

70584°—22——3

the energy of the bees by heat generation. When colonies are wintered in cellars they will, perhaps, be kept in one hive-body, but in

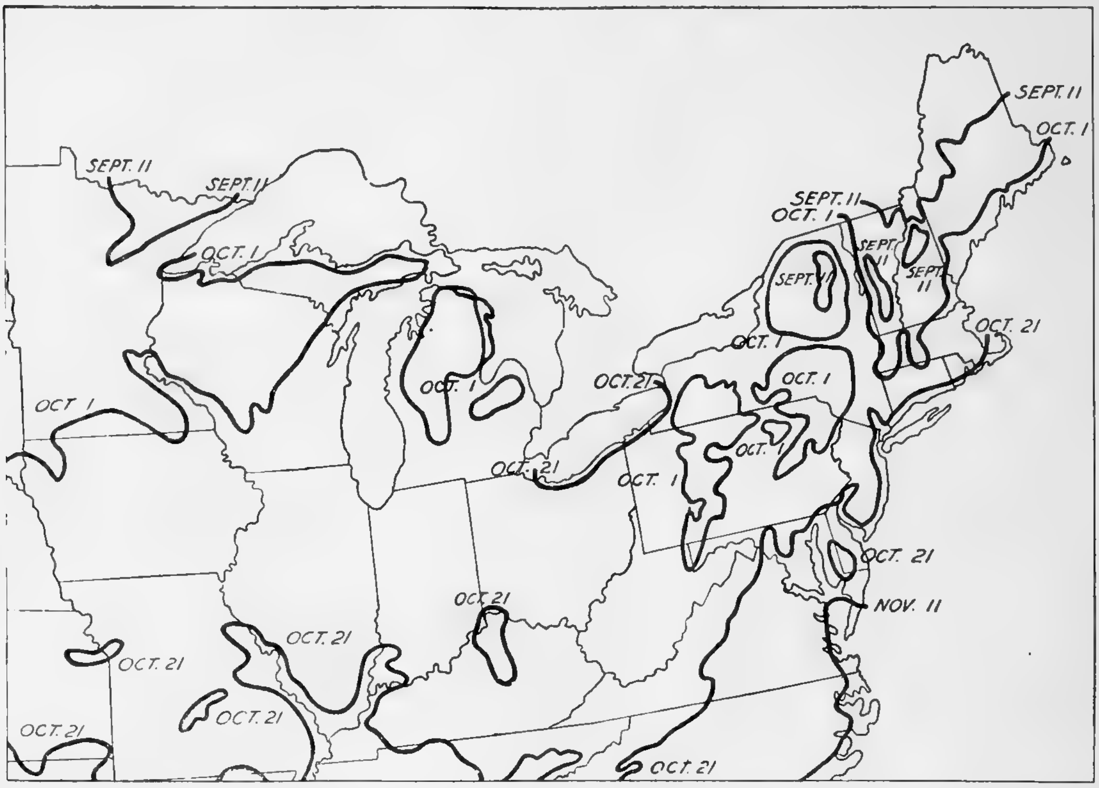

FIG. 3.—Map of buckwheat region showing average date of first killing frost in fall. From these data the beekeeper determines the time to pack colonies of bees wintered outdoors. Feeding for improvement in winter stores is done after the first killing frost.

this event it is imperative that a second hive-body well filled with honey be stored to be given to each colony during the period of heavy

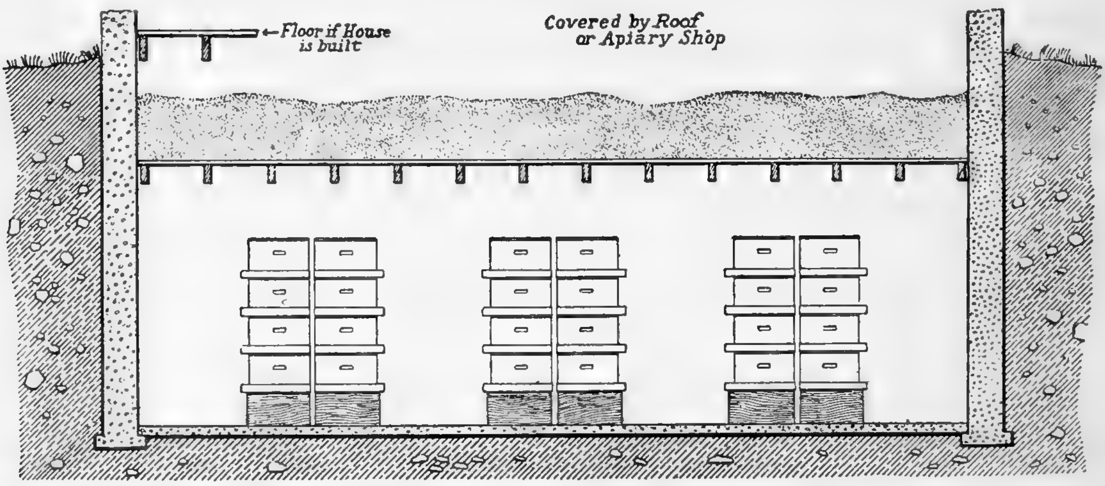

FIG. 4.—Diagram of bee cellar. Clearance 6½ feet, ceiling 2½ feet below ground level, packed with about 1½ feet of sawdust.

brood-rearing of spring. The hive-body with the bees should contain at least 25 pounds of honey. A failure to provide this extra room and stores is the cause of great loss from disease in many parts of the region. There is no better place to store the extra hive-body of honey or any better way to winter bees in the cellar than to leave all the honey with the bees, if one can arrange to handle the heavy hives as they are put in and removed from the cellar.

For outdoor wintering, which is increasing in popularity in this region, and which is much preferable in the southern part of the region, the reader is referred for methods to Farmers' Bulletin 1012 of the Department of Agriculture. The quadruple winter packing-case (fig. 5) described in this bulletin is one of the best that can be used in the buckwheat region. Throughout the buckwheat region the bees should be packed not later than October 1 and unpacked

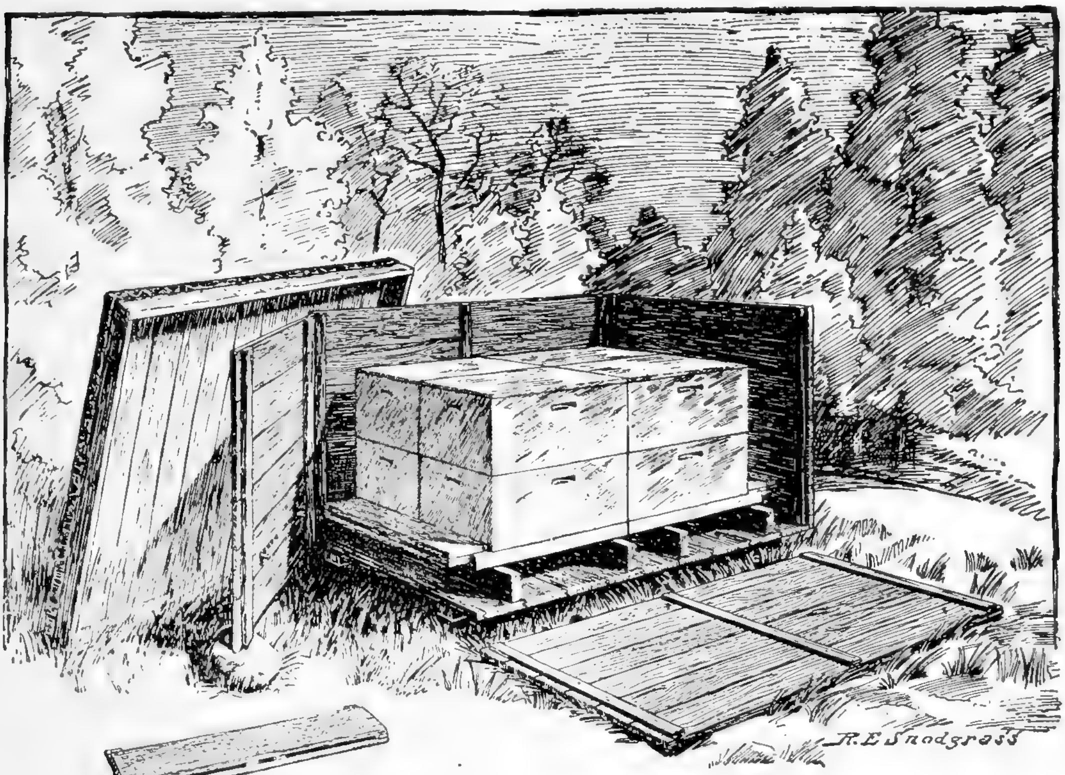

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FIG. 5.—The winter packing cases used in the Bureau of Entomology apiary: *a*, Detail of tunnel to hives. In the specifications given in Farmers' Bulletin 1012 provision is made for room for a third hive-body to be added in the spring.

about May 20 to June 1. (Fig. 6.) Early packing is important in conserving the vitality of the bees that are to start the work of the colony the following spring. Throughout the buckwheat region 4 inches of packing are needed underneath the hives, 8 inches at all sides, and 12 inches on top. Dry sawdust, fine planer shavings, well dried leaves, or any other finely divided packing material may be used. It is not safe to wait until the leaves fall before packing, for this is often more than a month too late. The entrances of the hives must be reduced, as described in the bulletin on outdoor wintering above mentioned, and the hives should be protected from wind.

The bees should be wintered in two hive-bodies, just as was described for the late summer (p. 13). It is not safe in this region to put bees into winter quarters outdoors on less than 45 pounds of stores, for while a considerable amount of nectar may come in during the early spring, occasionally this does not happen in this region, and it is necessary that the beekeeper leave the amount specified in order to insure the proper building up of the colony after March 1.

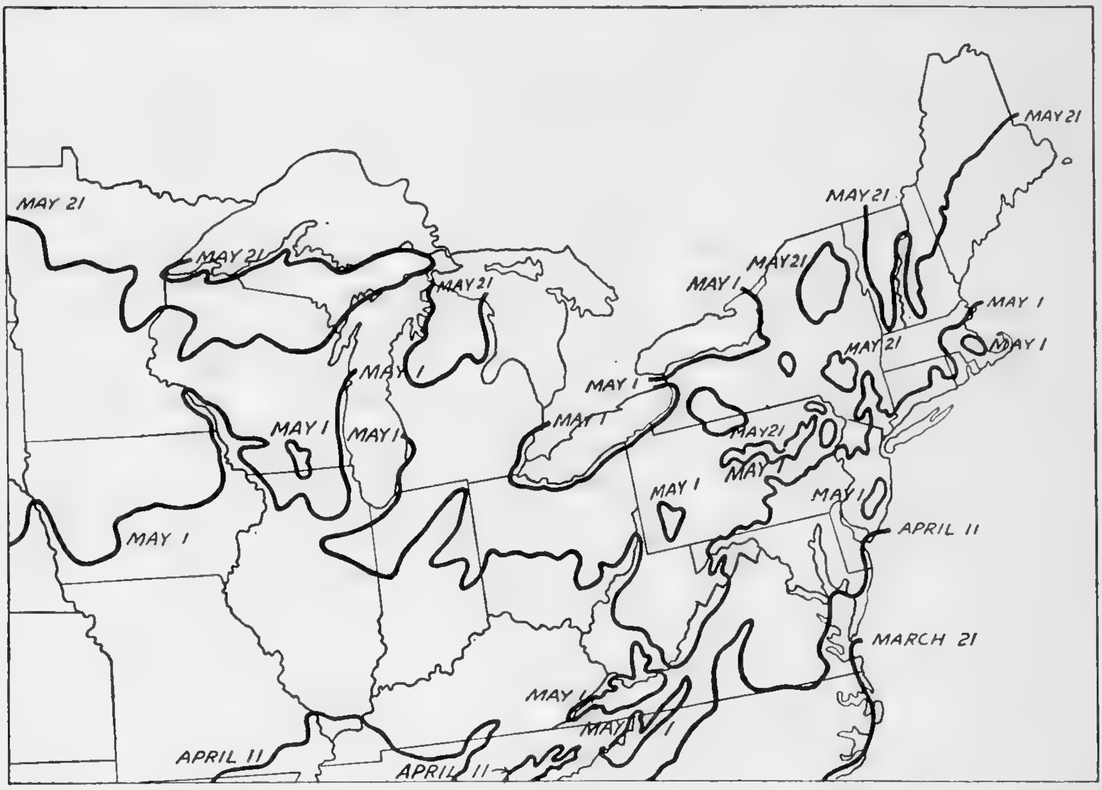

Fig. 6.—Map of buckwheat region showing average date of last killing frost in spring. From these data the beekeeper determines the time to unpack colonies of bees wintered outdoors and estimates the probable time of the beginning of nectar secretion from the clovers.

It is much safer to leave the entire amount all winter than it is to give more before the time of unpacking in May.

SPRING CARE.

If the bees have been wintered in a cellar in single hive-bodies, as is customary, they should be given the second hive-body containing the additional honey and room for brood-rearing not more than four weeks after their removal from the cellar. This should usually be given about May 1. If the lower hive-body has scant stores, the supply of honey should be given as soon as the bees are put out of the cellar. Unless the stores are needed, the cover of the hive should not be removed until the second story is added about May 1, since the bees will not be able at this time to seal the cover of the hive. Entrances to the hives should be contracted on removal from the cellar and no further spring manipulation is needed or desirable at least until May 20. In unusually favorable seasons it may be desirable to add a third hive-body to hold the honey from fruit-bloom. If it is thought necessary to examine any of the colonies early, this should be done from below, but if the proper care has been given the beekeeper knows the condition of each colony without examination, and the bees are better off without disturbance.

If the bees were wintered in packing-cases outdoors, the packing should not be removed until this is necessary to permit some essential spring manipulation. If there is any evidence of preparation for swarming or if there is an unexpected early spring honey-flow, the bees may need either more room or some different arrangement of the parts of the hive. Ordinarily the only spring manipulation necessary up to the time of unpacking is that of enlarging the entrances to the hives as the population of the colonies seems to require.

Some beekeepers practice the clipping of the wings of their queens in the spring to prevent the swarms from leaving, and this is most easily done before the colony population is so greatly increased. If the queens are clipped, the operation should be delayed at least until the time of unpacking outdoor colonies, as the bees need the protection until the time specified. With the methods of swarm control and requeening adaptable to and desirable for the buckwheat region, the clipping of queens is superfluous.

In some seasons the bees may make preparations for swarming before the usual time for removal of the packing. If this is general throughout the apiary, the packing-cases should then be removed. If any swarms should issue before the packing is off, they should be hived on new stands, thereby increasing the number of colonies in the apiary. Within a week of the issuance of the swarm, the parent colony must be unpacked and all queencells removed except one, to prevent the issuance of afterswarms. The swarm can be handled in this way, because in the buckwheat region both the swarm and the parent colony may be built up to full strength before the buckwheat honey-flow.

MODIFICATIONS OF PRACTICE BASED ON THE POSSIBILITY OF A JUNE HONEY-FLOW.

In the buckwheat region it is essential that every colony be brought practically to full strength by June 10 because of the widespread distribution of European foulbrood, even though no honey-flow is to be expected from clovers. A failure to recognize this fact fully is responsible for the terrible devastation from this disease in this region. However, if this is done the bees normally, in the absence of a clover honey-flow, come to the beginning of the buckwheat honey-flow with the colonies composed largely of old bees incapable of gathering the full crop of buckwheat honey. If there is a clover honey-flow there will also be a tendency for the old queens to reduce the number of eggs laid daily, thus causing the colonies not to be in the best condition for the buckwheat honey-flow. In the absence of a clover honey-flow it is most desirable that these strong colonies be utilized to the fullest extent, and to this end these bees should be used to rear many times more young worker bees for the buckwheat harvest, since there is fortunately ample time for this to be done. A failure to take advantage of this possibility has greatly reduced the buckwheat honey-crop. Since it takes about six weeks for the development of a colony of young bees from each part of a divided colony, it is possible in this region to follow the plan here outlined.

After the colonies of bees have built up almost to full strength, the beekeeper of the buckwheat region is called upon to determine his future work of the year, based on the probability of getting a crop of honey from the clovers or some other honey-source blooming in June. There will be two possibilities:

(*1*) *Prospect of no surplus clover honey-flow* (a) because of a failure for the year or (b) because the clovers do not normally secrete nectar in the locality due to their absence or to the peculiarities of the soil. In this event, each colony may be divided into two or more colonies and the queenless colonies given young queens which will begin laying not later than June 15. Unless permanent increase in the number of colonies is desired, the less desirable queens are killed and the parts of the original colony are united August 15.

If there is no prospect of a surplus honey-crop from the clovers in the locations now occupied by the beekeeper, he may sometimes be able to find other locations within moving distance to which the bees may be moved to take advantage of these sources.

This migratory beekeeping has not been practiced extensively by the beekeepers of the buckwheat region, but with fuller development of the area it is to be expected that this practice will increase, as it already has in other parts of the country. The presence of European foulbrood has been considered a drawback to this practice, but if the proper methods are used this may be entirely disregarded. In fact there is no better way to overcome this disease than to move to places where the bees may take advantage of an early honey-flow. This is the practice of many beekeepers of the European foulbrood regions of California.

(*2*) *Prospect of surplus honey-flow from clovers*, perhaps augmented by basswood in July. No increase should be made in June. Each colony should be requeened in connection with swarm control, but this should be done for every colony not later than June 15, so that the young queens will begin laying not later than June 25. If permanent increase is needed, this should be made by devoting certain colonies to this use after the close of the clover honey-flow at the sacrifice of the buckwheat honey-crop.

DIVIDING THE COLONIES IN JUNE.

By June each colony should have brood in two hive-bodies. It is understood that if this plan is followed the division is to be made before the normal time for the bees to swarm, thus controlling this instinct. About June 1 place the old queen in the lower hive-body with a small amount of brood, most of the brood being placed in the upper hive-body if necessary and a queen-excluder placed between the two hive-bodies. In 10 days all the brood in the upper hive-body will be sealed. At this time (June 10) remove the upper hive-body, give it a bottom board, and cover and place it beside the original colony. At this operation give the removed queenless portion a ripe queencell or virgin queen (or, if available, a young laying queen). If a young laying queen is given, the division may be made 10 days later. The young queens should, as previously stated, be laying by about June 15 to 20 in order that there may be adequate time for the development of the new colony to full strength for the buckwheat honey-flow. As the beekeeper increases in skill in wintering his colonies, he will find that the colonies are sufficiently strong so that it will be possible for him to increase each colony to three colonies and still have them sufficiently strong so that each portion may be ready for the buckwheat honey-flow, but great care should be exercised in this regard. Whatever plan is followed, the beekeeper should constantly keep in mind the fact that the object of this division is to have the maximum number of eggs laid between June 15 to 20 and the beginning of the buckwheat honey-flow.

For the proper development of the several parts of the original colony it is necessary that each part have never less than 15 pounds of honey (the equivalent of three full frames) at any time previous to the beginning of the buckwheat honey-flow. The amount which must be left with each portion at the time of division will be determined by the amount available in the field at that time. If honey in combs is not available, and if there is a scarcity of nectar from the fields, it will be necessary to feed each colony. If feeding is practiced, it is dangerous to depend on daily feeding unless more is given each day than is consumed by the bees. The better plan is to feed in large quantities at each feeding, bearing in mind at all times the necessity of keeping the requisite 15 pounds of stores in the hives every minute during this interval.

Each colony will need at least two hive-bodies for full development of the requisite brood at least by July 10. If the additional room is not given, it will be impossible to have full-strength colonies at the beginning of the buckwheat honey-flow, for there is not room in a single 10-frame Langstroth hive to provide for the adequate development of the colony population and at the same time leave with the bees the requisite stores for full brood-rearing.

SUPPLYING YOUNG QUEENS.

It is impossible in the space of this bulletin to give full directions for queen-rearing, but these directions are given in the various books on beekeeping, to which the reader must be referred. The beekeeper in the buckwheat region can not well afford to depend on the purchase of queens from queen-breeders for requeening all of his colonies, nor can he get the full honey-crop unless he requeens his colonies from good Italian stock reared in his own apiaries every year. Even though it were possible, the beekeeper could not afford to requeen before June 1, for that would interfere with the rearing of the large amount of brood necessary for combating European foulbrood. He must also not interrupt the rearing of brood after August 15, as this would interfere with the development of the winter colony. He is therefore limited to the period between June 1 and August 15, and will choose the particular time during this period when the stoppage of egg-laying will interfere the least with the development of the full colony for the buckwheat harvest. As has been stated previously, to accomplish this the young queens should be laying by June 15 to 20, and this determines the time when the colonies should be requeened.

To have these queens on hand at the proper time for dividing the colonies as described, the most economical method is to rear a large number of queencells and to introduce these just before emergence, thus utilizing the colonies for mating purposes instead of making many nuclei for this purpose. It will be desirable to make enough nuclei to replace those queens which are lost during mating (about 20 per cent). The number lost may be reduced by a proper arrangement of the apiary to avoid confusion of the returning young queens after their mating flights. These nuclei may be united with the colonies whose queens fail to mate, their queens thus being given them at the same time.

UNITING PORTIONS OF ORIGINAL COLONIES.

If permanent increase in the number of colonies is not desired, the expense of rearing the winter bees in half the colonies may be saved by uniting the portions of the original colonies now placed on adjacent stands by the system here outlined. About August 15 (eight weeks before brood-rearing ceases), place the supers of the colony having the old queen on top of the one on the adjacent hive (having a young queen). Now kill the old queen and set the hive-bodies containing her brood as supers on top of the supers of the adjacent hive. This uniting should be done when nectar is coming in freely. If at any time of the day there is a tendency for nectar-secretion of the buckwheat to slow down, as is often reported, it may be necessary to unite the upper brood-nest by placing it above two thicknesses of newspaper in which small perforations are made. The enormous colony of bees thus formed will be able to get the maximum crop from the buckwheat and swarming will rarely, if ever, result at this season.

It will often be found unnecessary to kill the old queen, since in most cases the young queen is the one which will survive. At the first manipulation of the colony after the uniting is done, the upper brood-chamber should be placed directly above that containing the young queen, thus giving the colony its two hive-bodies and old brood-combs for the winter and spring in adjacent positions. The upper of the two brood-chambers will be filled with good stores as the brood emerges. The queen-excluder should be left in position until the close of the buckwheat honey-flow. If there is drone brood in the upper brood-chamber, a small opening may be left above the queen-excluder from which the adult drones may leave this hive-body.

SWARM CONTROL WITHOUT DIVISION.

If the colonies are not to be divided, because of the possibility of getting a crop from the clovers, it will then be necessary to apply swarm-control measures. To induce the colonies to continue intensive brood-rearing, to keep them working vigorously in the supers, and at the same time to control swarming and prevent a division of the working force during the clover honey-flow, the following plan (fig. 7) may be used:

(1) About June 1, or before the clover honey-flow has begun, give each colony an extracting super on top of the second story of the hive, giving the queens full range of all three hive-bodies (fig. 7, B).

(2) By about June 10, if the colonies are strong, the queen will have abandoned the lower hive-body. Between June 10 and 15, depending on the progress of the clover honey-flow and on the development of the swarming instinct, find the queen and place her in the lower hive-body, over which is then placed a queen-excluder (fig. 7, C). The hive-body containing the most brood is now put on top, supers being added as needed between the queen-excluder and the top brood-chamber.

(3) About June 15 place in each of the top hive-bodies containing brood a ripe queencell, arranging for a small opening through which the young queens may fly out to mate.

(4) Make nuclei equal in number to 20 per cent of the total number of colonies in the apiaries in which young queens are to be mated, to provide for cases in which the queens in the upper hive-bodies fail to begin laying. If these are needed, they may be united with the strong colonies by the newspaper plan (p. 21), and these young queens thus introduced.

(5) Two weeks or more after these queencells have been introduced (after June 25) examine the combs of the top hive-body for eggs laid by the young queen. At any time toward the close of the clover honey-flow when convenient, provided the young queen has

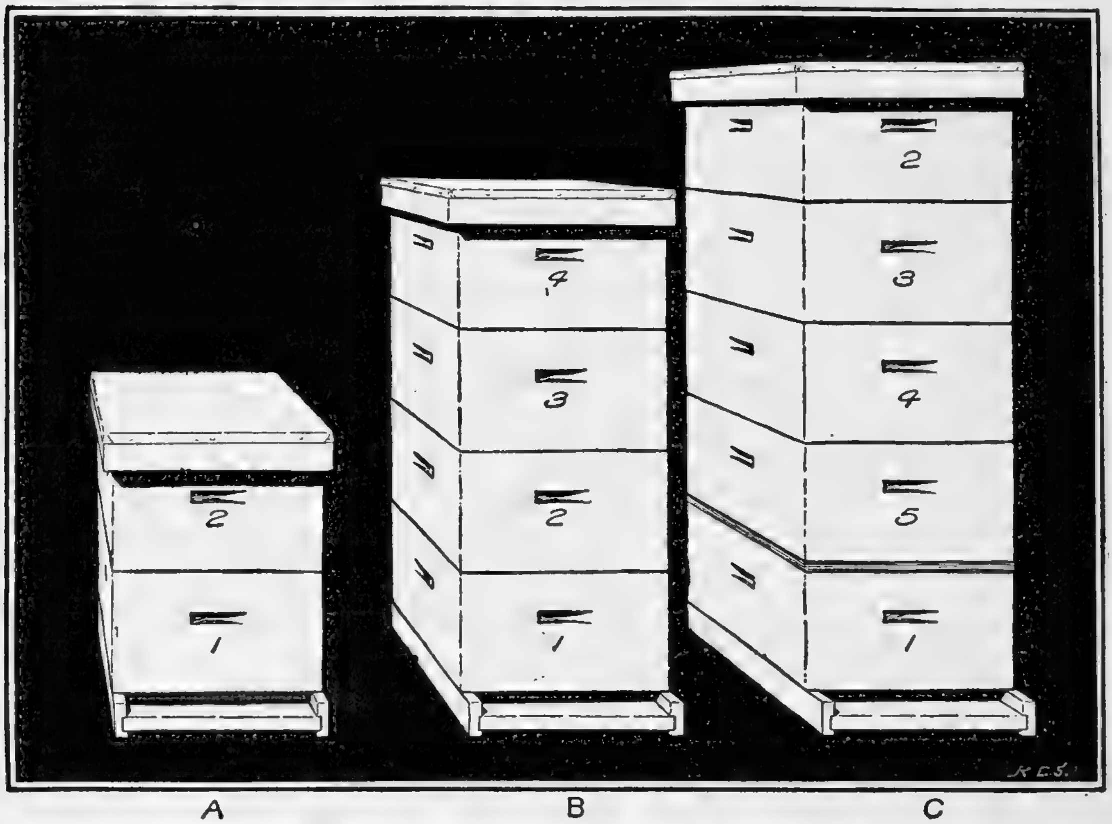

FIG. 7.—Creating conditions comparable to a swarm. Plan 2 for extracted honey. *A*, Brood in both hive bodies in the spring. *B*, Supers *3* and *4* are added as more room is needed, queen usually abandoning lower brood-chamber (*1*). *C*, Queen placed below excluder in lower hive body (*1*) after all brood in this chamber has been sealed. Empty super (*5*) is added and brood (*2*) is placed on top.

begun egg-laying, place the hive-body in which she is located on the bottom-board, cover it with a queen-excluder, and place the hive-body containing the old queen at the top (above the supers). When the clover honey is being extracted, place the hive-body containing the old queen directly above the queen-excluder. If deemed best the old queen may now be killed, but this is unnecessary in most cases as she will be killed by the worker bees after the close of the honey-flow from clover. Supers will, of course, be added as needed.

INCREASE AFTER THE CLOVER HONEY-FLOW.

If the clover honey-flow is abundant, permanent increase will usually be made at the close of the clover honey-flow and at the expense of the buckwheat honey-crop, because of the superior qualities of clover honey.

(*a*) *When outapiaries are maintained.*—At the time increase is made, divide the colonies into two or three parts, according to their strength, leave the ones with queens on the old stands, and move the other parts to outapiaries, thus preventing the return of the field bees to the original stands. Then provide each queenless portion with a ripe queencell. This should be done in time so that the young queens will begin to lay not later than August 15, in order to provide the requisite bees for the winter colony (see p. 13).

(*b*) *Where outapiaries are not maintained.*—After supers containing the clover honey are removed, the colonies should be in two hive-bodies. On or before August 1 take away the hive-body containing the queen and most of the brood to a new stand and close the entrance with fresh grass, which will retard the return of the bees to the former location. The grass will dry out and release the bees for flight within a few hours and it is unnecessary to do anything further with this colony for the present. Leave some brood in the hive-body on the old stand (at least one frame) and provide this portion of the original colony with a queencell from which the queen is almost ready to emerge. About August 10 to 14 examine the colony on the old stand to see if the young queen is laying. If she has failed to mate, provide this colony with a queen mated in a nucleus, as described above. The buckwheat honey-flow will provide conditions for the rapid development of both colonies, and each must be given a second hive-body for the storing of the honey for winter and spring use. Sometimes a little surplus may be obtained from these colonies, but care must be exercised to see that they have the requisite amount for their own use (see p. 16).

EXTRACTING

The outfit needed for extracting and the methods to be employed will depend on the size of the apiaries maintained. Special attention should be called to the necessity of having abundant supers so that the honey may be well ripened before extraction. A failure to provide these is at present responsible for the marketing of much poor-quality buckwheat honey. While efficiency in methods of extracting is important in enabling the beekeeper to maintain a large number of colonies, this phase of the work has been so fully discussed in the books devoted to beekeeping that it does not seem best to attempt to include it in the present bulletin. This plan is adopted because this part of the work is the same in the buckwheat region as in other beekeeping regions, and especially because it is far more important to produce honey to extract.

DISEASE CONTROL.

It is unfortunately true that both of the brood diseases of bees, American foulbrood and European foulbrood, are widely distributed throughout the buckwheat region, and the beekeeper must so plan his work as to have the control of these diseases constantly in mind. There is no hope of the eradication of these diseases from the region.

European foulbrood is a disease of weak colonies of bees, and is prevalent in the spring and early summer, especially in colonies of black bees. If the practices of beekeeping herein given are followed carefully, the beekeeper will find that this disease will not cause him any anxiety. In case the disease persists in the apiary, this is conclusive proof that the beekeeping methods followed are not such as to get the maximum honey-crop. For remedial measures in getting the disease under control the reader is referred to Farmers' Bulletin 975 of the Department of Agriculture. The reasons for the development of the colony strength in the spring as a preventive of this disease have already been pointed out.

American foulbrood can not, unfortunately, be prevented by the development of the colony strength, and the shaking treatment is necessary if this disease appears. This treatment is described fully in Farmers' Bulletin 1084 of the Department of Agriculture, to which the reader is referred. If this disease is found to be bad early in the season, the treatment should be given preferably during June, in order to permit the colony to build up for the buckwheat harvest. If not enough honey is coming in at this time, the treated colonies may be given combs of honey from healthy colonies not earlier than four days after treatment, or they may be given sugar sirup if starvation is imminent. If a mild case is discovered early in the season, and if there is no clover honey-flow, it may be best to wait for treatment until the buckwheat honey-flow, but precautions must be taken to prevent the robbing out of such colonies. Treatment for this disease should, if possible, be given only during a good honey-flow.

While with the beekeeping practices herein outlined European foulbrood will constitute only a minor trouble of the apiary, it is essential that the beekeeper keep a constant watch for American foulbrood and treat every case as soon as practicable after its discovery. In localities where this disease is present he should inspect the brood-nests of every colony at least once a year, in connection with some other manipulation of the colony. This should, if possible, be done about June 1. No colony should ever be packed for outdoor wintering in which this disease is known to be present. If discovered late in the season the fall treatment described in Farmers' Bulletin 1084 may be used.

MARKET FACILITIES AND METHODS OF MARKETING.

The channels through which buckwheat honey may be sold are less numerous than for lighter honeys. There is usually a demand for this honey from the baking trade for the manufacture of cakes with rather strong flavor, such as spice cakes, and there is also a considerable market for it in large cities among the foreign population. As has been mentioned, many persons living in the buckwheat region prefer this honey to that from other honey-plants. Since the buckwheat region is densely populated, this offers opportunity for the development of a good local trade, and it is desirable that as much of the crop be sold locally as possible. In case the producer of buckwheat honey can not sell all his honey locally, he should avoid selling it in the general markets in competition with light table-honeys. At the present time the market for which there is the best demand for buckwheat honey is New York City, and the producer with commercial lots of this honey should get in touch with wholesale dealers of honey in this city. The names and addresses of such dealers may usually be obtained from advertisements in the bee-journals or by correspondence with the Bureau of Markets and Crop Estimates of the Department of Agriculture. It must be expected that the price obtained in wholesale shipments will be considerably less than for local sales, and every effort should be made by the producer to keep this honey away from the wholesale markets where it enters into competition with lighter honeys.

Extracted honey is usually sold in the wholesale markets in 5-gallon square tins, but for buckwheat honey there is a considerable demand for kegs of about 180 pounds' capacity. For local trade this honey may be put in cans of smaller capacity, such as 2½, 5, and 10 pound sizes, glass being less useful for this honey than for the lighter grades.

Buckwheat honey may also be sold by parcels post through the development of a mail-order business, by means of advertisements in daily or weekly papers, but it will be well to choose as advertising media papers which have a circulation within the buckwheat region, for purchasers outside that region will probably not care for honey of this flavor. For parcels post shipments half-gallon and gallon cans have been developed and are advertised in the bee-journals and are usually for sale by dealers in beekeepers' supplies. In the development of a local or mail-order trade, the beekeeper should take pains to obtain a distinctive label, and for buckwheat honey this label should set forth the merits of this particular type of honey rather than extoll the use of honey in general. All advertisements and labels should state clearly that buckwheat honey has a distinctive flavor, so that the purchaser will have no reason to complain if he is unaccustomed to honey with such a strong flavor.

OPPORTUNITIES FOR DEVELOPMENT OF THIS REGION.

There are vast areas of the buckwheat region of the United States that are undeveloped or only partially developed in their honey resources. This is largely due to the widespread distribution of European foulbrood, but it is also doubtless due in part to a lack of information as to the right methods to be used in obtaining the crop. Although the honey from buckwheat is inferior to that from many other honey sources, there is a real need for all of it that can be produced, and there is especially an opportunity for the development of commercial beekeeping in this region. All the factors mentioned concerning this region point to the fact that this is not one in which it is desirable that bees be kept in small apiaries, for it requires great skill on the part of the beekeeper to make the most of the resources of this area.

Only by the education of the commercial beekeepers of the region in the best methods of beekeeping practices or by the taking up of the territory by thoroughly trained beekeepers from other sections will it be possible to develop this region completely. In order that the vast areas of buckwheat may be more thoroughly occupied, it is desirable that the commercial beekeepers of the region expand their businesses by the establishment of more outapiaries. This, together with a more thorough study of the special practices necessary for the region, will result in a great impetus to beekeeping and thus serve to save for human use the great stores of nectar now so largely wasted.

Since it is impossible in the scope of one bulletin to give all the details of beekeeping practice which will be needed by the commercial beekeepers of the buckwheat region, it is necessary to refer to certain other bulletins of the Department of Agriculture in which these practices are given in greater detail. Some of these bulletins have already been mentioned. Those of the greatest interest are:

Bees. (Farmers' Bulletin 447.)
Honey and its Uses in the Home. (Farmers' Bulletin 653.)
Transferring Bees to Modern Hives. (Farmers' Bulletin 961.)
Control of European Foulbrood. (Farmers' Bulletin 975.)
Preparation of Bees for Outdoor Wintering. (Farmers' Bulletin 1012.)
Wintering Bees in Cellars. (Farmers' Bulletin 1014.)
Control of American Foulbrood. (Farmers' Bulletin 1084.)
Swarm Control. (Farmers' Bulletin 1198.)

Semimonthly market news reports of commercial honey transactions may be had free on request to the Chief, Bureau of Markets and Crop Estimates, Department of Agriculture, Washington, D. C.

HOW TO DO IT.

DO YOU WANT practical suggestions on how to build a silo, a hog house, a poultry house, a potato-storage house, or how to make a fireless cooker or other farm-home convenience? Are you seeking ideas on how to prepare vegetables for the table, how to care for food in the home, how to bake bread and cake and other appetizing foods in an efficient and economical manner? Is there some practical question about your corn or wheat or cotton or other crops, or about your poultry or live stock, to which you are seeking an answer? The answers to thousands of such questions and practical suggestions for doing thousands of things about the farm and home are contained in over 500 Farmers' Bulletins, which can be obtained upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1922

THE GREEN-BUG OR SPRING GRAIN-APHIS:

HOW TO PREVENT ITS PERIODICAL OUTBREAKS

W. R. WALTON

Entomologist in Charge, Cereal and Forage Insect Investigations

FARMERS' BULLETIN 1217

UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief
Washington, D. C. Issued June,, 1921

Destroy volunteer grains during summer and early fall.

THE GREEN-BUG OR SPRING GRAIN-APHIS: HOW TO PREVENT ITS PERIODICAL OUTBREAKS.

CONTENTS.

DISTRIBUTION.

THE GREEN-BUG (fig. 1) is a small, soft-bodied aphid or plant-louse which is distributed throughout nearly the entire United States and extends into Canada (fig. 2). Its injuries prin-

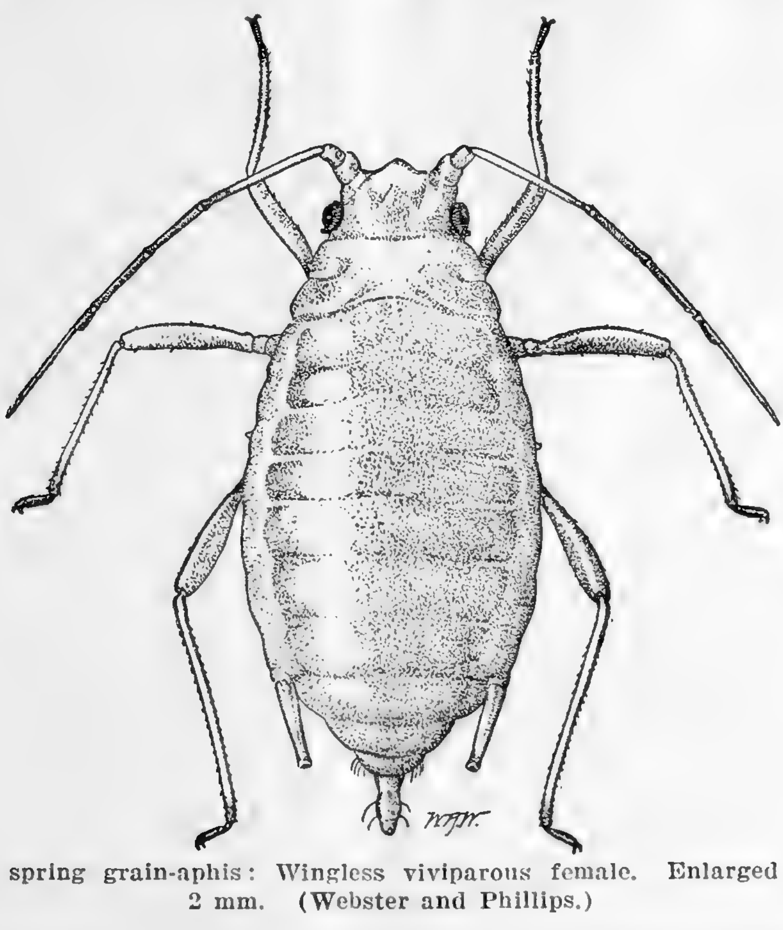

FIG. 1.—The spring grain-aphis: Wingless viviparous female. Enlarged; actual size, 2 mm. (Webster and Phillips.)

cipally are inflicted throughout the Mississippi Basin, where it often has been responsible for many millions of dollars' worth of damage to the small grains. It is estimated to have caused in one year (1907) a loss of not less than 50,000,000 bushels of oats and wheat in Kansas, Oklahoma, and Texas. Seventy per cent of the wheat acreage in Texas was abandoned that year because of the ravages of this formidable pest.

Smaller outbreaks occurred in 1911 and 1916 and outbreaks will continue to occur in the future unless growers generally adopt the control measures described in this bulletin. This statement applies especially to Texas, Oklahoma, Kansas, and Missouri, where the pest is present in greater or less numbers almost constantly and requires merely the advent of favorable conditions to become the agent of disaster to the wheat and oats crops.

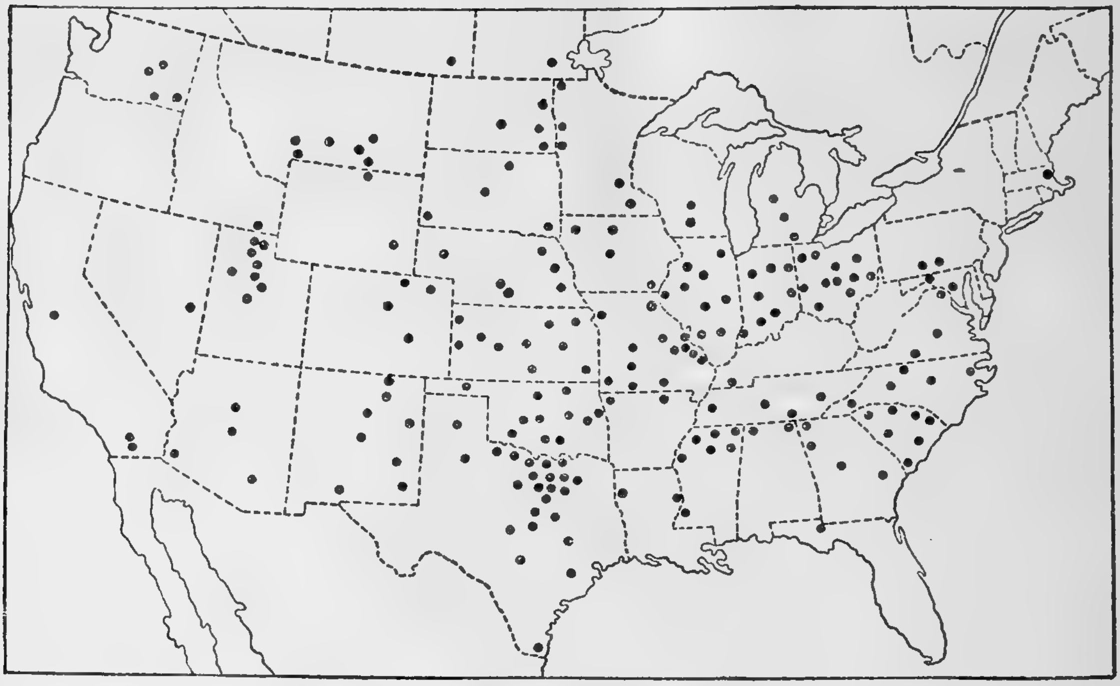

FIG. 2.—Map showing the known distribution of the spring grain-aphis in the United States and Canada. (Webster and Phillips.)

While the green-bug can exist to some extent on a wide variety of grass-like plants, including most of the small grains, it is injurious principally to oats and wheat. For this reason these plants must be considered as its favorite hosts and should receive the closest of attention in all control methods which may be adopted.

Outbreaks of the green-bug may be expected in the lower Mississippi Basin States during the early spring, following a mild winter, especially should the spring prove to be a cool, backward one. This is due to the ability of the pest to multiply constantly at comparatively low temperatures, under which its controlling agencies are dormant.

LIFE HISTORY.

The life history of the green-bug is a peculiarly complicated one and for this reason will not be described in detail in this brief, popular publication. There are no less than three distinct forms of adult females of the pest. A wingless one, producing its young alive (fig. 1); a wingless one, which lays eggs (fig. 3); and a fully winged one (fig. 4), producing its young alive. The male is of small importance, as ordinarily he is not required in the multiplication of the species.

In the southern latitudes the egg-laying females are not believed to exist, but both the other forms of females which produce living young are found at certain seasons. The wingless form of this type is practically always present and producing young all the year round. The egg-laying females appear in the north only in the

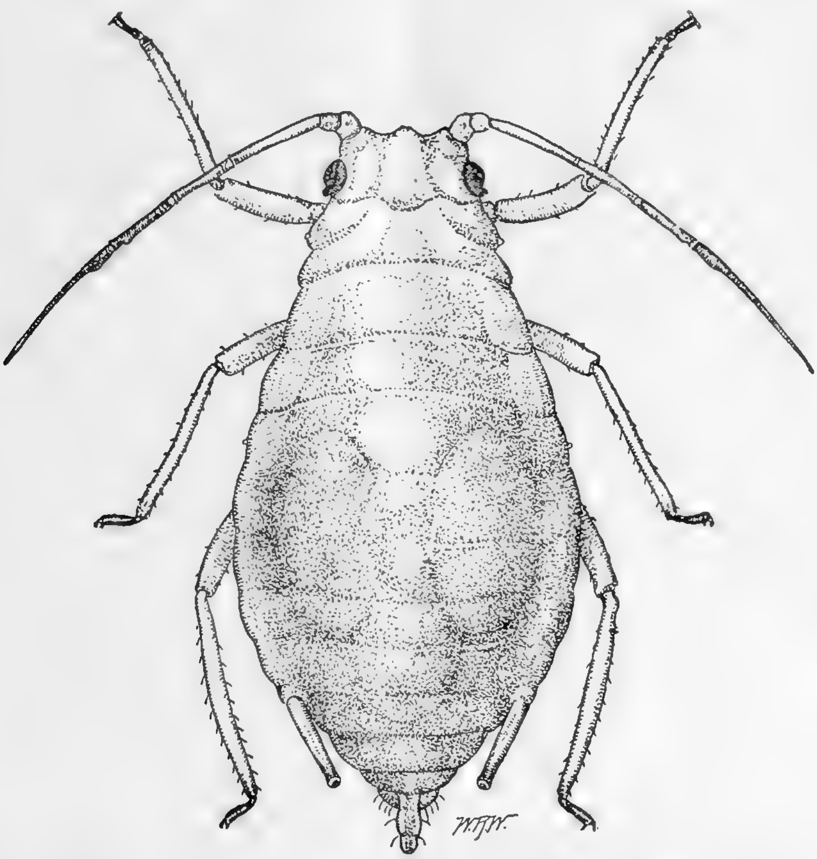

FIG. 3.—The spring grain-aphis: Oviparous female, showing eggs within the abdomen. Enlarged; actual size, 2.25 mm. (Webster and Phillips.)

fall of the year and the insect may pass the winter either in the egg stage or as active nymphs or adults on the lower parts of its food plants.

South of the thirty-fifth parallel this pest (except in high altitudes) appears to breed continuously throughout the year, and for this reason is most dangerous to the wheat and oats crops of these warmer regions.

The egg (fig. 5) of the green-bug is green when freshly laid, but soon becomes shiny black, and is to be found attached to the food plants of the pest. These eggs are deposited in the fall and do not hatch until the following spring. The young bugs (fig. 6), upon

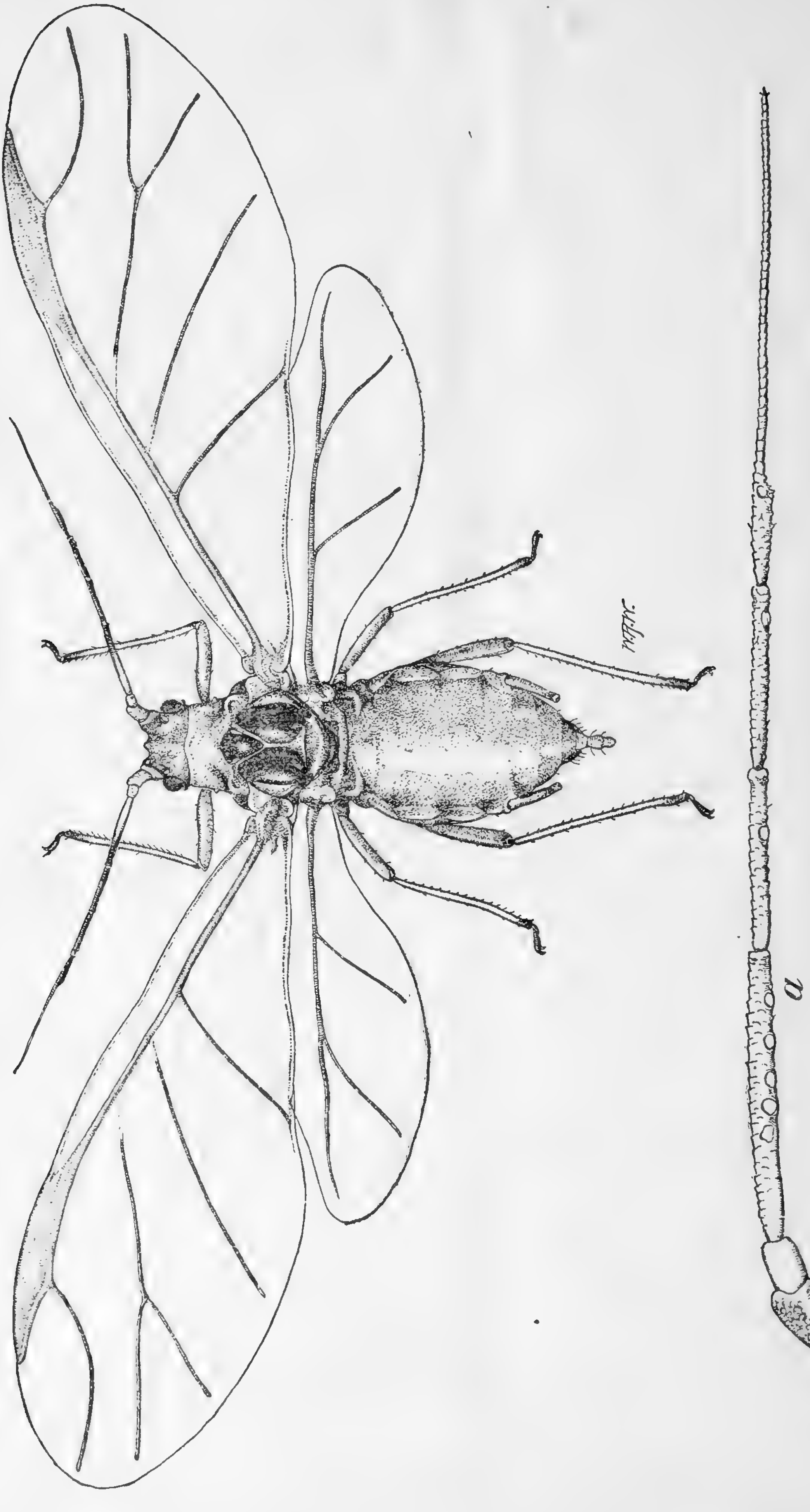

FIG. 4.—The spring grain-aphis: Winged viviparous female and antenna. Enlarged; actual size, 1.9 mm. (Webster and Phillips.)

hatching, are green with black feet, and begin to suck the sap from the grain almost immediately. The same is true regarding those born alive, as within a very short time they are to be found busily engaged in securing their nourishment from the wheat or oat plants at the expense of the grower.

The bugs do not change materially in color throughout their lives and the figures show the appearance of the various stages of the insect. As it requires only from 6 to 7 days for the young green-bug to become adult and begin to produce its young, the pest is able to multiply enormously during the most favorable season of the year and with most dangerous rapidity. It may have at least 20 generations a year in the latitude of Richmond, Ind., and even more in its favorite abode in Texas. A single female may produce from one to eight young per day for periods of at least two or three weeks. Unlike many other insects, the green-bug has no resting stage, and the adult insects are quite as injurious as the young ones, feeding almost continuously from the time they are born until old age overtakes them.

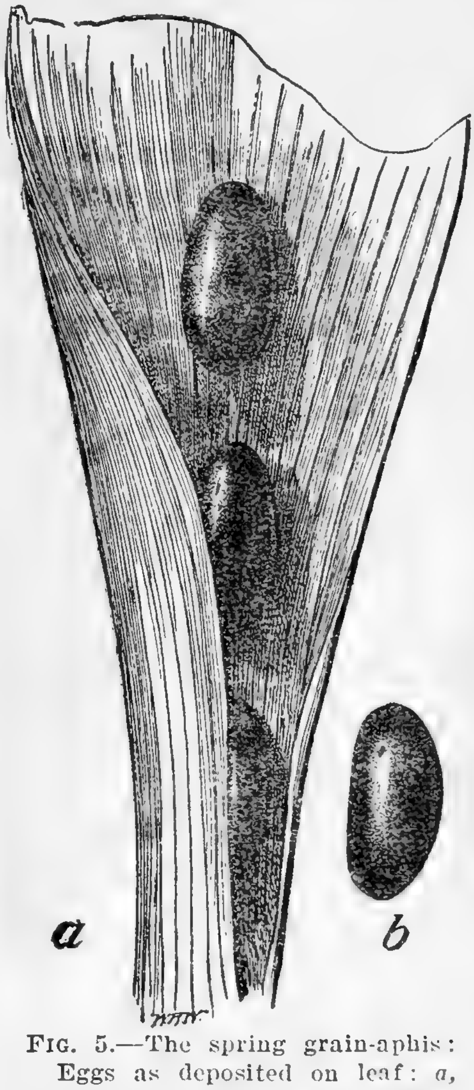

FIG. 5.—The spring grain-aphis: Eggs as deposited on leaf: *a*, Dorsal view; *b*, lateral view. Greatly enlarged. (Webster and Phillips.)

The green-bug secures its food by sucking the sap or juices of the plants upon which it feeds; it takes no solid food of any kind. Its effects upon the grain plants are quickly noticeable, as they appear in the form of yellow areas (fig. 7) on the blades, which turn reddish brown and die. It is probable that this pest in some way poisons the tissues of the plants, although this theory has not been proved.

NATURAL ENEMIES.

The principal reason why the green-bug is not injurious every year is the fact that it is attacked and kept in check by a very small wasp-like parasite (fig. 8). This little friend of the grain grower lays its eggs directly in the bodies of the green-bugs, both young and old, and the maggots hatching from these eggs devour the bugs (fig. 9), destroying them in great numbers. Unfortunately, however, this parasite is able to work and multiply only during comparatively warm weather, while its host, the green-bug, is not so restricted, but keeps right on breeding unless the winter weather is very severe. For this reason the parasite of the pest can not be depended upon to safeguard the crops, and the grain grower must adopt proper methods of protection if he expects ever to prevent the recurring outbreaks of the pest which have become so notorious throughout the Mississippi Basin States.

CONTROL METHODS.

The green-bug can not be destroyed by means of stomach poisons, such as arsenical insecticides, because it feeds upon nothing but the juices of the plants. It is impracticable to fight it with contact insecticides, such as nicotine sulphate or kerosene emulsion, not only because of the prohibitive expense involved but also because this pest often feeds in positions where it can not be reached with such sprays.

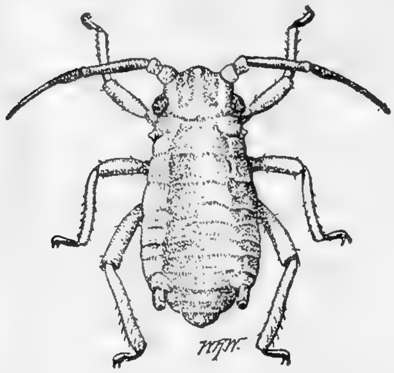

FIG. 6.—The spring grain-aphis: Young, first instar. Enlarged; actual size, 0.75 mm. (Webster and Phillips.)

In the control of the green-bug the old saying that "an ounce of prevention is worth a pound of cure" is most strikingly justified. In the southern half of its range the green-bug is dependent largely on volunteer grain for its existence from the time the crop of the current year is cut until the young grain is above ground in the fall, or even until the following spring in many cases. It naturally follows, therefore, that if the volunteer growth is destroyed the insects must perish in large numbers for want of food, and experiments have shown that this is indeed the case. **The most important control measure for the green-bug, therefore, is the destruction of all volunteer small grain, especially oats and wheat, during the period from midsummer to early fall. This method is of the utmost importance in Texas, Oklahoma, Kansas, and Missouri, where serious outbreaks may originate at any time and sweep northward throughout the wheat-belt States.**

It will not do for merely a few growers to adopt such measures, but they must be put into practice throughout large areas, wherever the green-bug winters in numbers, if satisfactory results are to be expected. The volunteer grain may be disked and plowed down or otherwise destroyed during the period mentioned above and some other short-season crop planted or the land fallowed until the next spring if the blowing or drifting of the soil is not a factor.

Unless grain growers are willing to cooperate and put into effect measures for the destruction of volunteer grain, it will be difficult for

FIG. 7.—The spring grain-aphis (*Toxoptera graminum*): Wheat plant showing winged and wingless viviparous females with their young clustered on the leaves, and a few parasitized individuals on lower leaves. About natural size. (Webster and Phillips.)

the Federal Department of Agriculture to expend further money to best advantage for investigational purposes in connection with the green-bug problem, because the eradication and control of the pest rests to a very considerable degree with the growers themselves, as is shown by the exhaustive investigations already conducted by the department.

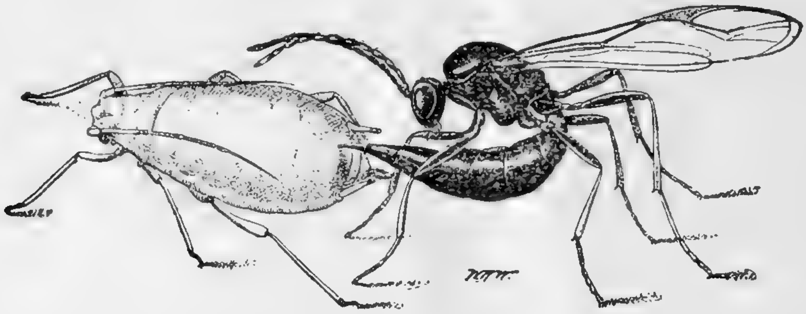

Fig. 8.—*Aphidius testaceipes* ovipositing in the body of the spring grain-aphis. Enlarged. (Webster.)

Destroy volunteer grain during the summer and early fall. Do not depend upon the hazards of the weather to protect grain crops from the green-bug.

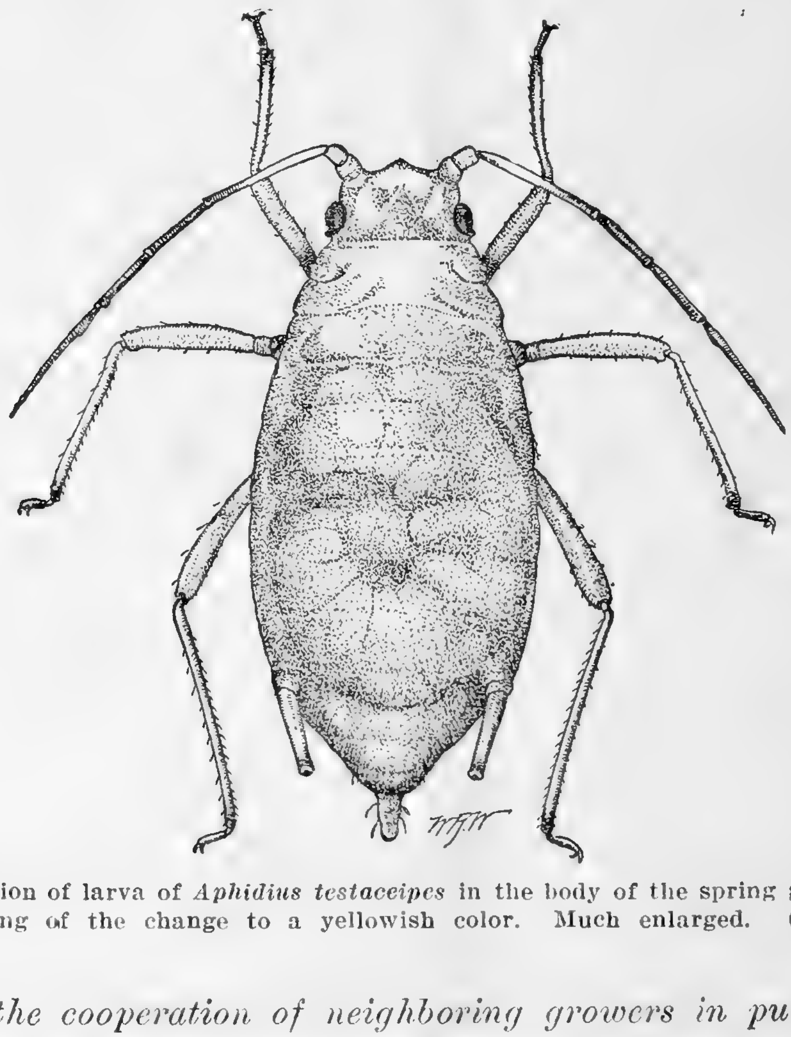

Fig. 9.—Position of larva of *Aphidius testaceipes* in the body of the spring grain-aphis at the beginning of the change to a yellowish color. Much enlarged. (Webster and Phillips.)

Obtain the cooperation of neighboring growers in putting such measures into effect, as individual efforts may be in vain.

PUBLICATIONS OF UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO INSECTS INJURIOUS TO CEREAL AND FORAGE CROPS.

AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Chalcis Fly in Alfalfa Seed. (Farmers' Bulletin 636.)
Grasshopper Problem and Alfalfa Culture. (Farmers' Bulletin 637.)
Wireworms Destructive to Cereal and Forage Crops. (Farmers' Bulletin 725.)
True Army Worm and Its Control. (Farmers' Bulletin 731.)
Corn and Cotton Wireworm in Its Relation to Cereal and Forage Crops (Farmers' Bulletin 733), with Control Measures.
Clover Leafhopper and Its Control in Central States. (Farmers' Bulletin 737.)
Cutworms and Their Control in Corn and Other Cereal Crops. (Farmers' Bulletin 739.)
Alfalfa Weevil and Methods of Controlling It. (Farmers' Bulletin 741.)
Grasshopper Control in Relation to Cereal and Forage Crops. (Farmers' Bulletin 747.)
Fall Army Worm, or Grass Worm, and Its Control. (Farmers' Bulletin 752.)
How to Detect Outbreaks of Insects and Save the Grain Crops. (Farmers' Bulletin 835.)
Bollworm or Corn Earworm. (Farmers' Bulletin 872.)
Rough-Headed Corn-Stalk Beetle in Southern States and Its Control Farmers' Bulletin 875.)
Corn-Root Aphis and Methods of Controlling It. Farmers' Bulletin 891.)
Common White Grubs. (Farmers' Bulletin 940.)
Controlling the Garden Webworm in Alfalfa Fields. (Farmers' Bulletin 944.)
Southern Corn Rootworm and Farm Practices to Control It. (Farmers' Bulletin 950.)
Controlling the Clover-Flower Midge. (Farmers' Bulletin 971.)
Control of the Green Clover Worm in Alfalfa Fields. (Farmers' Bulletin 982.)
How to Control Billbugs Destructive to Cereal and Forage Crops. Farmers' Bulletin 1003.)
Wheat Jointworm and Its Control. (Farmers' Bulletin 1006.)
Larger Corn-Stalk Borer. (Farmers' Bulletin 1025.)
European Corn Borer: A Menace to the Country's Corn Crop. (Farmers' Bulletin 1046.)
Hessian Fly and How to Prevent Losses from It. (Farmers' Bulletin 1083.)
Alfalfa Caterpillar. (Farmers' Bulletin 1094.)
Grasshopper Control in the Pacific States. (Farmers' Bulletin 1140.)
Spraying for the Alfalfa Weevil. (Farmers' Bulletin 1185.)
Western Corn Rootworm. (Department Bulletin 8.)
Alfalfa Caterpillar. (Department Bulletin 124.)
New Mexico Range Caterpillar and Its Control. (Department Bulletin 443.)
Studies on the Life History and Habits of the Jointworm Flies of the Genus Harmolita, with Recommendations for Control. (Department Bulletin 808.)
The Clover and Alfalfa Seed Chalcis Fly. (Department Bulletin 812.)
Western Grass-Stem Sawfly. (Department Bulletin 841.)
Clover-Stem Borer as an Alfalfa Pest. (Department Bulletin 889.)
Clover-Leaf Weevil. (Department Bulletin 922.)
Clover Mite. (Entomology Circular 158.)
Slender Seed-Corn Ground Beetle. (Entomology Bulletin 85, Part 2.)
Clover-Root Curculio. (Entomology Bulletin 85, Part 3.)
Contributions to Knowledge of Corn-Root Aphis. (Entomology Bulletin 85, Part 6.)
Range Crane Flies in California. (Department Circular 172.)

UNITED STATES DEPARTMENT OF AGRICULTURE

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United States Department of Agriculture

Insect and Fungous Enemies of the Grape

THE present paper treats of important insect and fungous enemies of the grape in the United States, and gives for each the methods of control at present known to be most effective. There is also given at the close of the bulletin a schedule of applications of combined insecticides and fungicides which, if carried out according to directions, will insure a high degree of protection from the various insect and fungous troubles of the grape. Commercial vineyardists, for the most part, follow some schedule of applications, though in many instances sufficient attention is not given to thoroughness or timeliness in treatments.

In the case of grapes grown principally for home use, or on a small commercial scale, there is each year a large loss in the aggregate from failure of owners properly to spray their vines. The spray schedule should be especially useful to these individuals, and if carefully followed will materially increase the quantity of fruit obtained.

Vineyards, however, should not be sprayed so near ripening time of fruit that there will be left on the berries at harvest a noticeable amount of spray residue. Thorough applications early in the season as indicated in the schedule of treatment (p. 74) will obviate the necessity of later treatments with consequent discoloration of the fruit with the spray mixture.

CORRECTION SLIP FOR FARMERS' BULLETIN 1220.

Page 5: This illustration shows the feeding marks of the grape rootworm beetle and should be figure 43.

Page 6: The cuts of figures 3 and 4 should be transposed.

Page 41: This illustration shows cocoons of the grape-berry moth and should be figure 2.

INSECT AND FUNGOUS ENEMIES OF THE GRAPE.

A. L. QUAINTANCE, *Entomologist in Charge, Fruit Insect Investigations, Bureau of Entomology,* and C. L. SHEAR, *Pathologist, Fruit-Disease Investigations, Bureau of Plant Industry.*

CONTENTS.

INSECT ENEMIES.

THE INSECT ENEMIES of the grape in the United States important at the present time are native American species, feeding originally, even as now, on various wild species of grapes and related plants. When vineyards were planted and the grape-growing industry extended, many species attacked the cultivated varieties and some few have become exceedingly troublesome pests. Perhaps no horticultural crop so well illustrates the serious loss which may result from native species of insects attacking cultivated varieties of their natural wild food plants as does the grape.

Of the large list of species of insects known to feed on the grape in the United States those treated herein include the ones of principal importance. Several of these species in certain sections rank as first-class pests, such as the grape rootworm, grape-berry moth, grape curculio, grape leafhopper, grape leaf-folder, grapevine flea-beetle, rose-chafer, grape phylloxera, and the like. Some of the species treated are ordinarily not important except during occasional seasons, or more or less locally, but are nevertheless the subject of considerable inquiry each year.

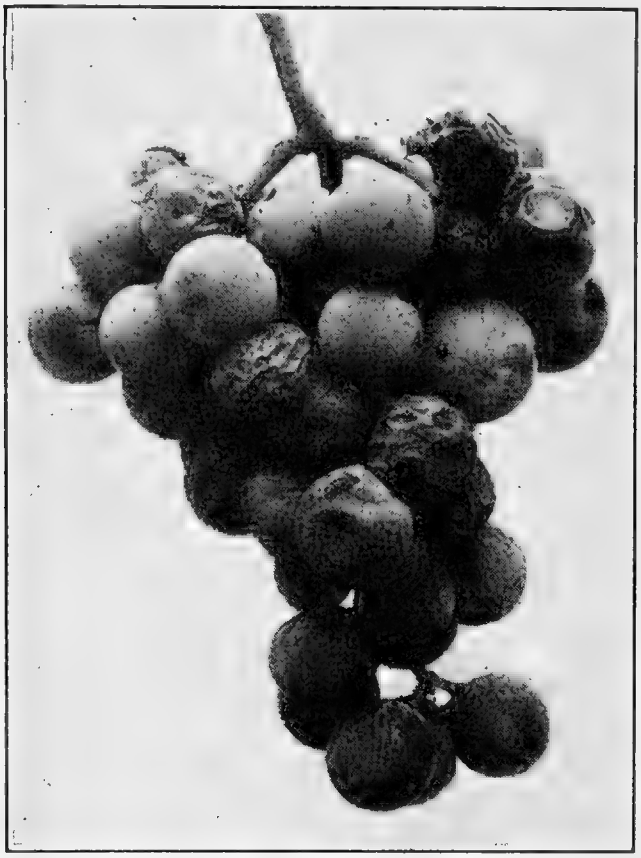

FIG. 1.—Grapes injured by grape-berry moth larvæ.

Grape insects are not less amenable to treatment than insect pests of other fruit crops, and the vineyardist may confidently expect to keep them under control by the application of the remedies herein recommended. As the reader will learn in the following pages, the principal insect and fungous enemies of the grape may be controlled with material reduction of cost by timely and thorough applications of a spray in which are included one or more insecticides and a fungicide. As in the control of most other insect pests, cultural methods are of very great importance. Vines kept in a vigorous and healthy condition by cultivation and fertilization are better able to withstand insect attack than those growing under conditions of neglect.

INSECTS ATTACKING THE FRUIT AND BLOSSOMS.

THE GRAPE-BERRY MOTH.[1]

The larva of the grape-berry moth infests the berry or fruit of the grape. The first generation attacks and webs together the grape clusters, even before the blossoms open, or soon after the grapes are set. Later appearing larvæ bore into the green or ripening fruit, often producing purplish spots, much resembling in appearance the injury due to the black-rot fungus. Within the fruit the larva feeds on the pulp and seeds, passing from one grape to another, and several discolored and shriveled berries will often be found more or less webbed together with particles of larval excrement and sticky with exuding grape juice (fig. 1).

[1] *Polychrosis viteana* Clemens.

The insect occurs from Canada south to the Gulf and westward to the Great Plains States. It has been reported in injurious numbers in New York, Pennsylvania, Ohio, Illinois, Missouri, Maryland, Texas, Virginia, and Canada. It is rather chronically troublesome in northern Ohio vineyards, as a result probably of a combination of causes. The extensive cultivation of the late maturing variety, Catawba, favors the development of the second brood of larvæ, which are mostly able to mature and find winter quarters in and around the vineyard before the crop is harvested. The practice in this region of plowing the earth to the vines in late fall and plowing it away again in the spring is a procedure that best insures the successful hibernation of the insect by covering up the pupæ in the leaves under the trellises; also the system principally employed for training the vines—namely, the fan system—is less favorable to the thorough application of sprays than are systems of training mostly in vogue in the Erie-Chautauqua grape belt. In the latter region the occurrence of this insect in seriously injurious numbers is more sporadic and local; nevertheless the amount of injury occasioned by it is on the average quite important. It appears that in the commercial grape-growing districts of Michigan, as in the neighborhood of Benton Harbor, Paw Paw, and Lawton, the grape-berry moth has not thus far proved to be of importance. Neither is the insect known to occur in the vineyard areas of California.

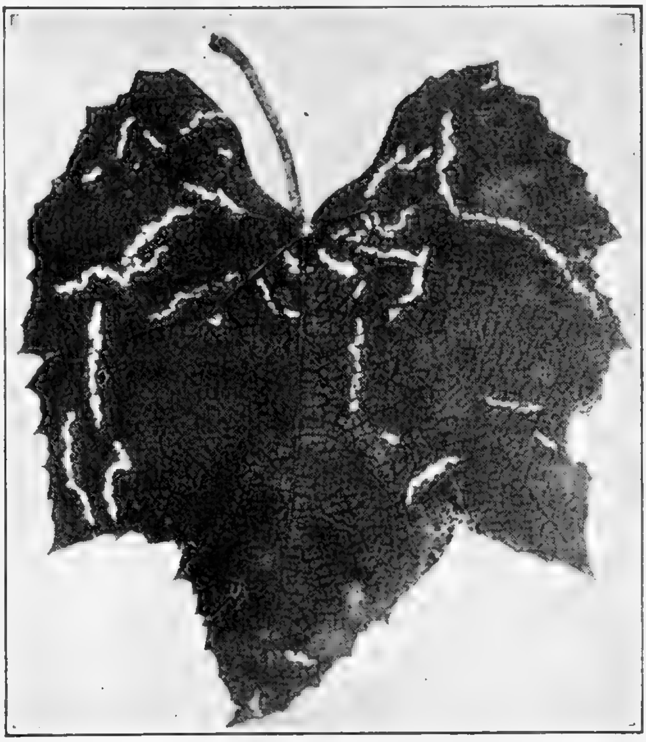

FIG. 2.—Cocoons of grape-berry moth as found on fallen grape leaf.

LIFE HISTORY AND HABITS.

The insect passes the winter in the pupal condition in fallen grape leaves in the vineyard (fig. 2). Most of the insects occur in the damp and decayed leaves along the rows of vines rather than in the drier leaves, which are blown readily here and there by the wind. Moths (fig. 3) from hibernating pupæ begin to appear in the spring when the shoots of the grape are well out, and continue to emerge for some weeks. The earlier appearing moths deposit their eggs on the blossom clusters, while those emerging after the blossoms are shed oviposit mostly on the clusters of young grapes. The minute scale-like eggs of the first brood are difficult to find, as they are relatively scarce, but they may be readily detected during the late summer and fall as glistening white spots on the surface of the green or ripening berries. Larvæ of the first brood feed upon the blossoms, webbing them together, and by their injury producing a more or less irregular bunch of grapes, or the clusters may be almost entirely destroyed. This brood, however, is usually small, because of the heavy mortality of the insects during the winter.

FIG. 3.—The adult grape-berry moth. Enlarged.

After feeding about three weeks the larvæ attain full growth (fig. 4), go to the leaves and cut loose a small portion which is folded over against the leaf surface (fig. 2), and under this flap a cocoon is made where the pupa stage is passed (fig. 5). In the northern grape-growing areas most of the first or spring brood of pupæ develop to moths the same season, but a few may remain in this stage until the following spring. In the Erie-Chautauqua and northern Ohio grape areas moths of the second, or summer brood, begin to appear about the middle of July, emergence continuing well into the fall, with a heavy emergence during normal seasons the latter part of July. The summer brood of larvæ with the later appearing individuals greatly exceed in numbers those of the spring brood and attack the berries almost exclusively, feeding on the pulp and seeds, passing from one grape to another in the course of their feeding (fig. 6). When full grown the larvæ go to the leaves and construct cocoons under a leaf flap, where the pupa stage is entered and the winter passed. Usually the older leaves are chosen by the larvæ, and as a result the pupæ are most abundant on the earlier dropped leaves under the trellises. These leaves later become more or less covered with other leaves and trash, which act as a protective covering, much enhancing the chances that the pupæ will go through the winter safely.

FIG. 4.—Larva of the grape-berry moth. Enlarged.

CONTROL.

The grape-berry moth can be effectively controlled by thorough, timely sprayings of the vines with arsenate of lead. Two applications of the poison are necessary; the first, three to four days after the blossoms have fallen; the second, when the little grapes begin to touch in the cluster, or about three to four weeks after the first treatment. The spray should be directed against the blossoms or fruit clusters, as these should be thoroughly coated to insure destruction of the larvæ. The poison is used at the rate of 1½ pounds of the powder or 3 pounds of the paste to each 50 gallons of spray. Where smaller quantities are desired, the poison is used at the rate of 2.4 ounces of the powder, or 4.8 ounces of the paste, to each 5 gallons of liquid.

Fig. 5.—Cocoon and pupa of grape-berry moth. Enlarged.

It is desirable to apply the poison in the Bordeaux mixture (pp. 68–70), necessary for the control of fungous diseases. If the arsenical is used in water, the milk of lime from 2 pounds of stone lime per 50 gallons should be added. One pound of rosin fish-oil soap to each 50 gallons of spray adds much to its adhesive qualities. Rosin laundry soap may be used if the former kind is not available. Little if any residue will persist on the fruit at harvest time from these two early treatments, and if these are thoroughly made they will, in the experience of the Bureau of Entomology, give

Fig. 6.—Grape berry infested by larva of grape-berry moth. Enlarged.

as good results as if additional applications were made with consequent danger of spray residue on the fruit at harvest time. On vines where the grape leafhopper is troublesome, there should be added to the second spray 40 per cent nicotine sulphate at the rate of ¼ pint to each 50 gallons, or about ½ fluid ounce to each 5 gallons of spray. (See p. 65.)

In commercial vineyards the arsenate of lead is generally used in Bordeaux mixture and the so-called trailer method of spraying (fig. 76) is recommended. This plan merely consists in the employment of two leads of hose with short spray rods to be handled by men on the ground, thus permitting much more thorough application of the liquid than by a fixed nozzle system. On pages 74–75 a schedule for the season of spraying grapes is given, which under ordinary conditions will afford maximum protection from important grape insects and diseases.

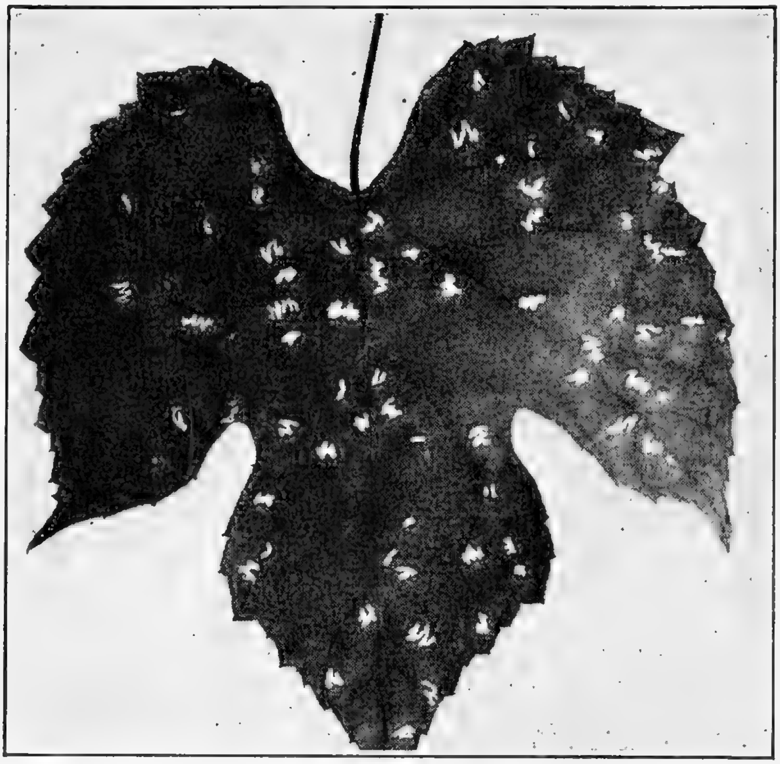

FIG. 7.—Feeding marks of grape curculio on grape leaf.

In the home vineyard it will often be practicable to rake up and burn the earlier falling leaves, thus destroying many grape-berry moth pupæ. Commercial vineyards should be so treated as to leave the fallen foliage under the trellises as much exposed to the weather as possible. From the grape-berry moth standpoint, fall plowing of the earth to the vines is undesirable as covering and protecting the hibernating pupæ under the trellises.

THE GRAPE CURCULIO.[2]

The grape curculio periodically attracts attention on account of the injury it does to the grape which in some localities has been quite severe. Important losses have been noted as occurring in Ohio, West Virginia, Illinois, Kentucky, and Arkansas. It occurs from New England south to Florida, and westward to Minnesota, Missouri, and Arkansas.

[2] *Craponius inaequalis* Say.

LIFE HISTORY.

The adult beetles appear to feed exclusively upon grape, wild and cultivated. They appear in vineyards in the spring about the time the Concord grape is in blossom, and spend 10 days or two weeks feeding on the foliage before beginning egg laying. The feeding marks are characteristic and occur on the upper surface of the leaves as short, somewhat curved lines, usually in groups, as shown in figure 7. The presence of this insect in vineyards can be detected best by these feeding marks on the leaves.

Eggs are placed singly in little cavities cut into the fruit (fig. 8), and the resulting larvæ bore into the flesh, feeding also on the seeds (fig. 9). After about three weeks the grubs have attained full growth and go to the ground, where they construct little earthen cocoons from which the parent beetles emerge in the course of three or four weeks. After emergence the new brood of beetles feed on grape foliage until the approach of cold weather, when they seek shelter under trash of various kinds and hibernate until the following spring.

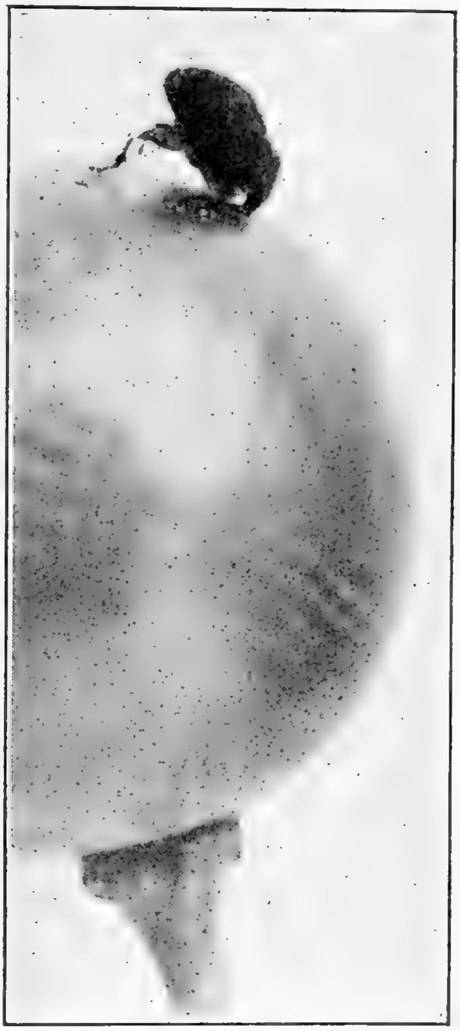

FIG. 8.—Grape curculio in act of excavating egg cavity on grape berry. Considerably enlarged.

CONTROL.

Because this insect feeds on the upper surface of grape leaves for some time before egg laying, it can be successfully controlled by arsenical sprays, such as arsenate of lead. Several times practically complete freedom from this pest has been obtained by the use of this poison at the rate of 1½ pounds of the powder or 3 pounds of the paste to each 50 gallons of water or Bordeaux mixture. The first application is given just after the blossoms fall and the second three or four weeks later. Vineyards sprayed according to the grape-spraying schedule (p. 74) will be practically free from attack by the grape curculio.

THE GRAPE BLOSSOM MIDGE.[3]

The grape blossom midge is a rather recent addition to the list of American grape pests, having been first recognized in 1904 in the

[3] *Contarinia johnsoni* Slingerland.

vicinity of Westfield, N. Y. It has since been found rather generally over the Erie-Chautauqua grape belt, and in 1919 was present in injurious numbers in certain vineyards in the vicinity of Sandusky, Ohio. It is likely to spread gradually over the country except as limited by climatic and other factors. Early varieties of grapes, such as Moore Early and Worden, are most subject to attack, whereas the Concord, Niagara, and other later blooming sorts principally grown in the commercial grape districts in the East, largely escape injury. This insect is a near relative of the gall-making gnats or midges discussed under the caption of "Fly gall-makers" (pp. 30–33).

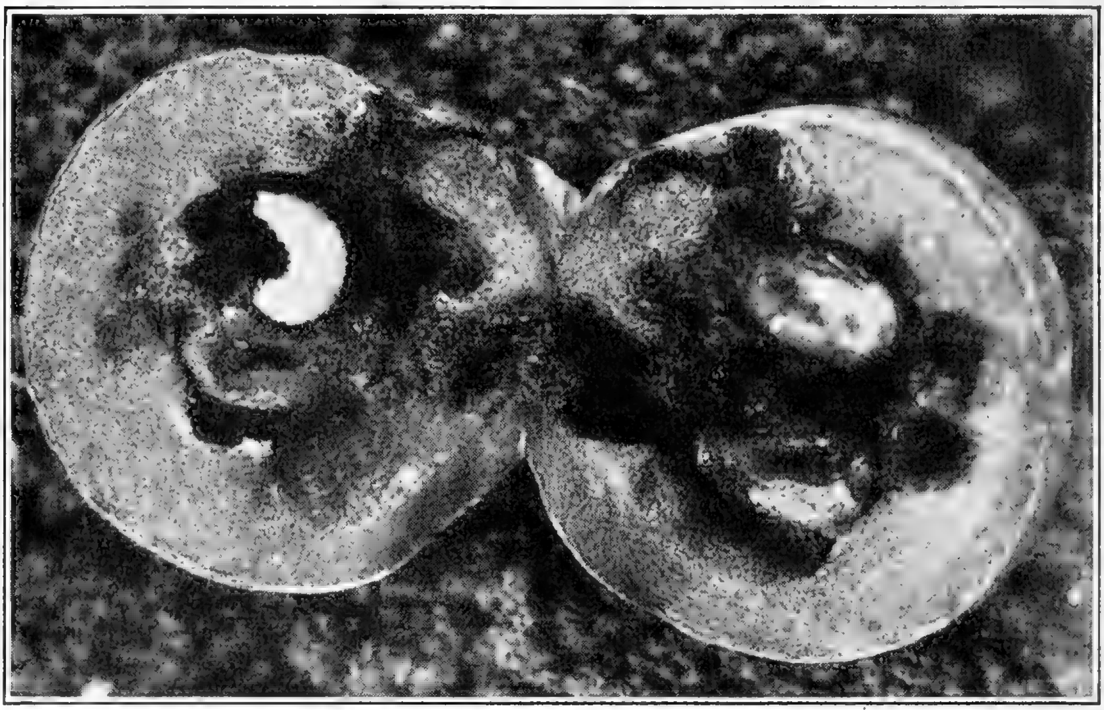

FIG. 9.—Grape berry infested by larva of grape curculio. Considerably enlarged.

LIFE HISTORY.

The damage is done by the larvæ or maggots, which infest the unopened buds, causing these to shed, and thus thinning the bunches of grapes. Infestation is indicated by the enlarged size of the buds which often become two or three times larger than uninfested adjacent buds (fig. 10). The number of larvæ in a given bud will vary greatly from a few to as many as 70, and the destruction of buds may reach as high as 60 per cent.

In the Erie-Chautauqua region, the adult fly or midge comes from the ground the latter part of May, at which time the blossom buds of early varieties are more or less spread at the apex. By means of a long flexible ovipositor, the female places its eggs within the buds, and in a few days these hatch into whitish maggots. After about two weeks of feeding the maggots are grown, at which time they are mostly of an orange or reddish color. The buds are then deserted, the larvæ burrowing beneath the soil where they construct cocoons in which they remain until the following spring. Pupation begins in late April, the adults emerging in time to deposit eggs in the earlier blooming varieties of grapes.

One very important chalcid parasite[4] has been reared from the grubs, as well as from those of the Catalpa midge, and is probably of considerable importance in keeping the insect in check. Unfortunately no very effective control measures for this insect are known. Experiments made by the Geneva, N. Y., Agricultural Experiment Station indicate that a nicotine extract sprayed over the plants will aid in reducing the number of eggs deposited.

FIG. 10.—Grape blossom cluster infested by maggots of grape blossom midge. Much enlarged.

THE GREEN JUNE BEETLE.[5]

The green June beetle is frequently complained of locally as destroying bunches of ripened or nearly ripened grapes. It attacks also other fruits, as peaches, plums, pears, figs, etc., and corn when in a milky condition. The insect occurs throughout the Southern States and along the Atlantic coast to about the region of southern New York. In the Southwest it is replaced by a related form with similar life history. The green June beetle, or fig eater, as it is called in the South, is dull green in color, more or less brownish on the sides. The females are somewhat larger than the males, averaging about an inch in length. The beetles appear when early sorts of grapes, peaches, etc., are ripening, often in large numbers, as 15 to 20 beetles to a single bunch of grapes, which may be quickly destroyed, only the empty hulls remaining (fig. 11). When disturbed the beetles fly away with a buzzing noise, some falling downward, others darting away above the vines.

The parent beetle lays her eggs in the soil and the young grubs burrow freely through the earth, feeding on decaying vegetable matter. There is only one generation each year, the winter being passed in the immature larva stage, growth being completed the following spring. The prevalence of this pest is thought to be connected with the occurrence adjacent to vineyards of decaying vegetable matter, as composts and old stable manure, or land which has

[4] *Zatropis catalpae* Crawford. [5] *Cotinis nitida* L.

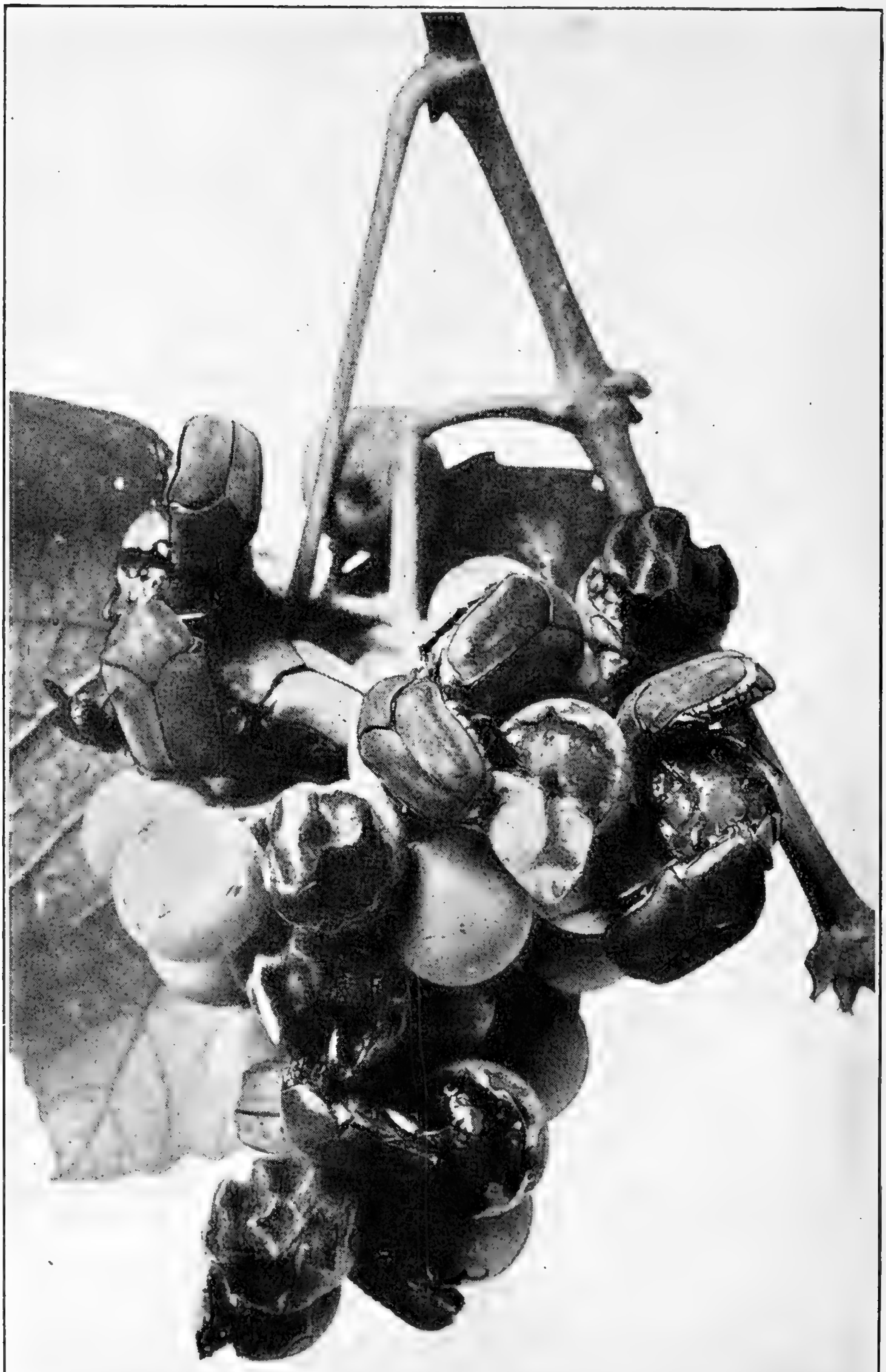

FIG. 11.—Green June beetles and their injury to grapes.

been heavily manured. An excessive quantity of humus in the soil is thought greatly to favor the insect.

CONTROL.

The use of poison sprays on ripening fruit is impracticable and other methods must be employed. Bagging the fruit when it begins to color and allowing the bags to remain in position on the bunches until gathered has been employed with much success and is worth while in localities where damage is to be expected more or less each year. Considerable benefit follows systematic hand picking of beetles or knocking them from the vines into a pail of water bearing a film of kerosene. This work is best done in the morning, when the insects are more sluggish than during the heat of the day. Whenever practicable, piles of compost and unusual quantities of humus on the soil should not be allowed in the neighborhood of vineyards.

BEES.

Frequent complaint is received from vineyardists of the destruction of the fruit by bees, and numerous actions in court have been taken against owners of colonies of bees to recover for loss of fruit supposed to have been destroyed by these insects.

Experiments by entomologists and others have proved conclusively that honeybees can not break the skin of sound grapes with their mouthparts. Bees confined with bunches of sound grapes will die of starvation. Where the skin of the grape has been broken, however, as by other insects or fungous diseases, bees attack the berries at the injured places and may quickly reduce the fruit to a worthless condition. Injury by bees is best avoided by protection of the fruit from insects and diseases which interfere with its soundness. In the absence of spraying, fruit in danger of attack by bees can be protected by bagging the bunches after the fruit is well set, or shortly before ripening begins.

INSECTS INJURING THE FOLIAGE AND BUDS.

THE GRAPE LEAFHOPPER.[6]

Throughout the United States and Canada wherever the grape is grown, the grape leafhopper will almost invariably be found in greater or less numbers infesting the lower surface of the leaf, where it feeds and breeds, increasing in numbers as the season progresses until by late summer and fall the vines are often literally swarming with it. Over its extended range the insect every year may be quite destructive in one or more localities, or it is likely to become so at any time. The grape leafhopper is an insidious pest usually not

[6] *Typhlocyba comes* Say.

noticed by the vineyardist until late summer and fall when the yellow and brown-blotched leaves fall prematurely, by which time the injury has been done. The insects in feeding extract large quantities of liquid food, sucking it from the leaf by means of piercing mouthparts. Often feeding constitutes a heavy drain on the vitality of the plant. The injury to and loss of leaves prevent the proper assimilation of food by the vines; and the fruit may be materially reduced in size and may lack much in flavor and sugar content (fig. 12). Although the annual loss of grape growers from this species is enough to place it among the first-class pests of the vine, it is only comparatively recently that systematic efforts have been made to control it in some of the important grape-growing regions. There are numerous records of its injury in the Erie-Chautauqua grape region during the past two decades and growers in that region probably more generally treat vineyards for the control of this pest than elsewhere. In California it is stated to be, next to the phylloxera, the most important of all insect pests of the vine.

Fig. 12.—Defoliated condition of grapevine by late summer from attack of grape leafhopper.

LIFE HISTORY AND HABITS.

The grape leafhopper is quite small, measuring not over one-eighth of an inch in length, and is very agile, moving with equal facility in all directions. It flies out from the vines often in swarms on slight disturbance. In general appearance it is light yellow, with deeper yellow or red markings, the exact pattern and color varying much among the different individuals and according to season (fig. 13). There are numerous varieties of the insect as based on these variations. The winter is passed by the adults in hibernation in trash in and near vineyards, in the edges of neighboring woods, in grass along gullies, in ditches, etc. Early in the spring the insects come from winter quarters and attack almost any succulent vegetation at hand. By the time the foliage of the grape is well out, they are out in numbers and infest the vineyards. The adult hoppers of the hibernating generation feed and breed on the lower or early appearing grape leaves, gradually disappearing as the season progresses, but not before some of their progeny have reached the adult condition. Eggs are placed just beneath the epidermis in the lower leaf surface, usually singly, but also in groups. When just hatched the young hopper or nymph is very small, whitish in color, with red eyes, later becoming striped with yellow. The nymphs (fig. 13, *c*) feed in the same manner as the parents, sucking juice from the leaves, at first from the lower surface of the older leaves where they were born

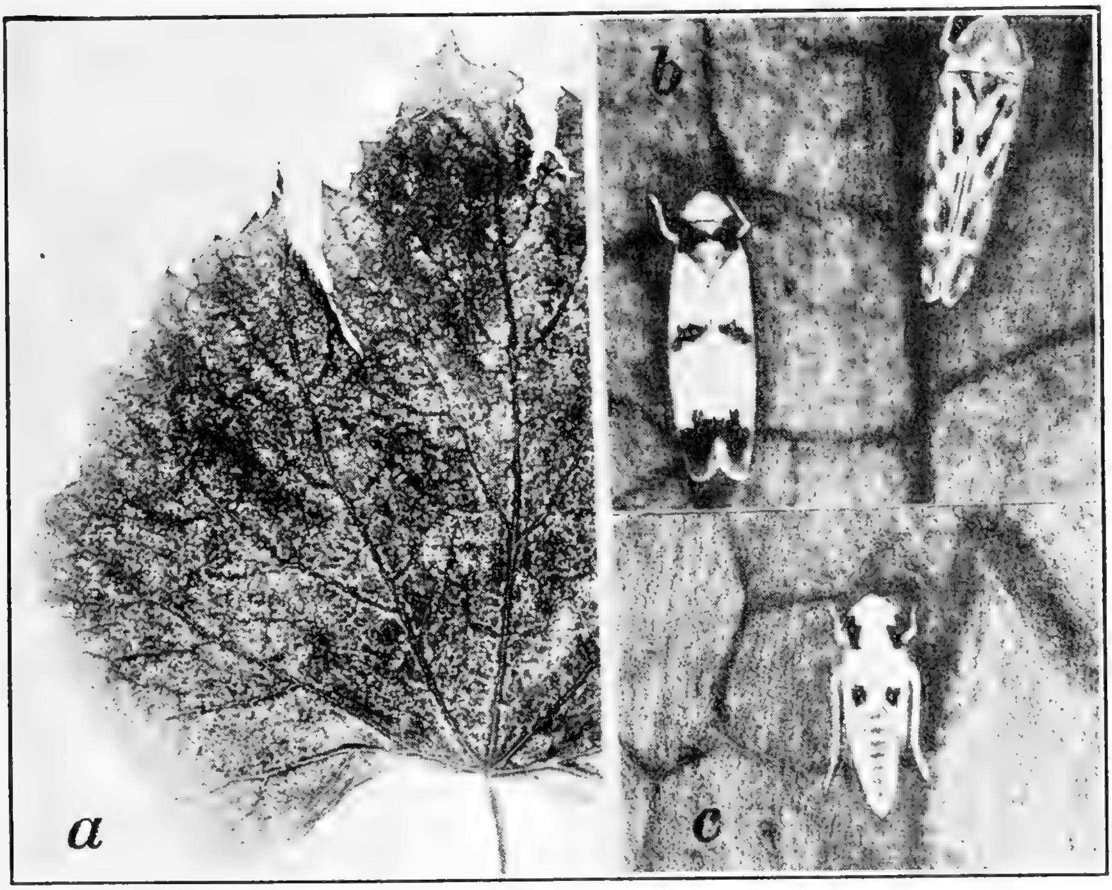

FIG. 13.—Grape leafhopper: *a*, Mottled appearance of injured grape foliage; *b*, the adult hopper; *c*, nearly full-grown nymph.

but later spreading more or less generally over the plant. They are very agile, running in all directions, but do not leap or hop. In the course of their growth they molt several times, and the cast skins are usually in evidence in numbers on the lower surface of infested leaves (fig. 14).

In the northern States there is each year one full brood of nymphs and a partial second, the extent of the second varying according to season. Farther south the second generation is doubtless complete, with perhaps a third in some sections. By late summer and fall the insect is often exceedingly abundant, and all stages are to be found together on the leaves continuously until the approach of cold weather, when the adults seek suitable hibernation quarters as described.

CONTROL.

Extensive tests of sprays by the Bureau of Entomology and others in the East have shown conclusively that the grape leafhopper can be controlled by a single application of a spray of dilute nicotine, such as nicotine sulphate containing 40 per cent nicotine. The nicotine sulphate is used at the rate of approximately one-fourth pint to each 50 gallons of spray, and in general it may be added to the Bordeaux mixture and arsenate of lead spray, employed for the treatment of other grape insects and diseases, as described in the spraying schedule (p. 74). Where the leafhopper is especially troublesome

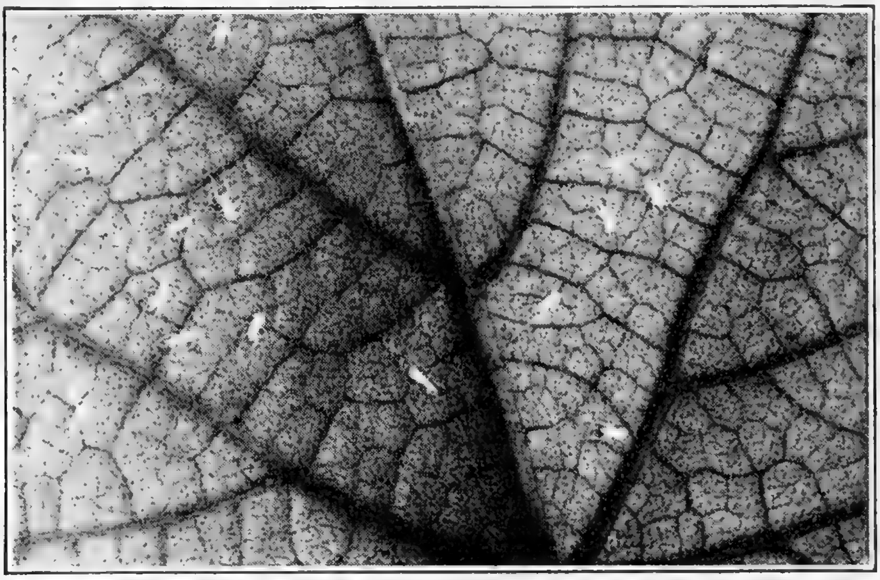

FIG. 14.—Grape leafhopper. Cast skins of nymphs on undersurface of grape leaf.

it should be promptly treated when the nymphs are in the proper stage of growth (see fig. 12, *c*), even if an extra treatment is necessary. It is essential to direct the spray against the nymphs on the lower surface of the leaves, and fairly coarse nozzle disks should be used, as a fine mist spray does not wet the insects sufficiently to kill them. The so-called trailer method (p. 72) of spraying has been found best to secure effective results, though in fairly level vineyards a system of nozzles mounted on swinging booms, developed by the Geneva, N. Y., Agricultural Experiment Station, has been employed with success. When treating only this insect, as may often be the case in California, the nicotine sulphate may be used in water, but there should be added rosin fish-oil soap, at the rate of 1 pound to 50 gallons of water, to improve the spreading and adhesive qualities of the liquid.

It is of the utmost importance that the first treatment be made at a time when the first-hatched nymphs are near the last molt and before they have developed wings. This will insure the destruction of the maximum number of the still younger insects. This time can be determined by examining the hoppers on the lower surface of the leaves. The earliest full-grown nymphs at this time will have the wing pads

FIG. 15.—Showing excellent condition of foliage and fruit as a result of spraying for the grape leafhopper.

reaching nearly or quite one-half the length of the body (fig. 12, *c*). For the Erie-Chautauqua grape belt this will be in ordinary seasons during the second and third weeks of July. One thorough, forceful spraying will so check the insects that further applications will be unnecessary. In fact, later applications have relatively little value, owing to the presence of many adults, which fly from the plants upon the least disturbance.

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It is entirely practicable to use the nicotine spray on vines growing around the home, using the nicotine sulphate at the rate of about one-half fluid ounce to each 5 gallons of soapy water. Spraying for the leafhopper when the leaves are yellow and brown, as in late summer and early fall, will not be profitable. In localities where this pest is usually troublesome careful watch should be kept in late spring or early summer of the older lower leaves and the spray applied before the first-brood nymphs attain wings, as above indicated. The injurious effect of the grape leafhopper in causing the shedding of the leaves is shown in figure 12, and the benefits resulting from the control of this pest by the nicotine spray are shown in figure 15. The destruction by burning, in the fall and early spring, of weeds and grasses growing along ditches, fences, and hedgerows, or around vineyards, will be highly advantageous as removing suitable hibernating quarters of the insect.

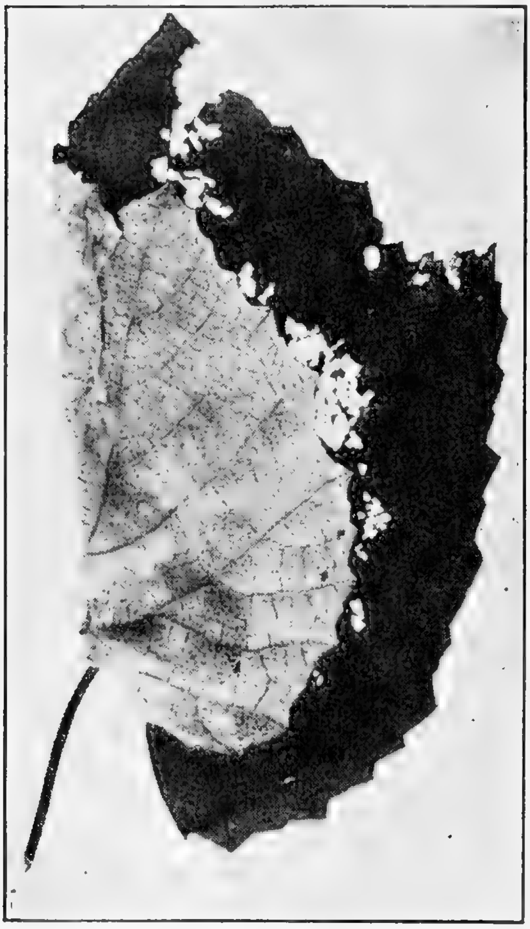

FIG. 16.—Injury by grape leaf-folder to grape leaf.

THE GRAPE LEAF-FOLDER.[7]

During midsummer and early fall the work of the grape leaf-folder is often in evidence on vines growing around the home, or in vineyards not regularly sprayed with arsenicals. The caterpillar folds the lower surface of the leaf over against the upper surface (fig. 16) and when they are abundant the lighter color of the lower leaf surface readily indicates their presence, even though the observer is some distance from the vines. Within the folded leaf the active slender larva feeds upon the interior (upper) surface of the leaf, eating out the soft tissues, leaving the veins and veinlets fairly well intact. Sometimes the grape blossoms are eaten by the caterpillars, but this is unusual. This injury causes many of the leaves to fall and prevents the proper ripening of the fruit.

The insect is widely distributed over the United States and a few are to be found in vineyards in any locality almost every year. During some seasons or for a series of years it may be quite abundant locally and require treatment.

[7] *Desmia funeralis* Hübner.

The insect winters in the pupa stage in the folded and fallen leaves, the moths appearing shortly after foliage puts out in the spring. Eggs are laid on the leaves and the larvæ soon begin to fold the leaves as described. In California, this insect on vinifera grapes is said to roll the leaves rather than fold them. In about a month after hatching the caterpillars are full grown and are grass green in color and about three-fourths of an inch in length (fig. 17). The pupa (fig. 18) is brown in color, about one-half inch long. This stage lasts for about a week or 10 days, and then the moth appears. In the adult stage the insect is rather striking in appearance (fig. 19), the wings expanding about an inch. The wings are dark brown or nearly black in color, with a narrow white band and with conspicuous white spots, varying according to the sex. There are two broods of larvæ each season and perhaps a third in the South. In the Middle and Northern States it is the second brood which is principally injurious.

FIG. 17.—Grape leaf-folder larva as exposed by opening folded leaf. Enlarged.

FIG. 18.—Pupa of grape leaf-folder. Enlarged.

CONTROL.

In vineyards regularly sprayed with arsenicals for other grape pests the grape leaf-folder will rarely, if ever, cause important injury. In vineyards and on vines much subject to attack, pains should be taken to spray the plants with arsenate of lead when the first signs of the folded leaves are noticed. An additional application in a week or 10 days is desirable in case the insect has been seriously troublesome during preceding years. In small plantings it will be practicable to destroy the larvæ by crushing them within the folded leaf by hand.

THE ROSE-CHAFER.[8]

About the time of blooming of grape in the spring the rose-chafer may suddenly put in an appearance, often in enormous numbers, the long, spiny-legged, awkward, brown beetles (fig. 20) literally covering the plants, feeding at first on the blossoms, but later attacking the young fruit and foliage, the leaves being eaten bare except the

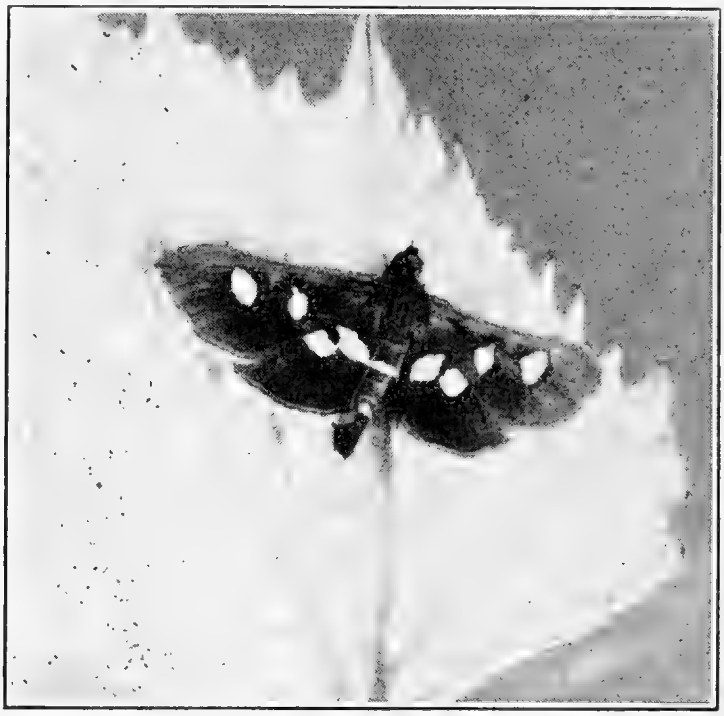

FIG. 19.—Grape leaf-folder moth. Enlarged.

larger veins (fig. 21). Injury to the young grapes often results in their cracking as they grow, the seeds sometimes protruding. This insect is a very general feeder, attacking practically all fruits, such as the apple, plum, cherry, peach, and many ornamentals like Spiræa, Deutzia, and roses. On this last-mentioned plant it is especially severe when abundant, and hence the common name of rose-chafer. After three or four weeks of feeding the beetles may disappear as quickly as they came.

This pest is widely distributed and occurs from Canada and Maine south to Virginia and Tennessee, and west to Oklahoma and Colorado. Light, sandy soils are favorable breeding grounds for the insect and vineyards in regions of clay soils are usually not seriously troubled by it.

[8] *Macrodactylus subspinosus* Fab.

LIFE HISTORY.

The beetles appear early in June, the date varying according to locality and season. Soon after mating feeding begins and continues for from 3 to 4 weeks. Eggs are deposited singly a few inches below the surface of the soil and hatch in two or three weeks. The young grubs feed on the tender rootlets of grasses and other vegetation and become nearly full grown by fall. With the appearance of cold weather they go deeper in the soil, each larva forming a hibernation cell, where they remain until spring, when they go near the surface and may feed more or less. In April or in early May or later, according to latitude, the grubs change to pupæ, and finally adults, about the time the grapes are in bloom. There is but one generation of the insect each year.

Fig. 20.—The rose-chafer on grape blossom cluster. Enlarged.

CONTROL.

Experiments made by the Bureau of Entomology in the grape belt of the Lake Erie Valley indicate that considerable protection of vineyards from rose-chafer injury may be obtained by timely and thorough use of arsenical sprays, the amount of benefit varying with the abundance of the insects. Since the use of poison sprays at the time of rose-chafer invasion is desirable for the control of other grape pests, such as the grape-berry moth, grape flea-beetle, and root-worms, vineyards in sandy regions and subject to rose-chafer attack should be sprayed regularly for this insect as a part of the routine of vineyard spraying.

Arsenate of lead is principally used at the rate of $2\frac{1}{2}$ to 3 pounds of the powdered form to each 50 gallons of liquid. The poison preferably should be used in Bordeaux mixture, essential for the control of fungous diseases. The first application of spray should be given just before the blossoms open, and if the beetles continue destructive the treatment should be repeated as soon as the blossoms have fallen.

FIG. 21.—Grape foliage severely injured by rose-chafer.

Some vineyardists have reported benefit from addition of glucose or molasses to arsenate of lead as rendering the spray attractive to the beetles. Experiments by the Bureau of Entomology have not shown added protection to vines so treated.

According to experiments by the New Jersey Agricultural Experiment Station, the self-boiled lime-sulphur wash (p. 66) thoroughly sprayed over the vines protects them from further important injury by this insect. The wash has been used with equal success in preventing injury to apply, cherry, and peach. Application should be made upon the first appearance of the beetles in numbers.

The old-fashioned remedy of hand picking is of service in protecting grapes growing around the home. The beetles may also be jarred from the plants onto sheets saturated with kerosene. These methods are tedious and must be practiced daily in the early morning or toward sundown to be effective. Choice plants may be securely protected by covering with netting or other suitable material.

In addition to the use of any of the methods described above, considerable can be done by destroying the insects in their breeding grounds. In the pupa stage they are so extremely sensitive to disturbance that stirring of the soil, as by cultivation, would doubtless be fatal to a great many of them. The plowing should be done to a depth of 3 or more inches, and in the Great Lakes region the time for such treatment will vary from about May 25 to June 10 and earlier in southern and warmer localities. In regions where sandy soils predominate the land in the neighborhood of vineyards should not be devoted to meadows, but planted to crops which require annual plowing and cultivation.

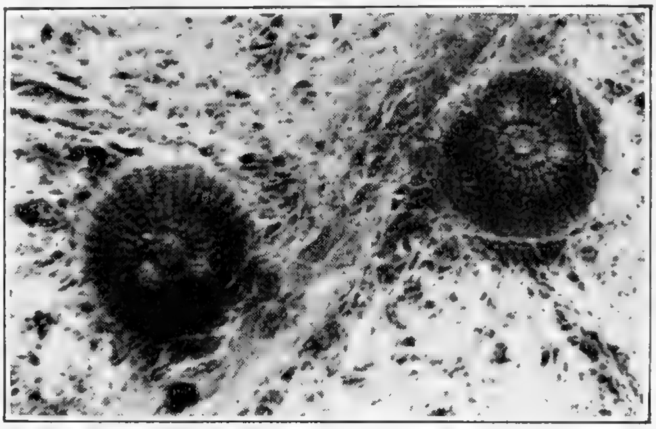

FIG. 22.—Eggs of 8-spotted forester. Greatly enlarged.

EIGHT-SPOTTED FORESTER.[9]

The caterpilllars of the eight-spotted forester moth probably never do injury in commercial vineyards, but are prevalent principally in small unsprayed home plantings. Although the insect is present rather generally over the Atlantic States, its occurrence in injurious numbers is decidedly local. Recently it has been the subject of much complaint in Brooklyn and other points on Long Island, in portions of Connecticut, and elsewhere in that general territory. Injury results from the defoliation of the vines by the caterpillars, and all varieties of grapes are apparently subject to attack. The larvæ feed also on wild grape, barberry, and Virginia creeper, and on this latter plant they are sometimes quite troublesome in parks.

In the Northern States, at least, the insect is single brooded. The moths are out during May and June and deposit their eggs on leaves of the host plant (fig. 22). The eggs hatch in 4 or 5 days, the result-

[9] *Alypia octomaculata* Fab.

ing larvæ feeding voraciously on the foliage, which may be stripped from the plants when the caterpillars are abundant (fig. 23). By August the larvæ are mostly full grown and have disappeared to the ground, where they pupate, remaining in the pupa stage (fig. 24) until the following May or June. Both caterpillars and moths (fig. 24) are rather striking in appearance, and there should be no difficulty in their recognition.

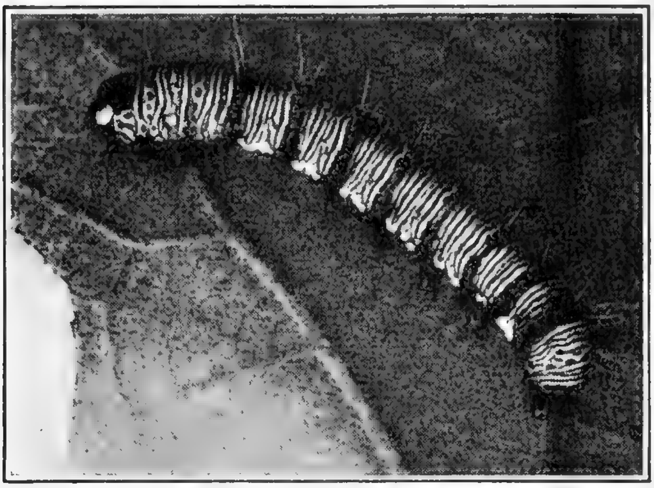

FIG. 23.—Larva of 8-spotted forester. Somewhat enlarged.

CONTROL.

The eight-spotted forester can be readily controlled by the use of arsenical sprays, such as arsenate of lead applied to the plants as soon as injury is first in evidence. The arsenical should be used, preferably in Bordeaux mixture, as described in the spraying schedule (p. 74), or may be applied in water at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water. For small amounts use the powdered form at the rate of about 1.5 ounces to 5 gallons of water.

FIG. 24.—Pupa and moth of 8-spotted forester.

THE GRAPE PLUME MOTH.[10]

During late May and June in the Northeastern States the caterpillars of the grape plume moth frequently attract attention by webbing together the terminal leaves and shoots of grapevines, as well as the blossom clusters (fig. 25). Although distributed over the Atlantic States, it has been the subject of complaint during recent years from New Jersey, southeastern New York, Connecticut, Massachusetts, and Rhode Island.

Within the webbed-up terminal growth, the greenish hairy caterpillars feed upon the leaves and blossoms, causing some loss in yield of fruit. The caterpillars are likely to be prevalent only in vines around the home and will not as a rule do serious damage. The life

[10] *Oxyptilus periscelidactylus* Fitch.

history of this insect is imperfectly known, as its injuries thus far have not been sufficiently important to require its careful study. Hand picking and destroying the webbed leaves with the contained larvæ should keep the insect in check in home plantings. Little, if any, loss from this pest is likely in commercial vineyards.

THE BROWN GRAPE APHIS.[11]

The brown grape aphis infests the tender growing shoots and leaves of the grape and when abundant may occur on the fruit clusters. Its dark brown color and relatively large size render it rather conspicuous (fig. 26), and hence it is the subject of frequent inquiry. The insect is common in the Southern States and ranges to Pennsylvania and New York, and westward to Missouri, Oklahoma, and Texas. It is probably a native species, infesting wild grapes. as well as cultivated sorts. It winters in the egg stage, the eggs being laid in the fall by the female on twigs of black haw. Hatching begins early in the spring and continues for two or three weeks. Young aphids feed on the expanding buds of the haw, and later on the flowers, twigs, and foliage. Migrants or winged individuals fly from the haw to wild or cultivated grapes in the neighborhood, where they establish colonies. The aphids continue to infest the grape throughout the summer, producing sometimes more than a dozen generations, though the colonies may become much decimated by the attack of predatory and parasitic insect enemies. In the fall migrants, which give rise to egg-laying females, return to the haw. The latter deposit the winter eggs.

FIG. 25.—Larva of grape plume moth and its injury to grape shoot. Somewhat enlarged.

This aphid has not thus far attracted much attention in commercial vineyards, but is quite prevalent throughout its area of distribution on vines growing around homes. It can be controlled by spray-

[11] *Macrosiphum illinoisensis* Shimer.

ing the infested vines with a contact insecticide, such as 40 per cent nicotine sulphate, fish-oil soap solution, kerosene emulsion, and the like.

THE GRAPE FLEA-BEETLE.[12]

Early in the spring as they are ready to burst, buds of the grape may be eaten into or entirely scooped out by a small blue or greenish beetle (fig. 27), measuring about one-fifth of an inch in length, of robust shape, with thick thighs, which jumps readily from the vines upon being disturbed. This is the grape flea-beetle. If the beetles are abundant, most of the buds on the vines may be destroyed, greatly retarding leafing out and resulting in a material loss of fruit. The insect is sporadic and more or less local in its occurrence in seriously destructive numbers, and these outbreaks are likely to subside as suddenly as they appear.

FIG. 26.—The brown grape aphis on grape shoots.

The females deposit their eggs largely in cracks in the bark at base of buds, between bud scales, or even in the holes which have been eaten into the buds (fig. 28). The larvæ hatch in a few days and feed on the leaves of the grape, mainly on the upper surface, and are thus readily destroyed with sprays (fig. 29). In three or four weeks, when the larvæ have attained full growth, they drop to the ground, construct an earthen cell an inch or so below the surface, and transform to pupæ, the adult beetles emerging in the course

[12] *Haltica chalybea* Illiger.

of one or two weeks. The new brood of beetles feed upon the foliage of the grape and other plants, going into hibernation in the fall under trash in and around vineyards, appearing the next spring in time to attack the swelling buds of the grape. This flea-beetle is a native species and occurs very generally throughout the eastern half of the United States, its western limits being Minnesota, Nebraska, Kansas, and Texas. In addition to cultivated and wild grapes, it has been reported as feeding on Virginia creeper, plum, apple, pear, quince, blue or water beech, elm, etc.

Fig. 27.—The grape flea-beetle. Much enlarged.

CONTROL.

Vineyards regularly sprayed with arsenicals and Bordeaux mixture for other grape pests are not so likely to be injured by the flea-beetle as are others. The insect thrives best in neglected vineyards, and in these may become quite abundant and destructive. Where it is desired to treat for this insect only, as during outbreaks, the vines should be thoroughly sprayed with an arsenical just as the buds are beginning to swell, or somewhat earlier. A close lookout must be kept for the first signs of the beetles and the poison applied immediately. Delay of a day or so may mean the loss of the buds, and hence serious injury to the fruit crop. In the small home vineyard it will often be practicable to search out the beetles during the morning, when they are sluggish, and remove them by hand. Destruction of the larvæ when feeding on the foliage may be effected by the use of an arsenical, such as arsenate of lead.

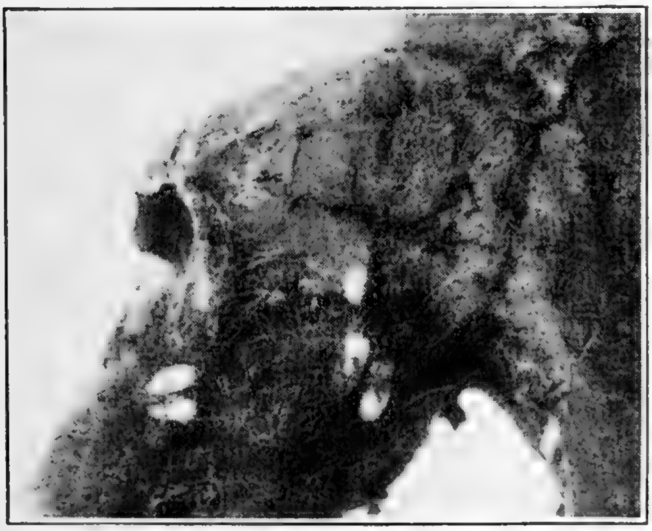

Fig. 28.—Eggs of grape flea-beetle. Much enlarged.

In spraying for the adults, or beetles, the poison should be used stronger than ordinarily—that is, 2 pounds of the powdered arsenate of lead or 4 pounds of the paste to each 50 gallons of spray.

THE GRAPE LEAF SKELETONIZER.[13]

The grape leaf skeletonizer is noted usually on vines grown around the home. Owing to the general spraying of commercial vineyards, it is rarely seen in these and practically never in such abundance as to cause serious injury. The insect occurs rather generally from the eastern United States west to Missouri and Arizona. The larvæ in their earlier stages feed in a characteristic manner, usually upon the upper surface of the leaf. Starting from a common point, the larvæ feed side by side, soldierlike, retreating as they feed until the leaf tissue is destroyed. Young larvæ eat out the parenchyma or soft leaf tissue, leaving the skeleton framework of the leaf intact. Full-grown larvæ, however, consume the leaf substance entirely, leaving only the larger veins (fig. 30). The full-grown larva is a little more than one-half inch in length, sulphur-yellow in color, slightly hairy, and having on each body segment four black tubercles, showing above as four distinct longitudinal rows. It is native to this country, and in addition to grape feeds on various wild plants, including Virginia creeper. The insect winters in the pupa condition in oblong-ovate cocoons in fallen leaves or trash around the vines. Rather late in the spring the moths emerge and deposit small, lemon-yellow eggs in clusters or masses, ranging from a few to over 200, usually on the lower surface of the leaves. The resulting larvæ require some 40 days to complete their growth, and the time spent in the cocoon during the summer is about 10 days. The complete life cycle from egg to the death of moths is about 66 days. Second generation larvæ are present over a considerable period of the summer, and this fact led earlier writers to believe there were two generations and a partial third each year.

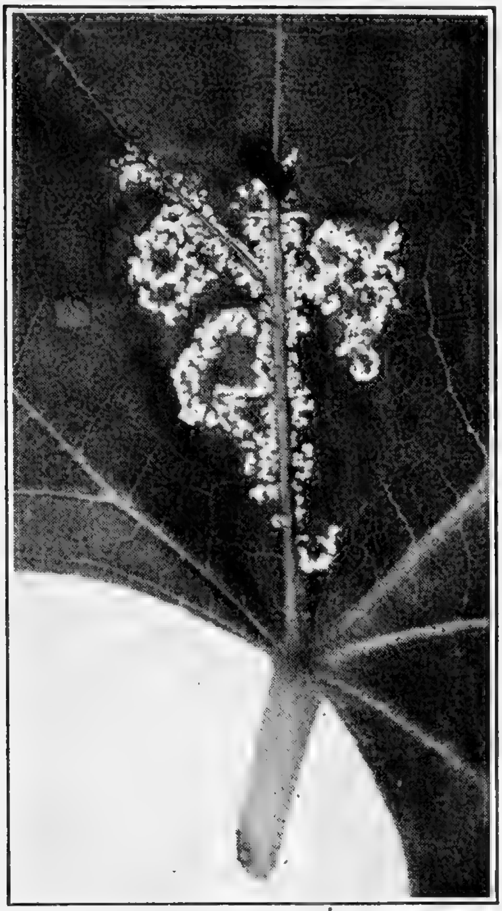

FIG. 29.—Grape flea-beetle larva and its work on grape leaf.

CONTROL.

Under ordinary conditions of abundance, hand picking and destruction of infested leaves will be sufficient to keep the insect in

[13] *Harrisina americana* Guér.

check. When occurring in numbers they can be easily and promptly destroyed by spraying with an arsenical, such as arsenate of lead. (See p. 65.)

CLIMBING CUTWORMS.

Several species of cutworms are known to attack the grape, and instances are recorded of serious damage resulting from their eating out the swelling buds in the spring (fig. 31). Injury of this character has frequently been reported in recent years in portions of the San Joaquin Valley, Calif., especially in vineyards permitted to become more or less grown up with weeds and grasses the preceding fall. The plowing under of such vegetation forces many of the hungry caterpillars to the vines for food, and the buds and foliage are attacked.

FIG. 30.—Larva of grape leaf skeletonizer on grape leaf.

CONTROL.

Cutworms will not as a rule cause important injury in vineyards kept reasonably free from grass and weeds throughout the growing season. When found destructive, poisoned baits should be employed as for the destruction of these insects in gardens. A poisoned bait may be made as follows: Dry bran, 1 peck; white arsenic or Paris green, 4 ounces.

The above is to be mixed thoroughly with 2 gallons of water, into which has been stirred one-half gallon of sorghum or other cheap molasses. After the mash has stood for several hours it should be scattered in lumps the size of marbles over the area where the cutworms are injurious. Apply late in the day, since the larvæ are active at night. For large-scale work the poisoned mash may be made up in any desired quantity according to the same formula.

FIG. 31.—A climbing cutworm and its injury to grape buds.

Grapevines around the home can be protected by fastening around the trunk several inches from the ground a collar of cotton batting or wool, which effectively prevents the larvæ from ascending the vines. The cotton batting may become more or less compacted after heavy rains and its value considerably reduced. This defect can be obviated in a measure by using bands 5 inches wide, tying with a string at the bottom, and turning the upper part of the band down over the lower edge.

A little searching in the soil around the base of vines will often bring to light the larvæ, which can be destroyed.

FLY GALL-MAKERS.

Galls of various kinds occur on the grape as a result of attack of unrelated species of insects, as the grape phylloxera (pp. 45–47), the grape cane gall-maker (p. 39), the vine Erinose, etc. There is a series of galls resulting from the work of small midges, or gnatlike flies, to be found on leaves, tendrils, blossom buds, and blossom clusters, which are sufficiently abundant some seasons to cause considerable injury, though as a rule their importance is not great. These small flies are representatives of a large family of insects which produce galls on many widely different plants. Although numerous species of gall midges attack the grape, the following will serve as examples of these insects and their injuries:

FIG. 32.—Grapevine tomato gall on grape blossom.

THE GRAPEVINE TOMATO GALL.[14]

The grapevine tomato gall with its associate (*Dasyneura vitis* Felt) is probably more complained of than any other attacking the grape. The general appearance of these galls is shown in figures 32 and 33. The irregular, succulent galls occur on wild and cultivated grapes, often in a mass, suggesting at times a group of small tomatoes, and hence the common name. The galls may be on the leaves, leaf stalk, tendrils, or stalks of the fruit clusters. They vary in color from greenish yellow to reddish, the latter color being often the predominant one. When cut open several cells will be found and in each, at the proper time, an orange-yellow larva, the grub or maggot of the parent midge. When mature the grubs escape the galls

[14] *Lasioptera vitis* O. S.

through holes cut to the exterior, and fall to the ground where they change to pupæ and remain until the following spring, the flies developing in time to start other galls on the tender growth.

No practical control for this insect is known. The cutting off and destroying of galls before the grubs have escaped should serve to reduce the attack another season.

THE GRAPE APPLE GALL.[15]

The hazelnut-like grape apple gall occurs on the shoots of the vine. It is somewhat less than an inch in diameter, greenish in color, becoming reddish as the season advances, more or less pear-shaped, and

FIG. 33.—Grapevine tomato gall on grape leaf and tendril.

marked on the outside with depressions extending lengthwise (fig. 34). When cut open it is found to be divided into cells or segments with a cross partition, each cell being occupied by bright yellow larvæ. The gall, succulent when small, later becomes quite hard and woody. Removing the galls by hand and destroying them when found are advised.

THE TRUMPET OR GRAPE TUBE GALL.[16]

The upper surface of grape leaves is frequently found to be more or less covered with nail-like galls about one-third of an inch long. The galls are reddish or crimson in color, shading to green. The par-

[15] *Schizomyia pomum* W. & R. [16] *Cecidomyia viticola* O. S.

ent insect is a small midge, or gnat, resembling the preceding species, and the larva or grub within the gall is pale orange in color. This species is not sufficiently abundant to require treatment.

HAWK MOTHS.

Several species of insects known in the adult stage as hawk moths and in the larva stage as hornworms attack the grape, cultivated and wild, the Virginia creeper, and numerous other plants. As a rule the caterpillars occur in small numbers, stripping the foliage from parts of the vines, though young plants may be entirely defoliated by them. There are records, however, of the local occurrence of certain species in very large numbers completely defoliating large vineyards and requiring prompt action to arrest their ravages. Such

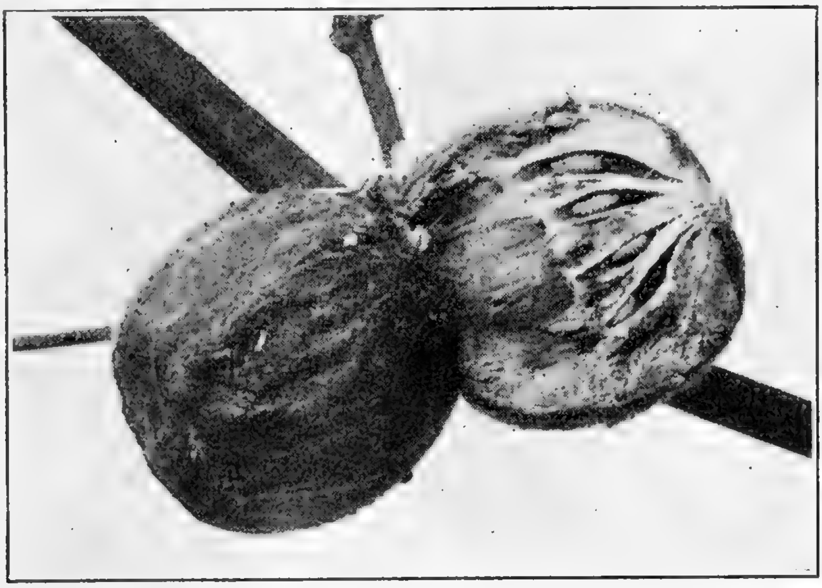

FIG. 34.—The grape apple gall.

an outbreak occurred in Tulare County, Calif., in 1919, involving some 700 acres of vines. Large-scale spraying operations were supervised by the bureau, requiring an outlay of about $11,000, but resulting in saving the crop, valued at $300,000.

The life and habits of the hawk moths attacking the grape are fairly similar. Eggs are laid by the parent moth, usually singly on the leaves, the resulting larvæ attacking the foliage and eating the leaves more or less completely. The young larvæ bear on the caudal end of the body a conspicuous horn-like process which may persist in the full-grown caterpillar, or be replaced by an eye spot, according to species. When mature, the larvæ go to the soil, change to brown pupæ, and pass the winter in this condition. In the case of some species the moths appear again the same season and deposit eggs for an additional generation or generations.

THE ACHEMON SPHINX.[17]

A caterpillar known as the Achemon sphinx is often inquired about, as it is commonly found on grape. It is this species which caused the serious injury in California in 1919, already mentioned. When young the larva is light green in color, with a conspicuous brown horn. The full-grown larva, however, which is about 3½ inches long, is of a straw or reddish-brown color, varying often to pinkish, with six diagonal cream colored stripes along each side, and the horn is replaced by a conspicuous eye spot inclosing a dark spot (fig. 35).

THE HOG CATERPILLAR.[18]

Another common hornworm of the grape is the so-called hog caterpillar. The larva measures about 2 inches in length, is green

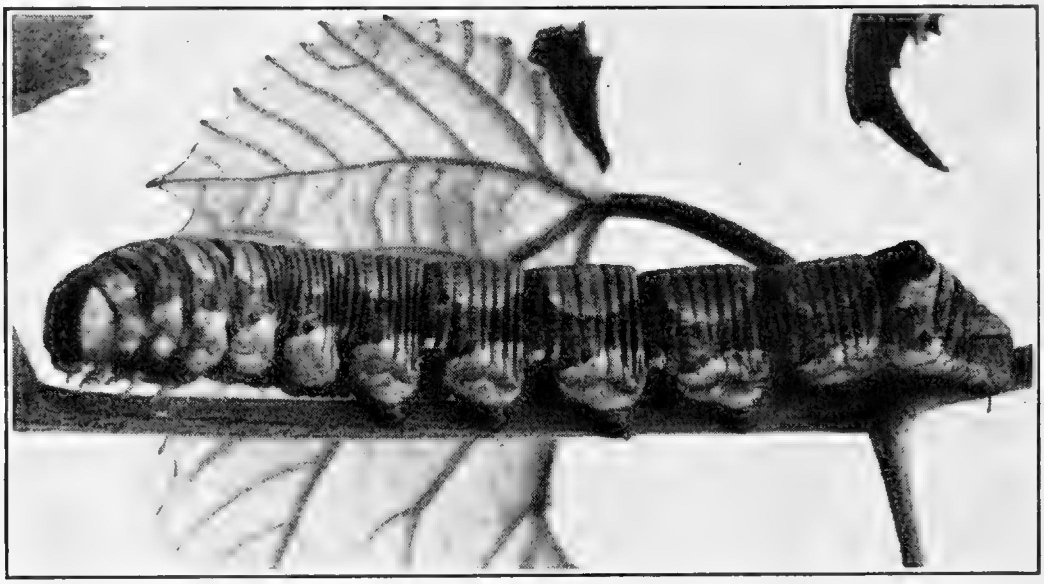

FIG. 35.—The Achemon sphinx.

in color, marked with small yellowish dots, and on each side with seven oblique stripes. From the horn to head along the back is on each side a wide dark green stripe. There are a number of broods each year and larvæ of the later broods are likely to be pinkish in color. The hog caterpillar is said to be very voracious, a few larvæ when nearly grown being capable of completely defoliating vines, and they are accused of biting into the stems.

THE WHITE-LINED SPHINX.[19]

The white-lined sphinx also attacks the grape and numerous other plants. It likes parsley, on which it multiplies, later attacking the grape. The larva is about 1½ inches long, varying much in color and markings. Some are yellowish green, while others are almost black with markings along the sides and a yellow line along the dorsum.

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[17] *Pholus achemon* Drury. [18] *Ampelophaga myron* Cramer. [19] *Deilephila lineata* Fab.

CONTROL OF HORNWORMS.

Vineyards sprayed with arsenicals for other grape insects will be little troubled as a rule by hornworms. Injury is likely to be evident in small unsprayed vineyards or on vines growing around the home. Thorough spraying of the plants with arsenicals should at once check the ravages of these insects. In the case of serious outbreaks in commercial vineyards, prompt measures are essential to obviate injury to the crop through the destruction of the leaves. A formula found effective in the outbreak in Tulare County, Calif., during 1919, is powdered arsenate of lead, 12 pounds; nicotine sulphate containing 40 per cent nicotine, $1\frac{1}{2}$ pints; water to make 200 gallons.

INSECTS AFFECTING THE CANES.

THE GRAPE SCALE.[20]

FIG. 36.—The grape scale on grape canes. Enlarged.

The grape scale has frequently been reported on grapevines, though it has not usually been so abundant as to cause serious injury. From the vicinity of the District of Columbia, however, frequent reports have been received during recent years, with specimens indicating its destructive work, particularly in small home vineyards, and to a small extent in commercial plantings. The grape scale attacks the wild grape, Virginia creeper, hickory, sycamore, and perhaps other trees. The insect is widely distributed in the eastern United States, ranging from Florida to New Jersey, westward to Missouri and Kansas, and has recently been found in California. It has also been reported from Brazil and the West Indies.

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[20] *Aspidiotus uvae* Comst.

Badly infested vines have a dirty white, whitewashed appearance, the infestation occurring on the 2-year-old canes. When abundant the scales materially check the growth of the vines. The rate of spread of the insect is slow, however, as the insect has been observed to occur for several seasons on a given vine in a row without spreading to adjacent vines. During May and June there develop from the parent insect some 35 to 50 living young which, after a brief period of activity, settle down on the canes, mostly in rows under the exfoliated bark of the previous season's growth (fig. 36). By fall the scales are nearly grown, and in this condition they pass the winter. There is probably but one brood each year.

FIG. 37.—A mealybug. Considerably enlarged.

CONTROL.

The grape scale is not difficult to control. The best treatment consists in the thorough application during the dormant period of winter-strength lime-sulphur wash as used for the San Jose scale. Previous to the application of the spray, loose bark should be removed from the vines as much as practicable, since many of the insects are well protected by the shreds of bark. This scale will also yield to applications of strong soap washes and kerosene emulsion.

THE GRAPE MEALYBUG.[21]

The grape mealybug (see fig. 37, illustrating a related species) has recently become known as a pest of grapes in California, especially in the counties of Fresno and Kings. Infestation of grapes has also been noted elsewhere in the State. The damage is not done by attack of the insects on the plant, but results from the soiling of the fruit by the copious honeydew voided by the mealybugs in the course of their feeding. This excrementitious matter accumulates on the fruit in various sized drops, causing the adherence of dirt, wax, and cast skins of the insects. It largely prevents use of the fruit as table

[21] *Pseudococcus bakeri* Essig.

grapes, and when the infestation is considerable it is not suitable for raisins. (Fig. 38.)

The insect upon hatching into the larva stage passes the winter, without further development, within the ovisac made by the female when depositing the eggs. With the first warm days of spring the larvæ leave the ovisac and make their way to the vine, settling down under the loose bark, in crevices, etc., where the tender bark of the grape is exposed. The spring brood of mealybugs mature in June and eggs are again deposited by the females. The young of this sec-

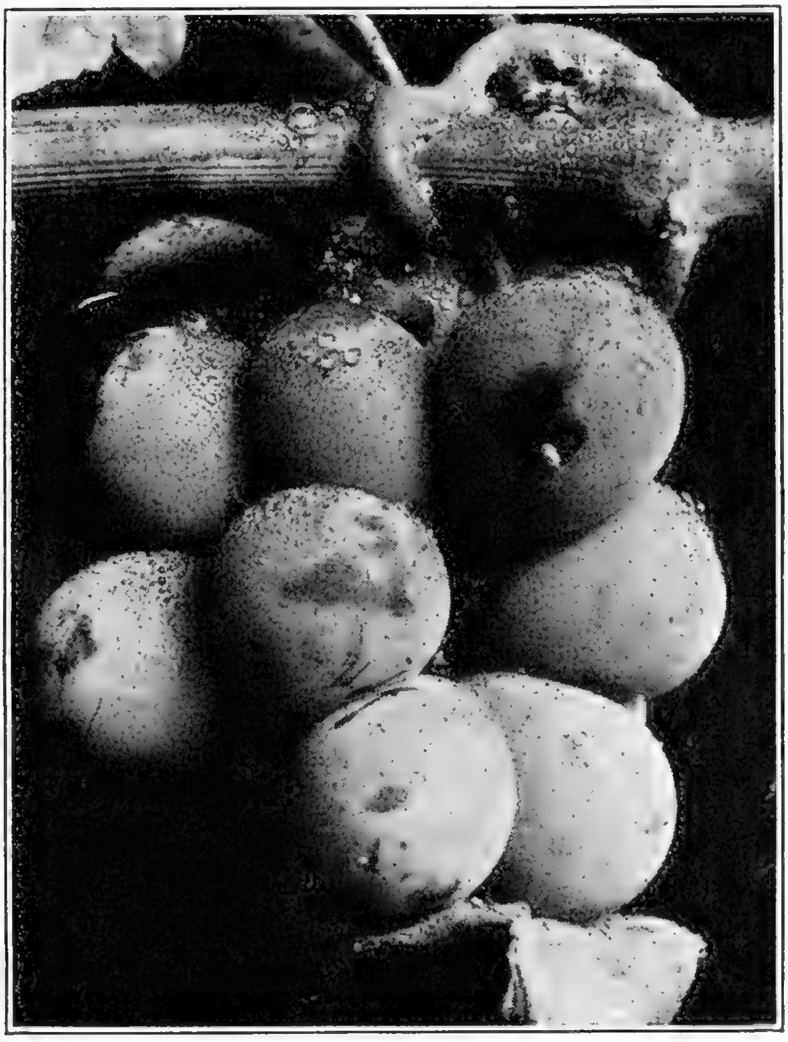

Fig. 38.—Accumulation of honeydew on grape cluster following presence of grapevine mealybug.

ond or summer brood feed on the tender canes and foliage and when nearly grown are to be found in the bunches of grapes, soiling these as described. During September and October females again deposit eggs, the larvæ hatching but remaining in the cottony ovisac over winter.

In its food habits the insect is practically omnivorous, and the grape is probably not especially suited to it as a host plant. The insect is averse to light and infests the vines where the dense foliage affords shade and the succulent fruit abundant food.

CONTROL.

The presence of honeydew on grapes at harvest time is usually proof of mealybug infestation, though the insects themselves may be so well hidden within the grape cluster as to escape ready detection. Honeydewed fruit should be excluded from the pack and promptly removed from the vicinity of the packing house, along with other cull grapes. Grape pickers should be instructed to exclude from the picking boxes bunches of grapes showing honeydew. Care should be taken to disinfect picking boxes by submerging them in hot water, by fumigation, or otherwise. The destruction of the insects in the vineyards offers difficulties. It is under investigation at the present time by the Bureau of Entomology and it is hoped that soon a practical control will be determined.

Fig. 39.—Grape cane-borer and its injury to pecan. Enlarged.

THE GRAPE CANE-BORER.[23]

The presence of the grape cane-borer in vineyards is usually first disclosed by the sudden wilting or breaking off of shoots in the spring. An examination of the canes will show a round hole opening into a burrow in the main stem (fig. 39, injury to pecan), in which will usually be found a cylindrical brown beetle about three-eighths of an inch long, with head set well under the body and the posterior end abruptly cut off and bearing a pair of horn-like protuberances (fig. 40). The beetle attacks a variety of fruit trees, including apple, pear, peach, plum, pecan, and certain forest and shade trees, but is most troublesome to the grape. The species is generally distributed in the United States and Canada east of the Rockies, but is most complained of in certain Mississippi Valley States, as Arkansas, Missouri, Texas, Iowa, Kansas, and Nebraska. On the Pacific Coast a related form occurs, working in about the same way. Injuries by this species are due to the apparently malicious borings of the adult beetle in grape canes, resulting in the wilting or dying of adjacent shoots, since the grubs breed in drying wood of shade and fruit trees, drying grape canes, or exposed roots of maple, etc.

[23] *Schistocerus hamatus* Fab.

There is only one generation of the insect each year, larvæ maturing by fall and mostly pupating and developing to the beetle stage, in which condition the winter is passed.

CONTROL.

The grape cane-borer is best kept in check by giving attention to the destruction in and around vineyards of dying trees, prunings, and the like, which are necessary for the development of the young. After the canes are bored into nothing can be done to correct the damage. It may be practical in some cases to destroy the beetles in their burrows by use of a curved wire. During warm days the adults are likely to be out of their burrows and can often be gathered by hand and destroyed.

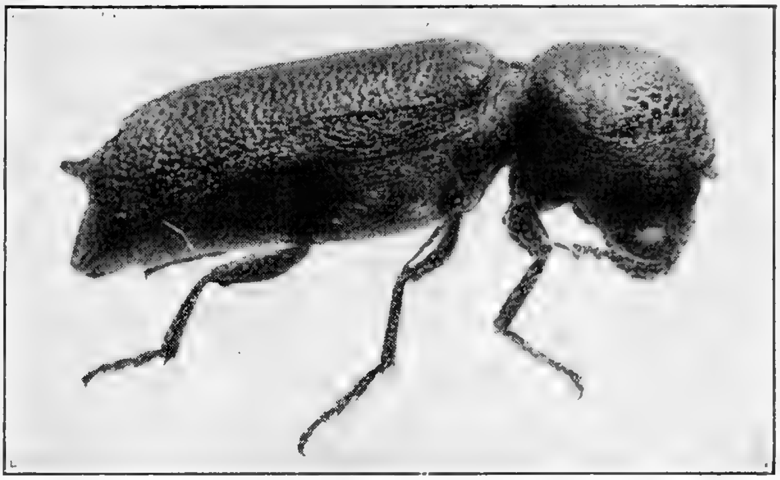

Fig. 40.—Grape cane-borer. Considerably enlarged.

THE GRAPE CANE GALL-MAKER.[23]

A small, reddish brown weevil, the grape cane gall-maker, sometimes punctures with her snout the shoots of the grape, usually just above one of the lower joints; in this puncture an egg is placed and several additional punctures may be made above the first, but in these no eggs are deposited. The larva upon hatching feeds in the pith, burrowing up and down the shoot. When full grown the pupa stage is entered in the burrow, the beetle emerging in midsummer. As the shoot grows it becomes enlarged at the punctured place, resulting in a gall-like swelling about twice the diameter of the cane in thickness and one or two inches in length. The injured canes continue to grow and, unless broken by winds, little harm results. No practical methods of preventing injury by this insect have been developed and ordinarily its attack is of very little importance.

THE GRAPE CANE-GIRDLER.[24]

The grape cane-girdler is a very near relative of the preceding species and has about the same life history. The egg-laying activities of the female practically girdle the shoots, which soon drop (fig. 41). The egg is deposited mostly at the joint next below where the shoot has been cut off. Cutting off and destroying the shoot a few inches below this joint will result in the destruction of the grub feeding on the pith within the shoot.

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[23] *Ampeloglypter sesostris* Lec. [24] *Ampeloglypter ater* Lec.

INSECTS AFFECTING THE ROOTS.

THE GRAPE ROOTWORM.[25]

The grape rootworm, as the name indicates, infests the roots of the grape, devouring more or less completely the small roots and rootlets and eating pits and burrows into the outer portion of the larger roots. It is the larva of a small, hairy, chestnut-brown beetle (fig. 42) which makes its appearance in vineyards at about the close of the blooming period of such varieties of grapes as Concord, Niagara, Catawba, etc. The beetles feed freely on the upper surface of the leaves, eating a series of patches or holes through to the lower surface, thus producing characteristic chain-like feeding marks, as shown in figure 43, by which their presence in vineyards can be readily detected. The injury to the foliage, however, is quite unimportant compared to the work of the larvæ on the roots (fig. 44). When the larvæ or grubs are abundant the vines may be killed in the course of two or three seasons, but usually the plants will linger, though making but a feeble growth and failing to produce profitable crops. The death of vines or gradual failure of a vineyard should call for an examination in late spring of the foliage for the characteristic feeding marks of the beetle, and of the roots for the work of the larvæ on these parts.

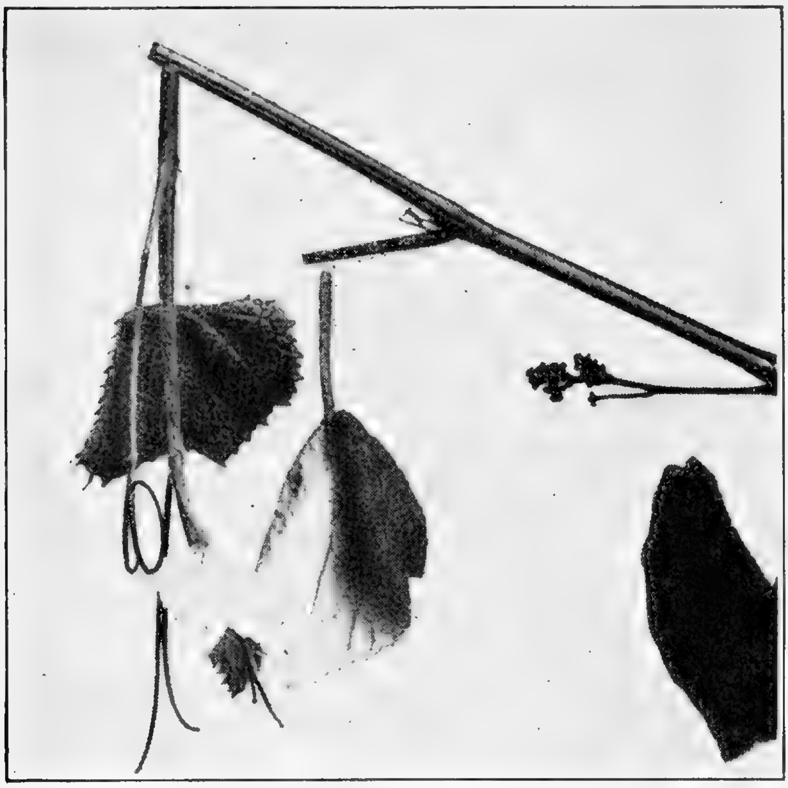

FIG. 41.—Grape cane-girdler and its injury to grape shoot.

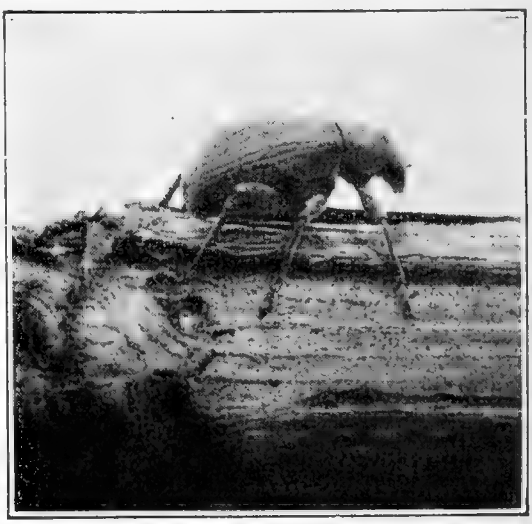

FIG. 42.—The beetle or parent of the grape rootworm. Considerably enlarged.

The insect is a native species, feeding originally on wild grapes, as it does at the present time. In addition to wild and cultivated

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[25] *Fidia viticida* Walsh.

varieties of grapes, it has been reported as feeding on Virginia creeper and the American red-bud. It is widely distributed in the Mississippi Valley and the Eastern States, and has been recorded as destructive in Kentucky, Missouri, Arkansas, Illinois, Ohio, Pennsylvania, and New York. It has been particularly injurious in northern Ohio, Erie County, Pa., and western New York. The insect thrives in vineyards which have been neglected. In the absence of cultivation and timely spraying it may become a serious pest in any vineyard throughout its range of distribution. This is especially true in light gravelly soils and in regions where grape growing is followed on a large scale.

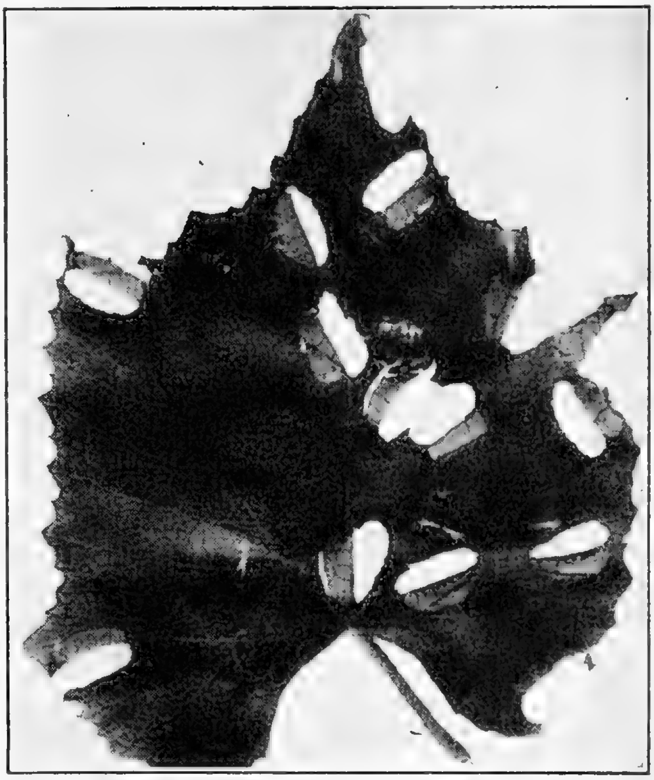

FIG. 43.—Feeding marks on grape foliage of the grape rootworm beetle.

LIFE HISTORY AND HABITS.

The adults make their appearance in vineyards, beginning about the close of the blooming period. In New York, Pennsylvania, and Ohio grape districts, emergence begins the latter part of June or in early July, varying with the season and soil. After emergence beetles begin to feed, eating rows of holes in the upper surface of the leaf, as described. Shortly the females begin to deposit eggs, the number for an individual female varying considerably, but averaging about 100. Eggs are deposited in patches under the bark of last year's wood and may be placed quite generally over the canes (fig. 45). In about 8 to 14 days the eggs here hatch and the resulting larvæ drop to the ground. Although their powers of locomotion and endurance are considerable to enable them to overcome difficulties in reaching the roots, many doubtless fail to do so and perish. When established on the roots, however, the grubs feed freely and grow rapidly, and by fall the majority of them are full grown or nearly so (fig. 46). The insect hibernates in the grub stage several inches deep in the soil. In the spring the larvæ ascend to near the surface of the earth, the immature ones complete their growth, and the pupa stage is entered, mostly at from 2 to 3 inches below the surface of the ground and within a radius of 1½ to 2 feet from the base of the vine. An earthen cell is prepared by the larva in which the pupa or "turtle" stage is passed (fig. 46). The insects in this condition are soft and helpless, and a stirring of the soil close along the rows by cultivation, as with the so-called horse-hoe, is doubtless fatal to many of them. Pupation is perhaps at its height just before the grape blossoms, though this time may be determined with some exactness by examination of the insects in the soil. The grape rootworm has several natural enemies, which in the aggregate do considerable to keep it reduced.

FIG. 44.—Injury by grape rootworm to roots of grapevine.

CONTROL.

Since the adults feed freely on the foliage for some days before egg laying, they can be destroyed by thorough spraying of the vines with an arsenical, such as arsenate of lead. This should be used at the rate of $1\frac{1}{2}$ pounds of the powder or 3 pounds of the paste form to each 50 gallons of spray. The poison should be applied in Bordeaux mixture necessary for the control of fungous diseases. According to experiments by the Geneva, N. Y., agricultural experiment station the effectiveness of the spray is greatly increased by the addition of 1 gallon of molasses to each 50 gallons of liquid, though its adhesiveness is much lessened, and care should be taken to apply it when weather conditions are favorable, and repeat after heavy rains. The first application should be given shortly after the first beetles or their feeding marks are to be seen on the leaves, and the second treatment about 10 days later.

While the time of treatments for best control of the grape rootworm and the grape leafhopper do not exactly coincide, yet under average conditions of abundance of these two pests they should be kept in check by a combination application of arsenate of lead and nicotine in Bordeaux mixture (see schedule, pp. 74–75). Where either pest is unusually abundant, spray applications should be made according to recommendations for that particular insect.

To offset as much as possible the injury of the grubs to the roots of vines in badly infested vineyards, care should be given to adequate cultivation, fertilization, and pruning. Severely injured vineyards, by improved care in these respects, together with spraying, have been brought back to a condition of satisfactory productivity in two or three seasons.

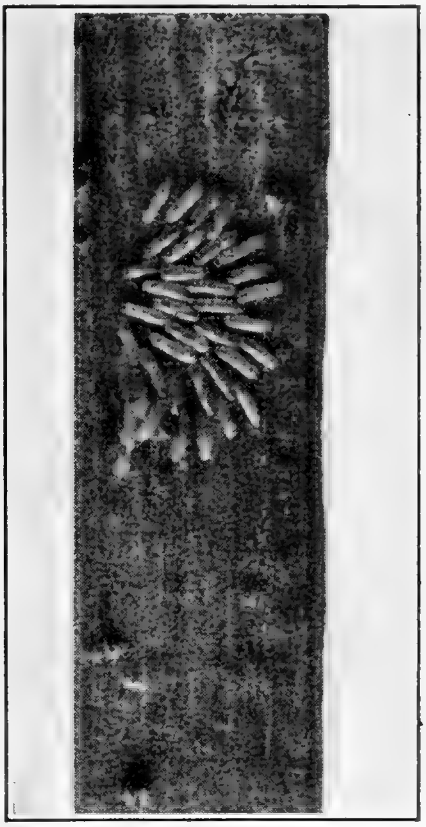

FIG. 45.—Egg mass of grape rootworm beetle.

THE CALIFORNIA GRAPE ROOTWORM.[26]

Another rootworm attacks the grape in California in a way very similar to its eastern relative, the grape rootworm. This insect, though widely distributed in the United States, seems to confine its attack to vinifera or European grapes in California. It occurs in Europe, Algeria, etc. In parts of Europe it is a pest of importance to the grape.

The remedial measures indicated for the control of the grape rootworm are applicable in the case of this species.

THE GRAPEVINE ROOT-BORER.[27]

Injury by the grapevine root-borer is confined to the roots of the grape, in which channels or burrows are eaten, or the roots often an inch or more in diameter may be girdled (fig. 47). In severe cases most of the main roots may be severed, leaving only a stub or mere stump, thus greatly reducing or destroying the vigor and productivity of the vines. The insect, so far as known, attacks the grape exclusively, wild or cultivated. It is inconspicuous in all its stages and thus is likely to be overlooked, the attack of larvæ on

FIG. 46.—Grubs and pupæ of grape rootworm.

[26] *Adoxus obscurus* L. [27] *Memythrus polistiformis* Harris.

the roots usually being first indicated by the unthrifty condition of the plants. The grape root-borer has been recorded from Kentucky, Minnesota, Missouri, North Carolina, Maryland, Ohio, West Virginia, and Vermont, and probably occurs elsewhere in the Middle West and in the Eastern States. Its most serious attacks have been in West Virginia, North Carolina, and Kentucky. The adult is a wasplike moth (fig. 48), a near relative of the so-called peach borer. The moths begin to appear from pupæ in the soil about the middle of July and continue to emerge until about the middle of September. The eggs (fig. 49) are deposited on the leaves and canes of the grapevine and very frequently on grass, weeds, or trash surrounding the plants. The resulting larvæ burrow into the soil and attack the larger grape roots and are able to penetrate the earth for a considerable distance in their search for food. The larvæ pass the winter in chambers or cells at the ends of their burrows in the roots. Feeding is resumed with the approach of warm weather in the spring. Upon completion of growth a cocoon is made, the pupa stage is entered (fig. 50), and the moths begin to emerge about the middle of July, as stated.

FIG. 47.—Larvæ and injury to grape roots by the grapevine root-borer.

FIG. 48.—Parent or moth of grapevine root-borer. Enlarged.

METHODS OF CONTROL.

This species can not be controlled by usual insecticidal practice in vineyards. Thorough cultivation of the vines during June and July is probably beneficial in destroying some of the larvæ, but by far the most valuable method is maintaining the plants in a vigorous and healthy condition by adequate fertilization, pruning, spraying, etc. In this way the infested vines are most likely to be kept in a productive condition in spite of the attack of the insect.

THE GRAPE PHYLLOXERA.[28]

FIG. 49.—Eggs of grapevine root-borer. Considerably enlarged.

The grape phylloxera has come into wide notoriety on account of its injurious relation to vinifera or European varieties of grapes. It is a native of the United States approximately east of the Rocky Mountains, where it lives on various wild species of American grapes and attacks more or less cultivated varieties. The phylloxera was introduced into France presumably on vines from America some time previous to 1867 and quickly became a most serious menace to the grape-growing industry. By 1884 a third of the vineyard area of France had been destroyed and much additional territory seriously injured. The phylloxera has spread to much of the vine-growing regions of Europe, and occurs in Russia, Algeria, and New Zealand. In California, where European or vinifera varieties of grapes are largely grown, the phylloxera has been for many years the most important insect enemy of the vine (fig. 51). It made its advent into that State about 1858 and was presumably introduced on American grapes from the Mississippi Valley or Eastern States. At the present time the insect in the United States is a pest of importance practically only in California, though reports of injury, especially to foliage (fig. 52), have occasionally come from States east of the Rockies, principally on varieties with considerable vinifera blood. Our wild grapes in the East possess in varying degrees immunity from injury by the phylloxera and thrive in spite of the presence of the insect. In Europe, California, and elsewhere the ravages of the phylloxera are now being circumvented by the use of American

FIG. 50.—Cocoon and pupal skins of grapevine root-borer. Enlarged.

[28] *Phylloxera vitifoliae* Fitch.

resistant vines for stock for vinifera sorts, and for some years new vineyard plantings have been of vines of this character.

In the protection of vineyards on vinifera or other nonresistant roots, direct remedial measures are employed, as the use of fumigants, such as carbon disulphid, the flooding of vineyards for stated periods, etc. A very large amount of experimental work has been done in determining the best resistant stocks and best remedial measures for the phylloxera, especially in France.

FIG. 51.—Phylloxera injury to vinifera vineyard in California.

The life history of the phylloxera is quite complicated and varies considerably, according to type of grape infested and the climate of the country inhabited by it. The phylloxera may be disseminated from nurseries on vines, or on vines from infested vineyards, and new centers of infestation come about principally in this way. In California spread from these centers is due to migration from infested vines over the soil, or through cracks in the soil of the small root-inhabiting nymphs or larvæ (fig. 53). These small larvæ may also be borne by wind and by picking boxes, and in hilly or irrigated vineyards perhaps some are carried by water. The winged form in that State appears not to be a factor of importance in the dissemination of the species.

CONTROL.

Growers of American varieties of grapes, with a few exceptions, will not find the phylloxera of sufficient importance as a pest to require consideration. Those planting vinifera sorts should use vines on resistant stocks. The kind of stock which should be employed varies with the variety of grape to be grown and other conditions, and expert advice on this subject should be obtained from the viticulturist of the Department of Agriculture or of the University of California.

FIG. 52.—Leaf galls of grape phylloxera as found in eastern United States.

In California the use of carbon disulphid injected into the soil to destroy the insects on the roots is, in most instances, impracticable, as is also the utilization of water in flooding vineyards.

FUNGOUS DISEASES.

Most of the fungous parasites of the grape are indigenous, and came originally from the native wild vines. With the gradual extension and development of the grape-growing industry there has also been an increase in the distribution and destructiveness of these fungous diseases. The conditions which necessarily obtain in commercial grape culture have disturbed the equilibrium which had become established between the vine and its parasites in their wild state, and have facilitated the reproduction and distribution of the diseases. In the selection and breeding of the grape attention has been devoted chiefly to the improvement of the fruit, and this has apparently resulted in some cases in a decrease of the natural powers of resistance to disease originally possessed by the wild vines.

FIG. 53.—Colon of grape phylloxera and its distortions on vinifera grape root. Considerably enlarged.

In certain sections of the country where grape growing was once a profitable industry it has largely been abandoned, chiefly on account of the great loss caused by disease. The amount of loss from fungous diseases of the grape in the United States varies greatly from season to season, according to conditions, varieties, and treatment. In the past they have frequently, in certain localities, caused a total loss of the crop when no preventive measures have been taken. The principal cause of the failure of the early American fruit growers in their attempts to grow the European varieties of grapes seems to have been the severe and destructive attacks of our native fungous diseases to which the vinifera grapes were more susceptible than the native varieties.

Injury due to fungous parasites depends largely upon weather conditions. The conditions most favorable for the development of the majority of the fungous diseases are excessive moisture and heat. The general physiological condition of the vines is also important. Vines which are kept thrifty and vigorous by proper care and cultivation are not likely to suffer as severely from most diseases as those which are neglected. Different varieties also show different degrees of susceptibility to the different diseases.

The principal fungous diseases in the order of their importance are black-rot, downy mildew, powdery mildew, anthracnose, ripe-rot, dead arm, and crown gall. There are also some minor diseases, but they are not of sufficient economic interest to require much attention here.

No attempt will be made here to treat of the nonparasitic diseases or those of obscure or unknown cause, such as the Anaheim or California vine disease, Little leaf, and Spanish Measles. These diseases are at present restricted to the European varieties and hybrids grown in the Pacific coast region, and no satisfactory methods of prevention or control are yet known. Their causes must first be determined by thorough research.

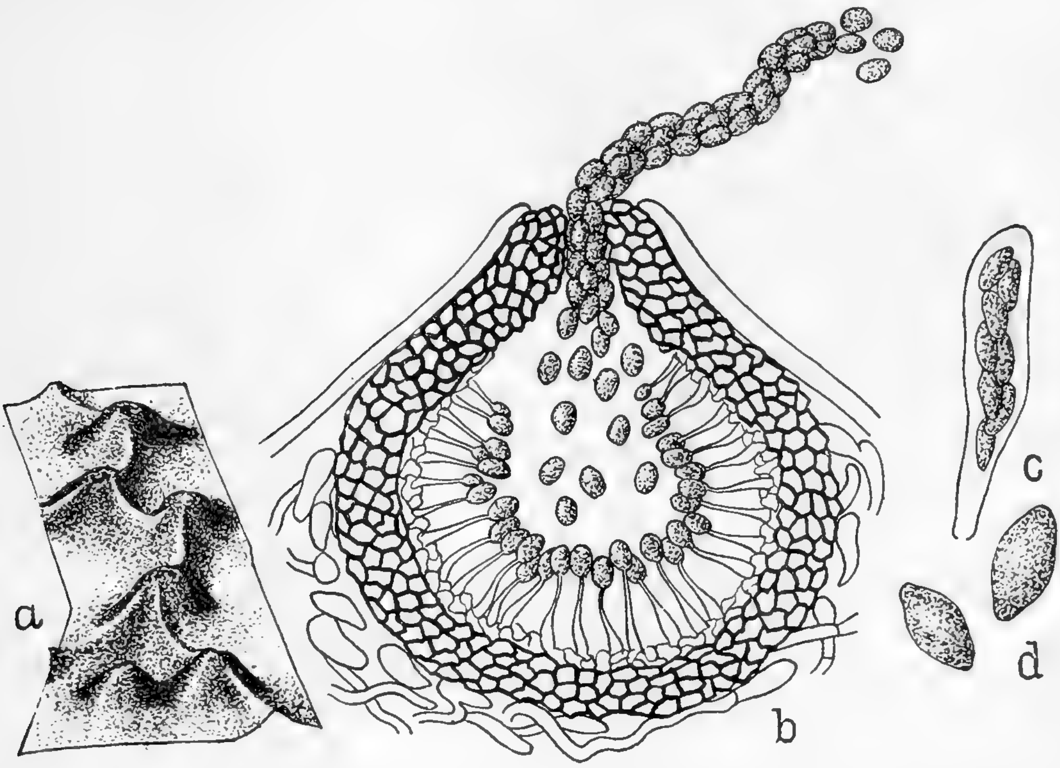

FIG. 54.—The black-rot fungus: *a*, A portion of an affected grape, showing the pustules in which the spores are produced (slightly magnified); *b*, a section of one of these pustules very highly magnified, showing the manner in which the summer spores are produced and discharged; *c*, a sac containing winter spores; *d*, single winter spores very highly magnified.

BLACK-ROT.

In the region east of the Rocky Mountains black-rot is the most generally distributed and destructive fungous disease of the grape. It does not occur in the arid regions of the West. It is caused by a parasitic fungus.[29] It gains entrance to the plant by means of minute germs called spores. These are borne in small black fruiting bodies as shown in figure 54, *a*, *b*, and can not be seen with the naked eye. They are distributed chiefly by the wind and rain. Two or more forms of spores are produced, as shown in the accompanying illustration (fig. 54, *c*). When these spores come in contact with the young and tender parts of the vine, under favorable conditions,

[29] *Guignardia bidwellii* (Ell.) V. & R.

they germinate and produce a slender germ-tube, which penetrates the tissue and may destroy it.

This disease attacks the leaves and shoots, as well as the fruit. It usually makes its first appearance on the leaves and young shoots, producing reddish-brown dead spots. The fungus may attack the blossoms, as shown in figure 55, or young fruit, this being especially true in case of the Scuppernong grapes, but usually the disease does not attract much attention until the berries are half grown or more. Livid or brownish, soft spots first appear; these spread and soon involve the whole berry, which later becomes black and shriveled or mummied, as shown in the accompanying illustration (fig. 56).

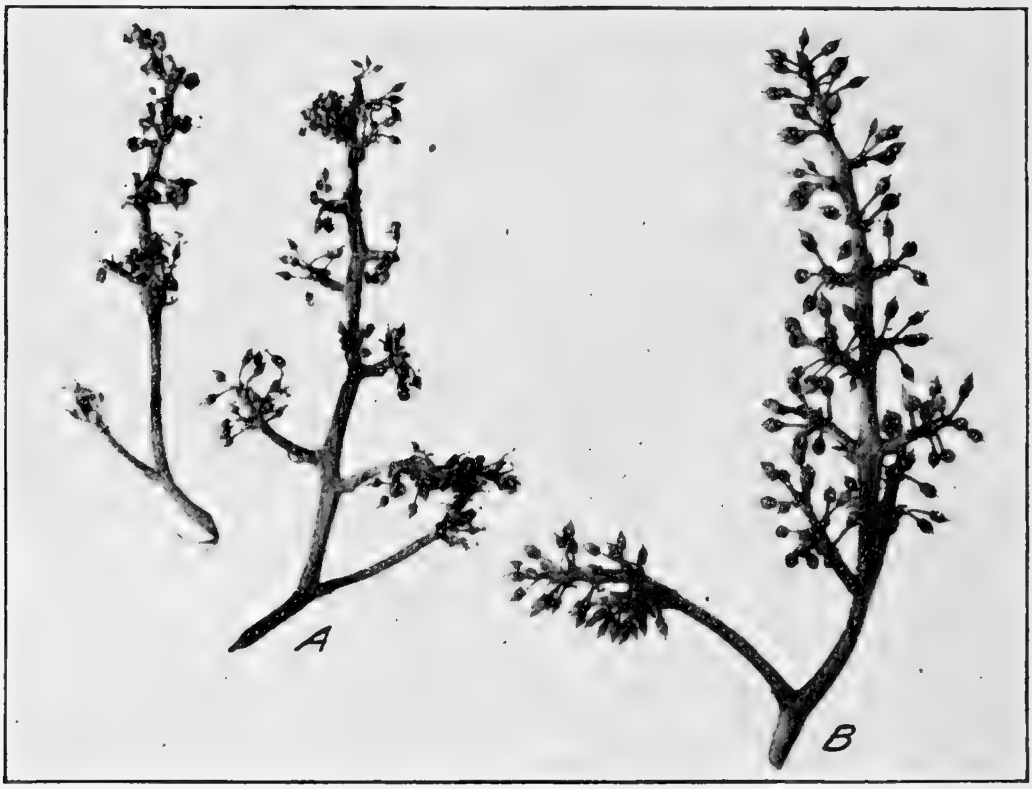

FIG. 55.—*A*, Two bunches of grape blossoms from an unsprayed check plat almost entirely destroyed by black-rot before blossoming. *B*, A sprayed bunch from the same vineyard showing no damage from rot. Natural size.

These diseased berries remain attached to the bunch and their surface becomes covered with minute black pustules, which contain the summer spores of the fungus. During the winter and spring another form, called the winter or resting spore, is produced upon these old, shriveled berries (fig. 54, *c*, *d*). These spores help to carry the disease over from one season to another. It is, therefore, desirable to destroy by burning or plowing under all diseased fruit and leaves as early in the spring as possible.

TREATMENT.

This disease can be effectually controlled by thorough spraying with Bordeaux mixture, as has been demonstrated by the Bureau of Plant Industry. (See spray schedule, p. 74.)

Covering the bunches of grapes with paper bags soon after the blossoms fall is usually an effective means of preventing black-rot and most other fungous diseases of the fruit. It is generally regarded as too laborious and expensive a method for large vineyards, but may be profitably practiced where only a small number of vines are grown or where special market conditions or prices make it advisable.

Fig. 56.—*A*, An average bunch of grapes, showing the proportion of rotten berries (90.7 per cent), in an unsprayed plat. *B*, An average bunch of grapes, showing the proportion of rotten berries (4.3 per cent) in a sprayed plat in the same vineyard. Three-fourths natural size.

DOWNY MILDEW.

Downy mildew [30] in certain seasons and in northern localities sometimes causes more loss than black-rot and is a close rival for first place among the fungous enemies of the grape. It attacks all the tender, growing parts of the vine. Usually it is at first most noticeable on the foliage, producing greenish yellow, irregular spots upon the upper surface, which become reddish brown. At the same time there appears on the under surface of the leaf, a thin, loose, white, downy growth, suggestive of hoarfrost (fig. 57). This growth consists of the fertile fungous filaments bearing the summer spores (fig. 58, *a*, *b*), which, under favorable conditions, are distributed by wind and water to the berries and other parts, where they germinate and produce zoo-

[30] Caused by *Plasmopara viticola* (B. & C.) Berl. & De Toni.

spores, which penetrate the tissues, and continue their destructive work. The young shoots are sometimes attacked and killed.

The fruit, if attacked when young or only partly grown, shows first a brownish spot, and later becomes covered with the gray, downy

FIG. 57.—A grape leaf attacked by the downy mildew, showing the appearance of the leaf above and below.

growth of the fungus. This form of the disease is sometimes called "gray-rot" by vineyardists (fig. 59). When the berries escape the disease until they are half grown or more it appears as a brown or brownish purple spot which spreads and soon involves the whole berry. The affected fruit becomes soft and wrinkled and falls to the ground when disturbed. This stage of the disease is sometimes called "brown-rot."

Besides the summer spores mentioned, there is also produced within the diseased tissues of the leaves another form of reproductive body, sometimes called a winter or resting spore. These spores are produced in much smaller numbers than the summer spores and are provided with a rather thick, dark-colored outer covering apparently intended for their protection during the winter.

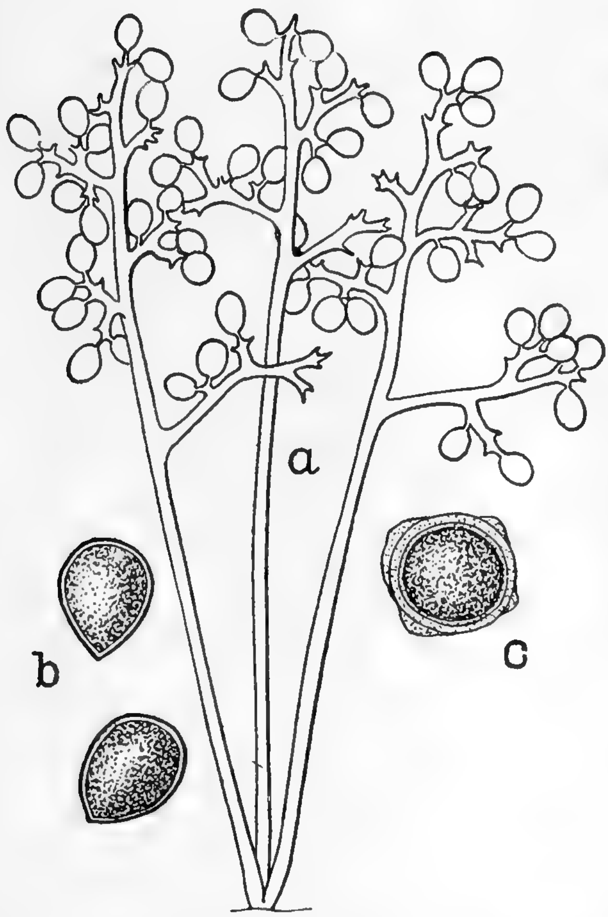

FIG. 58.—The fungus causing downy mildew. *a*, Fertile filaments of the downy mildew fungus, showing the manner in which the summer spores are borne; *b*, two summer spores; *c*, a winter, or resting spore. (All highly magnified.)

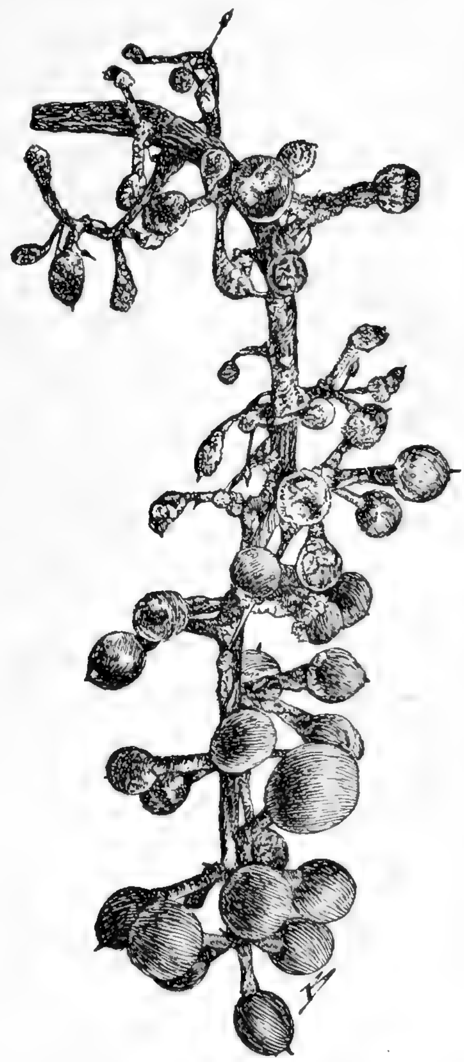

FIG. 59.—A bunch of young grapes partially destroyed by "gray-rot." This is a form of the downy mildew affecting the very young fruit.

This disease, like the black-rot and many others, develops most rapidly and does most injury during hot, wet weather and does not cause trouble in arid regions.

TREATMENT.

It is desirable to destroy as many as possible of the old diseased leaves, shoots, and berries, which may contain the winter spores. Thorough spraying on the under sides of the leaves, as recommended for the black-rot, will effectively control this disease.

POWDERY MILDEW.

The powdery mildew [31] rarely causes great loss to American varieties of grapes. It is most severe on the European, or vinifera, grapes. This mildew belongs to a group of fungi quite different from the downy mildew. It differs from all other parasites which attack the grape in its superficial habit of growth. The parasite obtains its nutriment by means of suckerlike organs which penetrate the cell walls of the surface layer of tissue only. The fine, white filaments of the fungus, which constitute the vegetative portion of the parasite, spread over the surface of the leaves, shoots, and fruit, and send up short, irregular branches upon which immense numbers of summer spores are produced in short chains (fig. 60, *a*). These are

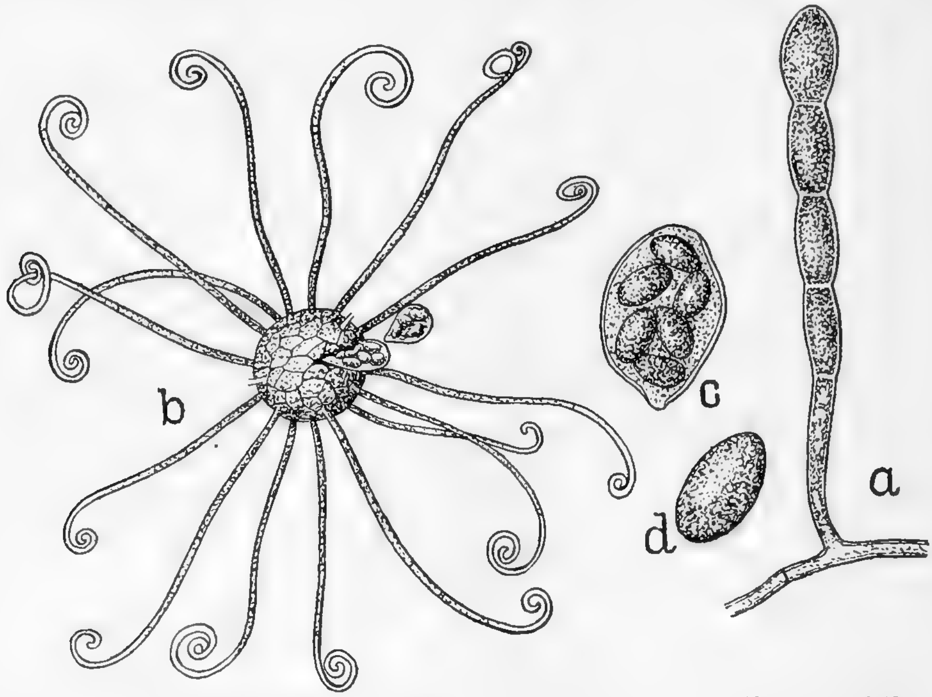

Fig. 60.—The fungus causing powdery mildew: *a*, A fertile filament of the fungus bearing a chain of summer spores; *b*, a spore case, in which the winter or resting spores are produced; *c*, a single sac containing winter spores; *d*, a single winter spore. (All highly magnified.)

most noticeable upon the upper surface of the leaf, giving it a fine gray, powdery, or mealy appearance. Finally the affected part of the leaf becomes light brown, and if the disease is severe the leaves fall. The fungus produces a similar appearance upon the young shoots. Berries which are attacked take on a gray, scurfy appearance, become specked with brown, and fail to mature properly. Affected grapes when nearly half grown sometimes burst open on one side, exposing the seeds. The fruit does not become softened and shrunken as when attacked by the downy mildew.

Besides the summer spores, winter or resting spores are also produced in the latter part of the season. These are borne in sacs which are inclosed in minute, black, globose fruiting bodies furnished with slender appendages curled at their tips (fig. 60, *b*, *c*, *d*). These black

[31] Caused by *Uncinula necator* (Schw.) Burr.

spore cases are so small that they can scarcely be seen with the naked eye, but by the aid of a hand lens they can be easily observed. This is the principal fungous disease of the vinifera grapes on the Pacific slope.

TREATMENT.

For American varieties east of the Rocky Mountains, where black rot and downy mildew are usually prevalent, Bordeaux mixture should be applied as recommended for black rot (see spray schedule, p. 74). For vinifera grapes on the Pacific slope dusting with sulphur has been found to be the most economic and efficient method of controlling this disease. Very fine sulphur, either ground or sublimed, should be used. It can be most effectively applied with a hand-dusting machine such as shown in figure 77 or a similar type. A can with perforated bottom or a cloth sack is frequently used, but this method is less effective and not economical.

Three thorough applications are usually sufficient to insure satisfactory results. The first application should be made when the new shoots are 6 to 8 inches long; the second just before or during blossoming. If the first two treatments have been thorough, practically covering all the foliage, the third dusting should not be necessary except under weather conditions unusually favorable for the disease or with very susceptible varieties.

If a third treatment is necessary, it may be made when the fruit is about half grown.

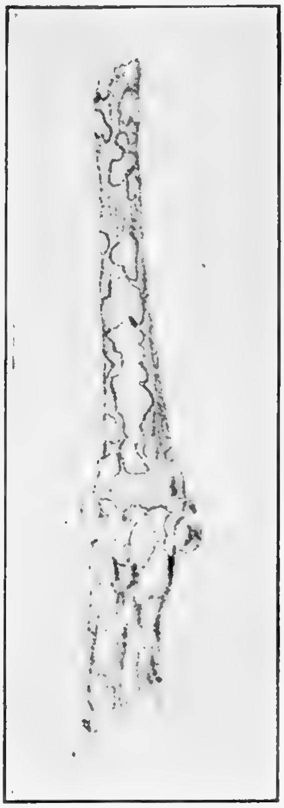

Fig. 61.—Grape shoot, showing spots produced by anthracnose.

ANTHRACNOSE.

Anthracnose[32] has also been called "bird's-eye rot," on account of the peculiar spots it produces upon affected grapes. Like most other diseases of the grape, it attacks the leaves and shoots, as well as the fruit. On the leaves it at first appears as minute, irregular, dark brown, slightly sunken spots, having a darker margin. These spots usually become lighter colored when old, and frequently crack or fall out, leaving irregular holes in the leaves. This disease presents much the same appearance on the shoots as on the leaves, though the spots are frequently larger and more sunken (fig. 61). They also tend to run together and form irregular patches or cankers.

The disease is most characteristic and conspicuous upon the fruit. The spots are usually brown at first and surrounded by a narrow, dark purplish margin; they increase in size and gradually become

[32] Caused by *Sphaceloma ampelinum* De By.

grayish white and somewhat sunken. Frequently two or more spots unite and cover a considerable part of the berry. The affected tissues do not become softened, as in the case of the downy mildew, but the fruit finally becomes hard and more or less wrinkled. If only a small part of the berry is affected, it may continue to grow, causing the diseased area to rupture and the seeds to become exposed. The bursting of the berries and the exposure of the seeds may, however, be produced by other causes, such as the powdery mildew and certain physiological disturbances or insect injuries.

On the diseased areas the minute spores or germs of the fungus are frequently produced in immense numbers. The way in which these spores are borne is shown in figure 62. The winter form of spore produced by this fungus is apparently not common. The fine threadlike filaments which constitute the vegetative part of the parasite live during the winter in the tissues of the vines and are ready for active growth in the spring.

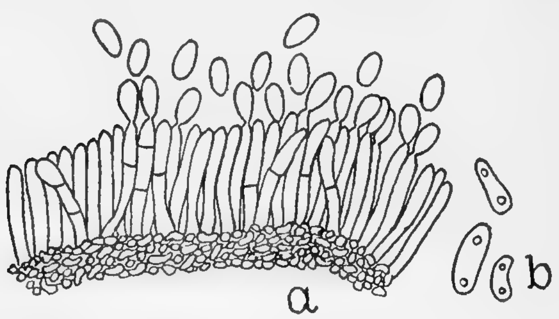

Fig. 62.—Section of an anthracnose spot, highly magnified: *a*, Showing the way in which the spores are borne; *b*, three of these spores more highly magnified.

The anthracnose is quite widely distributed in this country, but fortunately has not caused any great general loss. It is rather erratic in its behavior, sometimes being very serious in one locality or on a particular variety, but not general. It may attack vinifera grapes seriously where climatic conditions are favorable, as in the southern part of Texas and on the Gulf coast. On the Pacific coast the disease is not known to occur. It should be carefully watched, however, as when once well established under favorable conditions its control is difficult.

TREATMENT.

All branches or shoots showing cankers should be cut out and burned during the winter. Spray the vines thoroughly with commercial lime sulphur, 1 gallon of lime sulphur to 9 gallons of water, just before growth starts in the spring. During the growing season spray with Bordeaux mixture as indicated in the spray schedule (p. 74). Lime-sulphur solution has been found just as effective as sulphuric acid for a dormant application and much less unpleasant and dangerous to handle. A comparison of figures 63 and 64 will show the benefits resulting from this method of treatment.

RIPE-ROT.

Ripe-rot[33] has also been called bitter-rot. The name bitter-rot is, however, applied to another fungous disease of the grape (p. 62). As

[33] Caused by *Glomerella cingulata* (Atk.) Spauld. & v. Schrenk.

FIG. 63.—A portion of an average vine with some leaves removed, showing the condition of fruit on the treated portion of the vineyard in 1912.

FIG. 64.—A portion of a vine from the control plat in 1912 seriously damaged by anthracnose, about the same number of bunches being shown as in figure 63.

the present name indicates, the disease usually appears on the fruit when the latter is nearly mature, and under favorable conditions continues its development and destruction of the fruit after the grapes are picked. It also attacks the leaves and stems, but is most noticeable and injurious on the fruit. The first indication of the disease is the appearance of reddish-brown discolored spots (fig 65), which spread and finally extend over the whole fruit. The surface then becomes dotted with dark, slightly elevated pustules, in which the spores are borne. At this stage of development the disease is not easily distinguished from the early stages of black-rot and bitter-rot. The berries do not shrivel up, however, as in the case of the black-rot, and usually are easily detached from the bunch. The spores mentioned are produced in large numbers and serve to spread the disease.

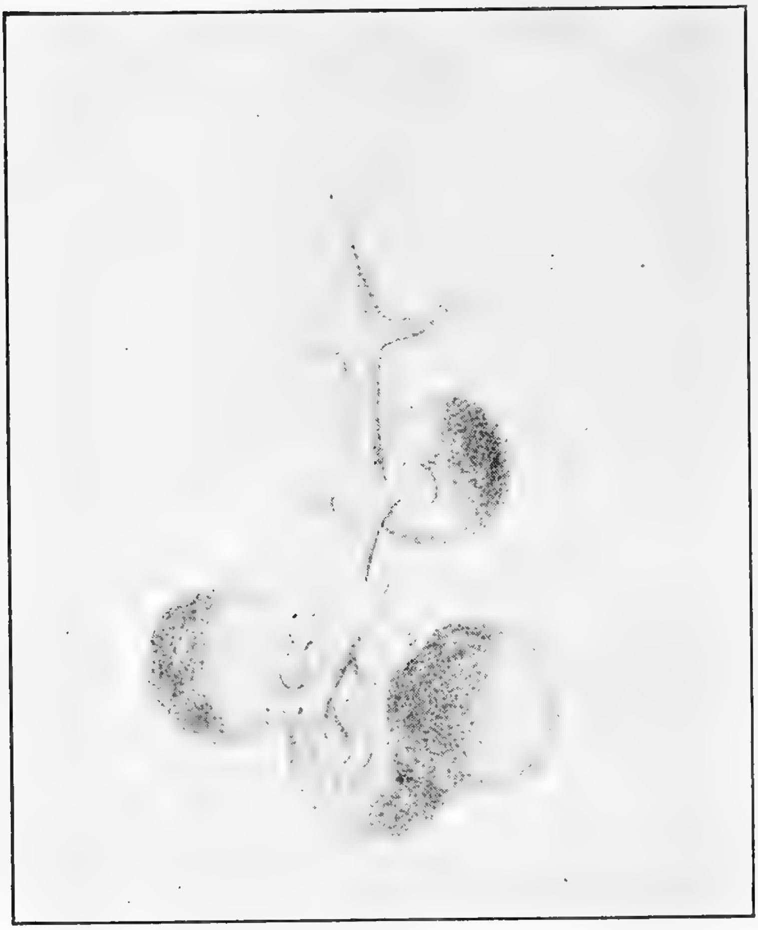

FIG. 65.—Grapes attacked by the ripe-rot fungus.

The fungus causing this disease is closely related to that which produces the bitter-rot of the apple, and by some is regarded as the same; but no entirely conclusive cross-inoculation experiments have yet been reported. The pathologists of the Department of Agriculture have demonstrated by means of pure cultures of this fungus that there is another stage, producing spores very similar in appearance to those just mentioned, but borne in sacs which are inclosed in spore cases similar to those of the black-rot fungus. This spore form is of very infrequent or doubtful occurrence in vineyards, and is probably not an important factor in the distribution of the disease.

It is difficult to determine how much injury is done by this disease on account of the likelihood of confusing it with other fungous troubles and its usual occurrence with other diseases. It is quite generally distributed, and may cause more loss than is usually attributed to it.

TREATMENT.

Spray as recommended for black-rot in the spray schedule (p. 74). The later applications are especially important and should be very thorough.

DEAD-ARM.

Dead-arm of grapevines is caused by a wound parasite.[34] The organism, having gained entrance to the trunk or branches of the vine, continues to grow and kill the tissues, forming a dead spot or canker, as shown in figure 66, and finally encircles the whole cane, causing the part of the vine beyond to die. Figure 67 shows a vine in which the fungus has attacked the trunk just above the two lower arms, causing the death of the whole upper portion of the plant. Cankers on dead areas, caused by the fungus, become more or less covered with the small black pustules or fruiting bodies which produce the spores of the fungus.

Magnified views of these fruiting bodies and also of the various spore forms which they produce are shown in the accompanying illustration (fig. 68). This fungus has three spore forms, two sometimes called summer spores and one winter spore form. Most of the new cases of the disease are apparently occasioned by the summer spores which are very abundant. The winter spore form is apparently rare in occurrence.

Fig. 66.—Dead-arm canker on a young vine. The minute black pustules on the dead portion of the canker are fruiting bodies of the fungus.

[34] *Cryptosporella viticola* (Red.) Shear.

This disease is rather common in the vineyards of New York, Pennsylvania, Ohio, and Michigan.

TREATMENT.

Spraying does not prevent this disease. As soon as the first conspicuous symptom of the disease is noticed, which is the development of weak, slender shoots, with small yellowish leaves, as shown in figure 69, an examination should be made of the vine between the

FIG. 67.—Dead-arm disease of grape. The portion of the vine above the lower wire has been killed by the dead-arm fungus. The point of infection is just above the lower trellis wire. The parasite has girdled the vine at this point, causing the death of the portion above.

point of origin of this weak shoot and the next healthy shoot below, in order to locate the diseased spot or canker. Having located the canker, the vine should be cut off far enough below this to be sure of removing all of the infected wood. These prunings should be burned at once.

If the canker forms on the main trunk below the arms, the vine should be cut off near the ground. The root will then send up vigorous, healthy shoots. The disease apparently does not attack the roots.

CROWN GALL OF GRAPE.

Crown gall is a disease caused by a bacterium.[35] This germ is a wound parasite which, after gaining entrance to the root or cane of the vine, causes an abnormal gall, wart, or elongate tumorlike outgrowth, sometimes of considerable size, as shown in figure 70,

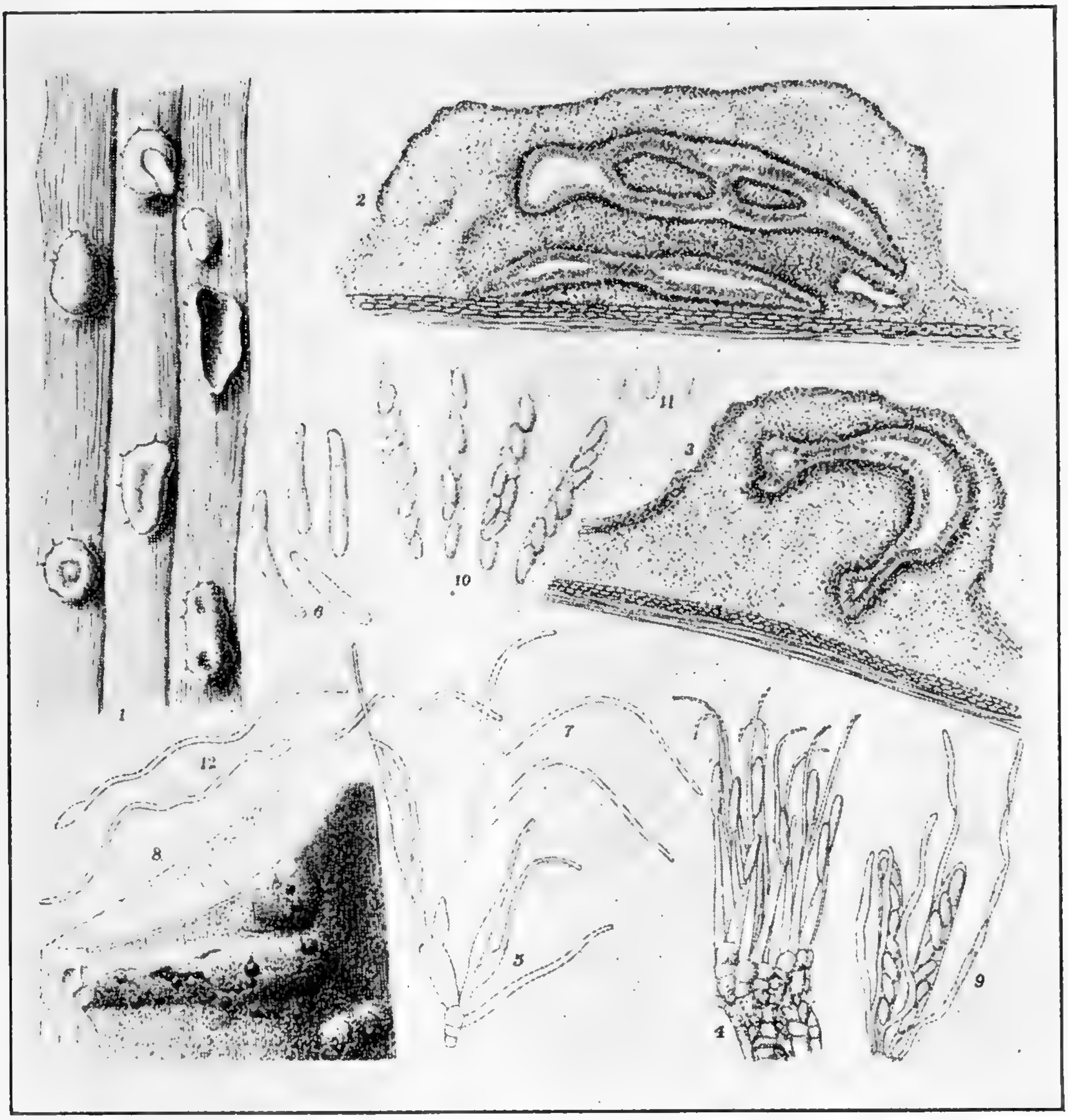

Fig. 68.—The dead-arm fungus. (1) Fruit bodies (pycnidia); (2) Section through one of these fruiting bodies. (3) Another section of smaller fruiting body. (4) Summer spores or pycnospores. (5) Sporophores. (6) and (7) Two forms of spores produced in the pycnidia. (8) Portion of dead cane showing perithecia. (9), (10), and (11) asci and spores from (8). All but (1) and (8) highly magnified.

at other times of smaller size and very numerous, extending along the trunk or branches of the vine.

The larger galls shown in figure 71 are most frequent on the European varieties of grapes which are grown on the Pacific coast and in the Southwest. The smaller and more numerous galls united in elongate masses are the common form on American varieties of

[35] *Bacterium tumefaciens* Smith & Townsend.

grapes in the East. This disease is not common on American varieties and does not usually cause serious loss. It has been most frequently found in heavy or wet, poorly drained spots in vineyards, and may in some cases follow winter injury of the vine.

TREATMENT.

As the germ producing the disease lives in the soil, it can not be controlled by spraying. Diseased plants showing galls at the crown should be dug up and destroyed by burning. Where galls are confined to branches these should be removed far enough below the gall

Fig. 69.—Dead arm of grape. The right arm is nearly killed by the disease. The canker produced by the fungus is located between the terminal, abnormal, weak shoot and the fully developed healthy shoot near the base.

to include all affected tissues. In setting new plants great care should be taken to see that they are entirely free from any signs of swellings or galls on the roots or canes. As this disease also attacks various fruit trees and bushes and other cultivated plants, soil in which such diseased plants have been found should be avoided, if practicable, in planting grapevines.

LESS IMPORTANT DISEASES.

BITTER-ROT

Fruit attacked by bitter-rot[36] presents an appearance very similar to that produced by the ripe-rot. Bitter-rot is no doubt sometimes

[36] Caused by *Melanconium fuligineum* (Scrib. & Viala) Cav.

confused with other diseases. such as ripe-rot and black-rot. It is most frequently found in the Southern States and is not usually serious enough to need special treatment.

Treatment.—Spraying as directed for black-rot will probably prevent this disease.

WHITE-ROT.

The effect of the disease known as white-rot[37] upon the fruit of the grape is somewhat similar to that of the brown-rot form of the downy mildew. It is frequently confused with ripe-rot. It occurs in Missouri and the Southwest, but has not yet been found sufficiently destructive to need special treatment.

ROOT-ROTS.

The roots of the grape are known to be attacked by several different fungi, especially when the root system has become weakened or injured by other causes. Only two forms of root-rot are of sufficient importance to be mentioned here.

VIBRISSEA ROT.

The vibrissea rot[38] is usually associated with insect injury, due either to Phylloxera or to the grape root-worm. It has been found

Fig. 70.—Crown gall on Concord grapes. The numerous wart-like galls are mostly produced on the main stem and larger branches in Eastern vineyards.

[37] Caused by *Coniothyrium diplodiella* (Speg.) Sacc.

[38] Caused by *Vibrissea hypogaea* Ch. Richon & Le Monnier.

in New York, Pennsylvania, and Missouri, and where present appears to hasten the death of plants, especially those injured by the rootworm.

Treatment.—This fungous rot can be prevented only by the destruction of the insects which injure the root system and thus give the fungus opportunity to gain a foothold. (See control of grape rootworm, pp. 42–43.)

OZONIUM ROT.

There is a root-rot of a more serious nature, ozonium rot, prevalent in and chiefly restricted to Texas, New Mexico, and Arizona. This is attributed to a fungus[39] which also attacks the roots of cotton and a great variety of other plants. It is most destructive in the black waxy, clay soils, which are very poorly aerated. Plants attacked die suddenly, the leaves and fruit withering up in a day or two and remaining on the vines.

FIG. 71.—Crown gall on a vinifera grape. The large galls have formed near the crown of the plant just at the surface of the soil.

Treatment.—No remedy is known for this root-rot of the grape. Soil upon which other plants have died with the same disease should be carefully avoided in planting vines, and poorly drained, heavy soils should also be avoided if possible.

SHELLING.

The shelling or dropping of grapes from the bunches before maturity may be due to various causes. In certain localities in New York and Pennsylvania this trouble is rather serious some seasons. The cases which the department has had an opportunity to study have been found to be associated mostly with the dead-arm disease in its early stages. Unfavorable climatic conditions as well as unbalanced nutritive conditions also apparently tend to produce this trouble.

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[39] *Ozonium omnivorum* Shear.

INSECTICIDES.

ARSENATE OF LEAD.

Arsenate of lead is the arsenical principally used in spraying grapes, and the commercial article is probably universally employed. It comes on the market in both powdered and paste forms, though the former is now rapidly replacing the latter. Arsenate of lead is used for the control of biting or chewing insects, such as the grape-berry moth, the grape rootworm, the rose-chafer, various caterpillars, and the like. It can be added to Bordeaux mixture, used for the control of fungous diseases, without reducing its effectiveness, or used alone in water, in which case there should be added to the spray the milk of lime from slaking 2 or 3 pounds of good stone lime for each 50 gallons to obviate danger of burning the foliage.

The powdered arsenate of lead is used on grapes mostly at the rate of 1½ pounds, and the paste form at the rate of 3 pounds per 50 gallons of spray. Before adding the powdered arsenate of lead to the spray tank it should be mixed with a little water. Water should also be added to the paste and the whole worked until of a thin consistency.

NICOTINE SOLUTION.

Nicotine or tobacco extract is used principally for the control of the grape leafhopper and plant-lice. It may be extracted from tobacco refuse by soaking in the full quantity of water, with occasional stirring, for a period of about 24 hours. This removes about 70 or 80 per cent of the nicotine; and after straining to remove coarse particles the solution is ready for use. The nicotine content of tobacco refuse, stems, etc., varies widely, and the number of pounds to use with a given quantity of water to obtain an effective extract can not be accurately indicated without chemical analysis. In general, however, a pound of the refuse for each gallon of water will yield sufficient nicotine for a killing spray. Those especially interested in the utilization of refuse tobacco for spraying purposes should consult Farmers' Bulletin 908, United States Department of Agriculture.

Nicotine is offered for sale in various grades, and a concentrated preparation is the so-called 40 per cent nicotine sulphate, containing 40 per cent of nicotine. The nicotine strength of the commercial articles will not affect their insecticidal value if diluted so that the spray will contain about 0.05 per cent of nicotine. In spraying with homemade tobacco extract or with commercial nicotine solution in water a soap should be added, preferably rosin fish-oil soap, at the rate of 1 pound to 50 gallons of spray. If this soap is not available, 2 pounds of ordinary laundry soap may be used.

ROSIN FISH-OIL SOAP.

Abundant experience has shown that a small amount of soap added to sprays increases their spreading and adhesive qualities. Of the various soaps available the rosin fish-oil soap has proved best and has come into considerable use in sprays for grapes, plums, cranberries, etc. The soap is used at the rate of 1 pound to 50 gallons of spray and may be added to a spray composed of Bordeaux mixture, arsenate of lead, and nicotine sulphate, or used with any one of these, in water.

In the absence of fish-oil soap, ordinary laundry soap may be used at about twice the strength of the fish-oil soap, namely, 2 pounds to 50 gallons of spray.

Soap sprays may also be used for the destruction of various soft-bodied insects, as plant-lice, the leafhopper, etc. For plants in foliage the soap, according to its quality and the insects to be treated, is used at the rate of 1 pound to 3 or 4 gallons of water, or at even greater dilutions. If a fish-oil soap be employed for the treatment of vines during the dormant condition, it should be used at the rate of 2 pounds for each gallon of water, as for the grape scale.

SELF-BOILED LIME-SULPHUR MIXTURE.

The self-boiled lime-sulphur mixture, while primarily a fungicide for the treatment of stone fruits, has come into some use as an insecticide. According to experiments by the New Jersey Agricultural Experiment Station it is effective in preventing injury to grapes by the rose-chafer (pp. 20–23).

Except under special conditions, sulphur sprays should not be used for spraying grapes.

The self-boiled lime-sulphur mixture may be made as follows:

Stone lime	pounds	8, or 2
Sulphur (commercial ground[40] or flowers)	do	8, or 2
Water to make	gallons	50, or 12½

The lime should be placed in a barrel or suitable container and enough water poured on almost to cover it. As soon as the lime begins to slake the sulphur should be added, after first running it through a sieve to break up the lumps. The mixture should be stirred constantly and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

[40] Commercial ground sulphur is the cheaper and is equally as satisfactory as the flowers of sulphur.

The stage at which cold water should be poured on to stop the cooking varies with different grades of lime. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot 15 or 20 minutes after the slaking is completed the sulphur gradually goes into solution, combining with the lime to form sulphids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulphur and lime, with only a very small percentage of the sulphur in solution. It should be strained to take out the coarse particles of lime, but the sulphur should be carefully worked through a strainer. The mixture can be prepared in larger quantities if desired, say, enough for 200 gallons at a time, making the formula 32 pounds of lime and 32 pounds of sulphur to be slaked with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons. Arsenate of lead and nicotine solution may be added to this mixture, exactly as with Bordeaux mixture. Soaps should not be used in lime-sulphur sprays.

KEROSENE EMULSION.

Kerosene emulsion has long served as a standard spray for the control of soft-bodied sucking insects, especially aphids or plant-lice. If well made and properly diluted it will give satisfactory results for this purpose. *It should never be combined with lime sulphur.*

A good stock solution of kerosene emulsion containing 66 per cent of oil may be made according to the following formula:

Kerosene (coal oil, lamp oil)	gallons	2
Fish-oil or laundry soap (or 1 quart soft soap)	pound	½
Water	gallon	1

First dissolve the soap in boiling water, then remove the vessel from the fire. Immediately add the kerosene and thoroughly agitate the mixture until a creamy solution results. The stock solution may be more conveniently made by pouring the mixture into the tank of a spray pump and pumping the liquid through the nozzle back into the tank for some minutes. The stock solution, if properly made, should last for some time, but it is better to make it up as needed. Do not dilute until ready to use. To make a 10 per cent spray (the strength for trees in foliage) add for each gallon of the stock solution about $5\frac{2}{3}$ gallons of water. For 20 and 25 per cent emulsions (for use on dormant vines) use, respectively, about $2\frac{1}{3}$ and $1\frac{2}{3}$ gallons of water for each gallon of stock solution. Agitate the mixture in all cases after adding the water.

The preparation of the emulsion may be simplified by the use of a naphtha soap. No heat will be required, as the kerosene will combine readily with the naphtha soap in water when thoroughly agitated. If naphtha soap is used, twice as much will be required as is given for the other kinds of soap in the foregoing formula, and soft or rain water should be used in making the emulsion. In regions where the water is "hard" this should first be "broken" with a little caustic potash or soda, or common lye, before use for solution, to prevent the soap from combining with the lime or magnesia present, thus liberating some of the kerosene; or rain water may be employed.

FUNGICIDES.

BORDEAUX MIXTURE.

The form of Bordeaux mixture which has been found most effective in the control of grape diseases is composed of 4 pounds of bluestone (copper sulphate) and 3 pounds of stone lime to 50 gallons of water. To prepare Bordeaux mixture for use in an ordinary barrel sprayer, dissolve 4 pounds of bluestone in 25 gallons of water and in a separate container slake 3 pounds of stone lime and dilute to 25 gallons; then pour these solutions simultaneously through a strainer into the spray barrel and stir thoroughly. When a considerable number of vines are to be sprayed it will be most convenient and economical to prepare the bluestone and lime in the form of stock solutions by dissolving in a barrel a quantity of bluestone at the rate of 1 pound to 1 gallon of water. The bluestone should be suspended in a sack in the upper part of the barrel or other wooden container so that it is just beneath the surface of the water. It will dissolve if left overnight in cold water and more quickly if hot water is used. Stock solutions of lime are made by slaking the desired quantity of lime in a small quantity of water and then diluting so that 1 gallon of water contains 1 pound of the lime.

Before using the stock solutions, especially the lime, they should be thoroughly stirred. To prepare 50 gallons of Bordeaux mixture from the stock solutions, take 4 gallons of stock solution of bluestone and 3 gallons of stock solution of lime. If any other form of lime than good stone lime is used it will probably be necessary to use 4 pounds to 50 gallons, especially when arsenate of lead is also used. Dilute them in separate containers and pour them together into the spray tank. Unless the solutions are diluted at the time they are poured into the spray tank, it is necessary to agitate the mixture thoroughly as the materials are being poured in. A very satisfactory Bordeaux mixture can be made by pouring the stock solution of bluestone into the sprayer tank which has been filled three-fourths full of water, then pouring the lime stock solution through the strainer, adding enough water to fill the tank and keeping the agitator working. The important thing in making good Bordeaux mixture is to stir or agitate the materials sufficiently as they are mixed to afford an opportunity for the proper combination of the lime and bluestone.

BORDEAUX MIXING PLANTS.

When using Bordeaux mixture in large quantities much time may be saved if arrangements are made for convenient handling of the

FIG. 72.—Bordeaux mixing plant.

stock solutions and the water needed. Figure 72 shows an arrangement for rapid preparation of Bordeaux mixture. Various modifications of this plan can easily be devised to suit the conditions and requirements in any particular case. The main feature is to have the lime, bluestone, and water arranged on platforms or in tanks high enough so that the solutions may be handled by gravitation. The water supply tank should be on the upper platform and connected by pipes to dilution barrels, which may be connected by 3 or 4 inch pipes with a flexible hose through which the Bordeaux mixture may be conducted into the spray tank below. By the side of each of these dilution tanks a 50-gallon barrel, one containing stock solution of bluestone and the other stock milk of lime, should be placed. Each gallon of stock solution should contain 1 pound of bluestone or 1 pound of lime.

To make 200 gallons of Bordeaux mixture, 4–3–50 formula, with a mixing plant of this type, dip out 12 gallons of well-stirred stock milk of lime and pour into the lime dilution barrel or tank and pour 16 gallons of stock bluestone solution into the bluestone tank. Then fill each of these tanks to the 100-gallon mark by running in water from the storage tank above or whatever the most convenient source of water supply may be. The stopcocks of the dilution tanks may be opened then so that the diluted lime and bluestone may run together through the discharge pipe and into the spray tank, the opening of which should be covered by a good brass wire strainer in order to remove any sediment or dirt present and avoid clogging of the spray nozzles. If more convenient, water may be pumped directly into the sprayer tank until it is three-fourths full. Then add the stock solution of bluestone, after which the stock lime may be added, diluting as necessary to make it pass through the strainer and fill the sprayer tank. While the lime is being added the agitator should be kept running in order to insure thorough mixing of the ingredients. If thoroughly agitated, a Bordeaux mixture made in this way is entirely satisfactory.

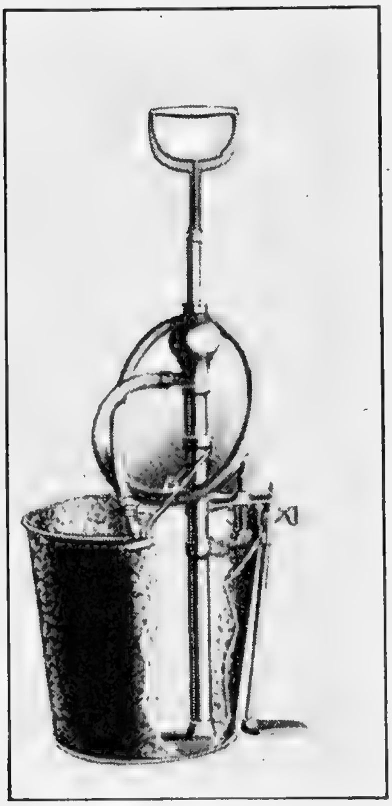

FIG. 73.—Bucket spray pump.

NEUTRAL COPPER ACETATE.

Neutral copper acetate, or basic copper acetate, dissolved at the rate of 1 pound to 50 gallons of water, has been found to be the best nonstaining preparation for use on grapes when nearly mature.

SPRAYERS.

BUCKET PUMPS.

Bucket pumps (fig. 73) are convenient for spraying small gardens and shrubs or a few small trees. They should be made of brass or other noncorrosive metal and preferably equipped with an agitator. In some of these pumps agitation is provided by means of a small jet of liquid that is forced from the bottom of the pump through the mixture as the pump is operated. For convenience in use these pumps may be clamped to the bucket or used free in a tub or other vessel containing the spray material. They should be supplied with a spray rod and sufficient hose to reach conveniently all parts of the plants to be sprayed.

SMALL COMPRESSED-AIR PUMPS.

Compressed-air pumps (fig. 74) are frequently used in small fruit gardens and are preferred to the bucket pump by those who do not wish to pump while applying the spray. These pumps are usually made of brass or galvanized sheet steel and have a capacity of 3 to 4

FIG. 74.—Compressed-air sprayer.

gallons. They are carried by means of a shoulder strap. In the better types agitation is provided by the entrance of the air at the bottom of the tank. After the spray material is poured into the tank and the opening closed by an air-tight cap, the air is pumped until the liquid is under sufficient pressure. The tank is usually emptied by three or four pumpings of a dozen strokes each.

BARREL PUMPS.

The barrel hand-pump outfit (fig. 75) has a capacity of about 50 gallons and is widely used for the fruit or the home orchard, small vineyard, and fruit garden. The pump should be provided with an efficient agitator, either of the paddle or rotary type. To insure sufficient pressure and uniform discharge of the spray material, the pump should be provided with an adequate air chamber to which a pressure gauge may be attached if desired. The pump may be mounted either on the head or side, and the whole outfit placed on a cart or sled or wagon.

SPRAYING OUTFITS FOR LARGE OPERATIONS.

Spraying outfits for large vineyards are generally operated by gasoline engines, although traction sprayers and compressed-air outfits are sometimes used.

GASOLINE POWER SPRAYERS.

Spraying outfits operated by gasoline engines are by far the most useful type of sprayer and are made in various sizes and styles to suit almost any requirement. Special outfits have been designed for vineyard spraying. Some have a series of fixed nozzles attached at either side at the rear. These may give satisfaction for spraying when the vines are young and all parts can be easily covered. After the fruit is set, however, it is necessary to use an outfit operated with trailers, that is, long leads of hose having the nozzles directed by hand, as shown in figure 76. With a small power outfit a one-leader hose is generally used. Two leads may be employed with a pump of sufficient capacity to keep up the necessary pressure. Large power sprayers are made with pumps of from two to four cylinders, having a capacity of 5 to 15 or more gallons per minute under a pressure of 150 to 300 pounds. These sprayers are equipped with engines of from 2 to 4 horsepower.

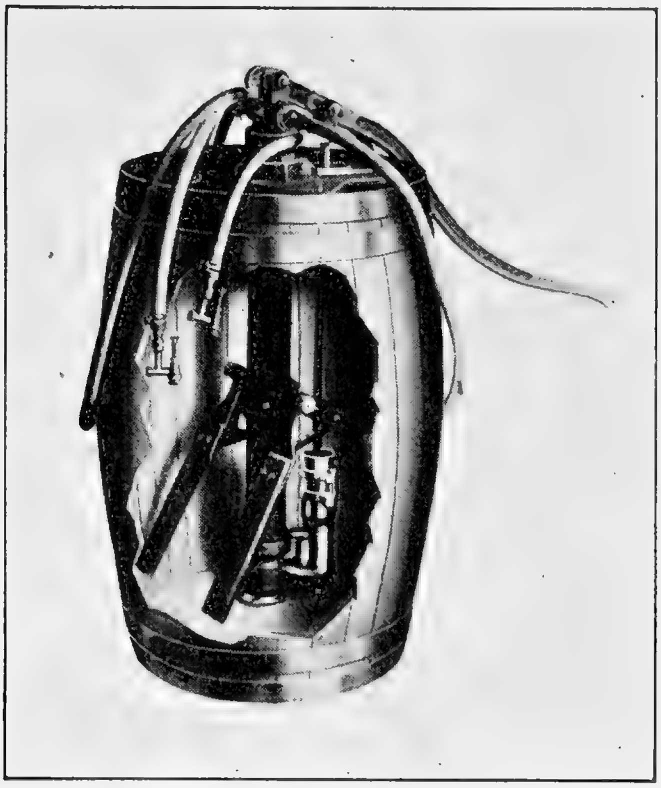

Fig. 75.—Barrel-spray pump.

The various spraying outfits now on the market differ much in durability and efficiency. The fruit grower, therefore, before selecting an outfit should study carefully the various kinds and determine by observation and inquiry from users which outfit will best meet his requirements.

DUSTING APPARATUS.

Apparatus of various styles adapted to a wide range of use for applying insecticidal and fungicidal dusts is available on the market.

FIG 76.—Gasoline power grape sprayer, illustrating the so-called trailer method of applying the spray.

For use in a small vineyard a small hand-duster similar to that shown in figure 77 would be sufficient. Power dusters of various sizes are also available for larger operations.

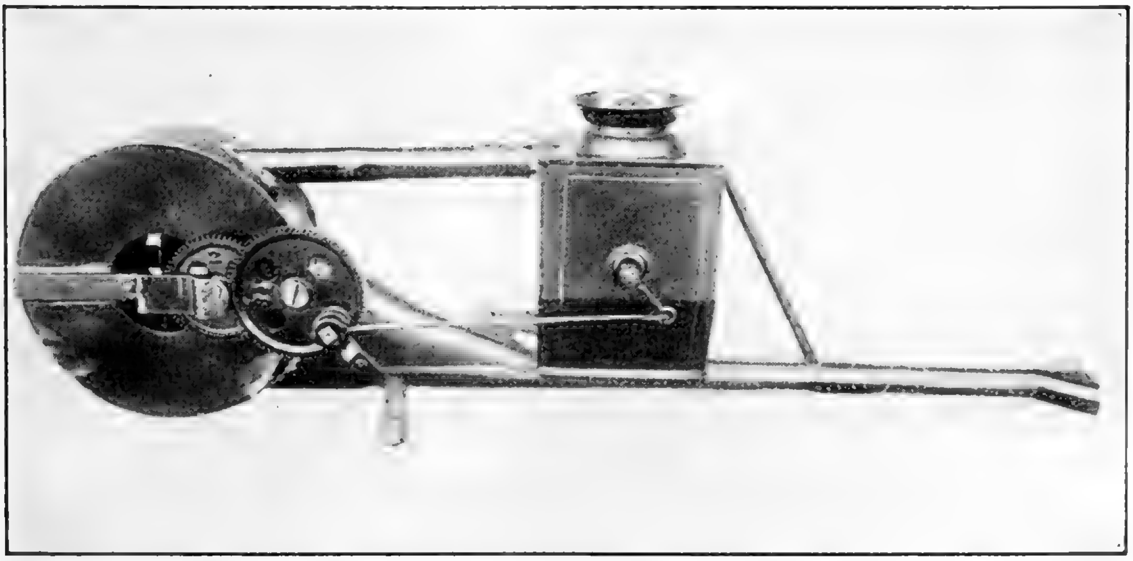

FIG. 77.—Hand duster for applying dust mixtures in the fruit garden.

SPRAYING ACCESSORIES.

SPRAY NOZZLES.

The disk-whirlpool type (fig. 78) of spray nozzle is extensively employed by commercial fruit growers and is well adapted for use with vineyard outfits. These nozzles are provided with interchangeable disks, each having a different sized opening to give a fine, medium, or coarse spray. For rapid spraying with outfits having sufficient capacity and pressure, two nozzles may be used on each spray rod. These may be attached by means of a Y.

FIG. 78.—Angled nozzle of the eddy-chamber of whirlpool-disk type.

STRAINERS.

To avoid trouble and delay from clogging of nozzles it is necessary thoroughly to strain the mixture as it is put in the sprayer. A strainer such as is shown in figure 79 is convenient for this purpose. The brass-wire screen should be 20–22 mesh to the inch.

GRAPE-SPRAYING SCHEDULE.

FIRST APPLICATION.

About a week before the blossoms open, or when the new shoots are from 12 to 18 inches long, spray with Bordeaux mixture 4–3–50 (pp. 68–70) for fungous diseases, adding 2 to 3 pounds of arsenate of lead paste, or one-half that quantity of the powdered form, for the flea-beetle, rose-chafer, etc.

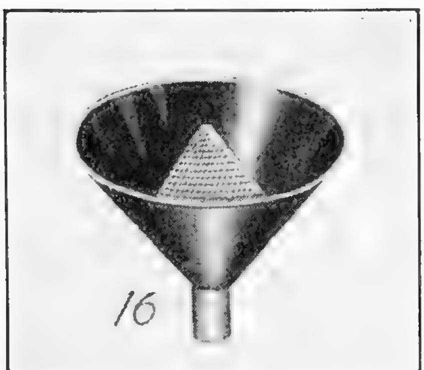

FIG. 79.—Strainer for use in removing sediment in sprays when being poured into the spray tank.

SECOND APPLICATION.

Just after the blossoms fall spray with the same materials as in the first application for the same fungous disease and insects and also for the grape-berry moth, grape leafhopper, and the adults of the grape rootworm, using the "trailer" method (p. 73, fig. 76).

THIRD APPLICATION.

About two weeks later use Bordeaux mixture 4–3–50, arsenate of lead paste 2 to 3 pounds (or one-half quantity of powdered arsenate of lead), 40 per cent nicotine sulphate ¼ pint, and 1 pound rosin fish-oil soap to 50 gallons of spray mixture for fungous diseases, the berry moth, eight-spotted forester, grape leaf-folder, grapevine aphis, grape rootworm, and grape leafhopper. To destroy the leafhopper direct the spray against the lower surface of the leaves. To control the berry moth thoroughly coat the grape bunches with the spray, directing the spray nozzle by hand.

FOURTH APPLICATION.

About 10 days later, or when the fruit is nearly grown, if black-rot, mildew, or ripe-rot are still appearing, spray with 4–3–50 Bordeaux mixture, or if there is danger of the Bordeaux mixture adhering to the fruit when picked use neutral copper acetate or verdigris at the rate of 1 pound to 50 gallons of water, adding 1 pound of commercial rosin fish-oil soap. In severe cases of black-rot and ripe-rot a fifth application may be necessary, in which case the period between the earlier applications should be somewhat shortened and neutral copper acetate solution used. To secure satisfactory results the spraying must be timely and thorough so as to cover as nearly as possible the entire surface of the foliage and fruit with a fine spray.

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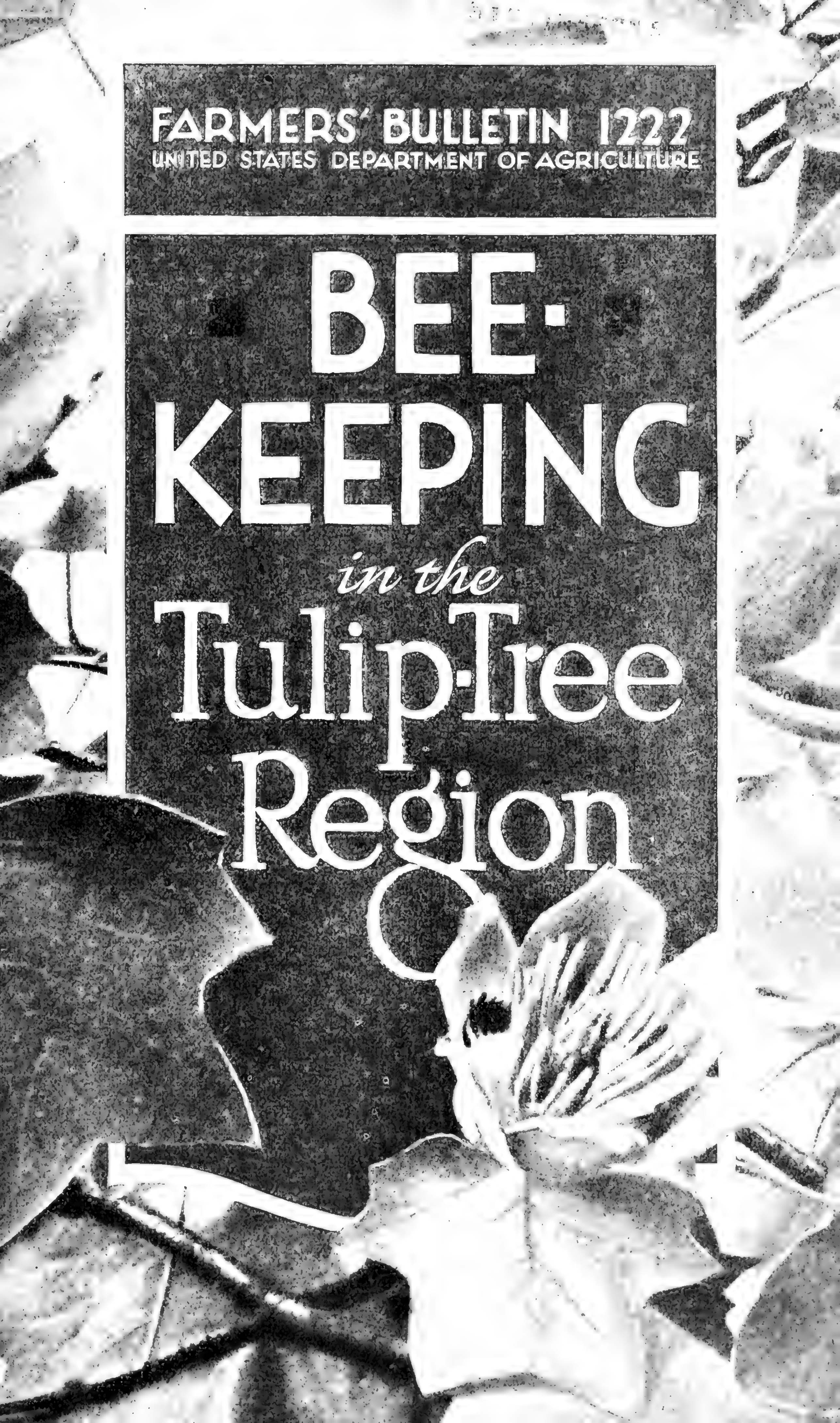
FARMERS' BULLETIN 1222

UNITED STATES DEPARTMENT OF AGRICULTURE

BEE-KEEPING

in the

Tulip-Tree Region



MANY THOUSAND colonies of bees occur in the region where the tulip-tree is abundant but the honey crop from tulip-tree flowers is inconsiderable. Too few beekeepers in this region have modern equipment, it is true, but the greatest loss comes from the fact that they do not care for their bees so as to have them ready to gather the abundant nectar from this early-blooming tree.

In this bulletin a method is given for the management of the apiary so that the full honey crop from this source may be obtained.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

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BEEKEEPING IN THE TULIP-TREE REGION.

E. F. Phillips, *Apiculturist*, and George S. Demuth, *Apicultural Assistant, Bee-Culture Investigations.*

CONTENTS.

The tulip-tree is one of the most dependable early sources of nectar throughout a wide region. It is not, however, the source of much honey at present, for most beekeepers of the section in which this tree is found fail so to manage their bees that they are ready and able to get its vast store of nectar. A lack, in American beekeeping literature, of descriptions of the methods especially applicable to this region is perhaps the chief cause of this loss. The object of this bulletin, therefore, is to outline the practices which will enable the beekeepers of the region to take full advantage of this source. It has been thought best to describe a single successful system, rather than several methods for each phase of the work.

The tulip-tree[1] is also known locally as tulip-poplar, yellow-poplar, blue-poplar, white-poplar, whitewood, cucumber-tree, saddle-tree, saddle-leaf, hickory-poplar, and erroneously as linn-tree, basswood, and lime-tree. It is, of course, quite unlike the basswood.[2] The name "yellow-poplar" is used almost exclusively in the lumber trade. The tulip-tree belongs to the same plant family as the magnolias and is the most northern representative of that family.

GEOGRAPHICAL BOUNDARIES OF THE TULIP-TREE REGION.

The tulip-tree is occasionally found as far north as Vermont and Rhode Island, and west to Michigan, Arkansas, and Louisiana, as indicated in figure 1. On the outer limits of its distribution it is not

[1] *Liriodendron tulipifera*, family Magnoliaceae.
[2] *Tilia americana*.

abundant. It is more abundant on the south shore of Lake Erie. It is rare west of the Mississippi River, except in northeastern Arkansas and southeastern Missouri. It is most abundant and the

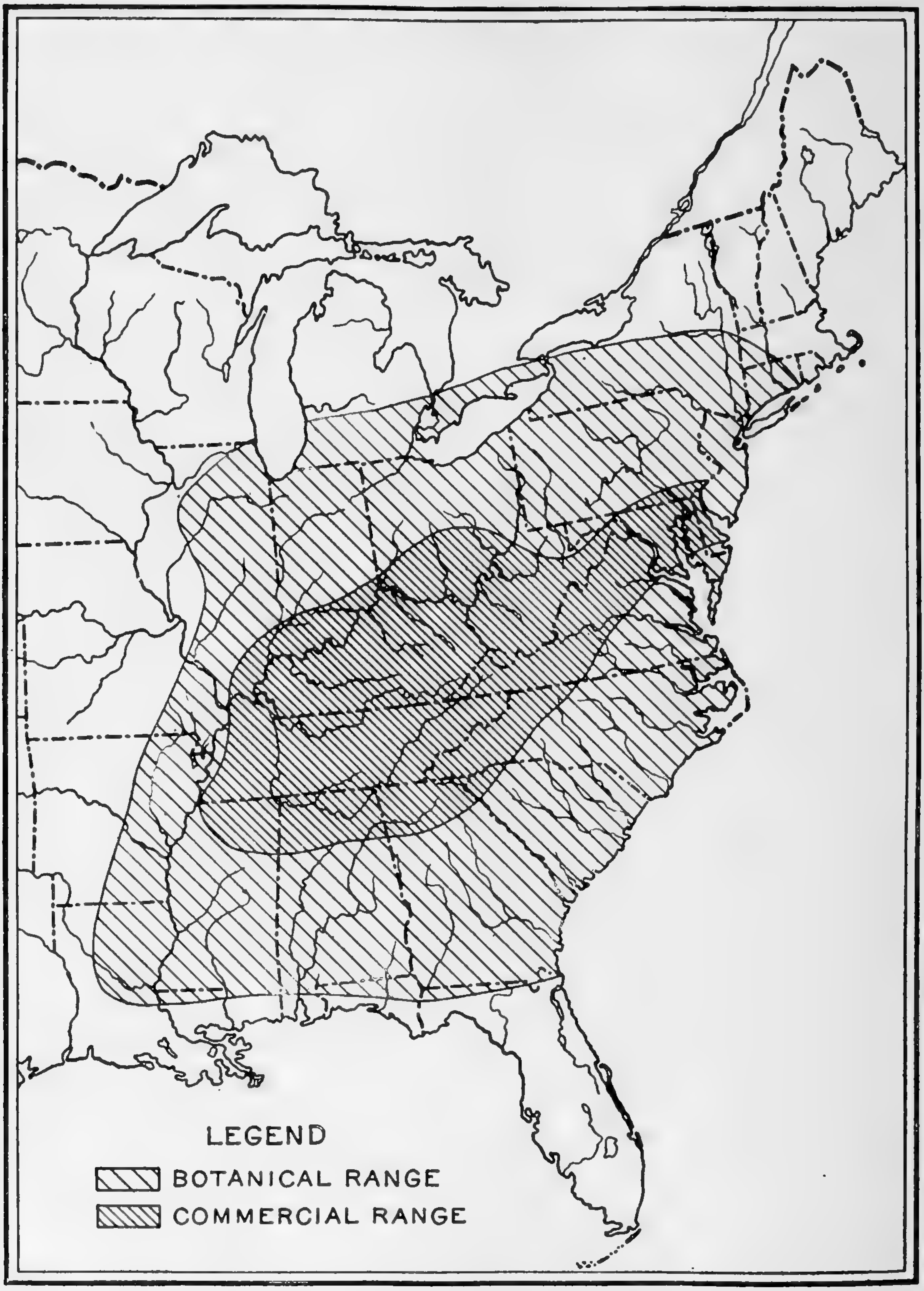


FIG. 1.—Map showing distribution of tulip-trees in the United States. In the heavily shaded area these trees are usually sufficiently abundant to furnish surplus honey. (From data furnished by the Forest Service, United States Department of Agriculture.)

trees are larger in the south-central portion of its range, especially in Tennessee, Kentucky, the western portion of the Carolinas, and in the Ohio River basin. It is common throughout the Piedmont

Plateau in Maryland and Virginia. In the outer limits of its distribution it is found as single trees or in small groups; and it is rarely the dominant forest tree except in the South and under favorable conditions. The tulip-tree beekeeping region may be considered as restricted to those places where it is a common tree, the area being roughly indicated in the closely shade area in figure 1. The tree is, of course, not equally abundant throughout this area.

VARIATIONS WITHIN THE REGION.

The variation in the number of trees of this species within the geographical range has already been mentioned. The trees vary also in size, being larger and more thrifty in those parts of the region where it is more abundant numerically. Beekeepers in regions where the tree is not common rarely list it among the honey-plants, and it is quite possible that in these places the individual flowers do not secrete nectar quite so profusely. No accurate information is available as to any differences in the amount and character of the nectar due to differences in soil. So far as known, the nectar is always dark in color and the resulting honey is somewhat strong in flavor, the variation observed in the nectar of other honey-plants not being observed in this case.

RELATION TO OTHER BEEKEEPING REGIONS.

The northern limits of the tulip-tree are in the clover region, but the tree is most abundant in those parts of the country where white and alsike clovers are not reliable sources of honey. The tulip-tree extends southward into the sourwood [3] region of the southern Appalachian Mountains and is common in some parts of the Coastal Plains of the South, where the tupelo and black gums,[4] gall-berry,[5] and titi [6] are the chief sources. As a rule the tulip-tree region is not coincident with any region where a leguminous plant is the chief source of honey, and in the other regions mentioned tulip-trees are not sufficiently abundant to be considered a main honey source. Since the tulip-tree is found throughout the entire range of sourwood, the modifications of beekeeping practice to obtain sourwood honey will be mentioned later. As the tulip-tree is such an important source of early nectar, the region is one in which the beekeeper will wish to choose methods that will enable him to get all the honey possible from this source.

CHARACTERISTICS OF THE TULIP-TREE.

The tulip-tree is a magnificent forest tree, growing at times to a height of 125 feet and a diameter of 5 to 6 feet. The leaves are large

[3] *Oxydendrum arboreum.* [4] *Nyssa* spp. [5] *Ilex glabra.* [6] *Cyrilla racemiflora.*

and broad, truncate or broadly notched at the apex, with two apical and from two to four basal lobes. The flowers (see title page) are large and erect, with greenish-yellow petals, and are orange-colored within, their resemblance to the flowers of the cultivated tulip giving the tree its common name. Few flowers are more beautiful, but usually they are so high on the branches of tall forest trees that not many persons are familiar with them. The flowers open about three weeks after the average date of the last killing frost in the spring and the blooming period seldom exceeds two weeks. As the flowers wither the petals are gradually reflexed and the flower somewhat loses its resemblance to the tulip. The fruit is a cone about 3 inches long, somewhat resembling a cucumber, hence the common name "cucumber-tree." The trees are badly injured by fires, even when mature.

The tulip-tree has been extensively lumbered wherever it is abundant, and this has doubtless worked a hardship to beekeeping in these regions, but young trees are constantly coming on where conditions are favorable and the region is not permanently injured for beekeeping. Trees begin blossoming when about 15 years old.

The tulip-tree is exacting in its soil and moisture requirements, although it is found under a variety of conditions. The best conditions for growth are a deep, fertile soil, well drained but with constant soil moisture. The tree thrives on moist loam and on rich sandy soils with abundant humus. It does poorly on heavy clay, on dry ridges, or in standing water. It is rare in river swamps, on the serpentine barrens, in lowland forests, in meadows with compact soil, and on hill and mountain tops. On Parrs Ridge, near Westminster, Md., it is scarce, although on near-by hills it constitutes 20 per cent of the forest stand, the rock on Parrs Ridge being igneous with some limestone. The tree is at its best on slopes and in protected coves along water courses and usually on the north and east exposures. It rarely grows in solid stands, but is usually in association with chestnut, oaks, walnuts, hickory, maples, and beech, and sometimes, but infrequently, with pines. In Maryland, the area with which the writers are most familiar, it is found from almost sea level to the mountain slopes of the western part of the State, but it is not found in the mountains in the western part of the State in locations similar to those farther east where it is abundant. Climatic conditions are probably important in its distribution, for it seems to thrive only in those locations where the average length of the annual growing season is over 150 days. Its distribution has been greatly modified by agricultural operations in the regions where agriculture is prosperous, for in some Maryland counties little more than 10 per cent of the land is in forest.

The tulip-tree is one of the finest trees native to America. The foliage is handsome, and it is a clean tree. It is relatively free from insect attacks, although in some localities it is the host of abundant plant-lice which secrete honeydew. This is unfortunate from the standpoint of the beekeeper, and it discolors the leaves somewhat, detracting from their beauty. The reader is referred to Forest Service Circular 93 for information concerning this tree, it being called yellow poplar by the Forest Service.

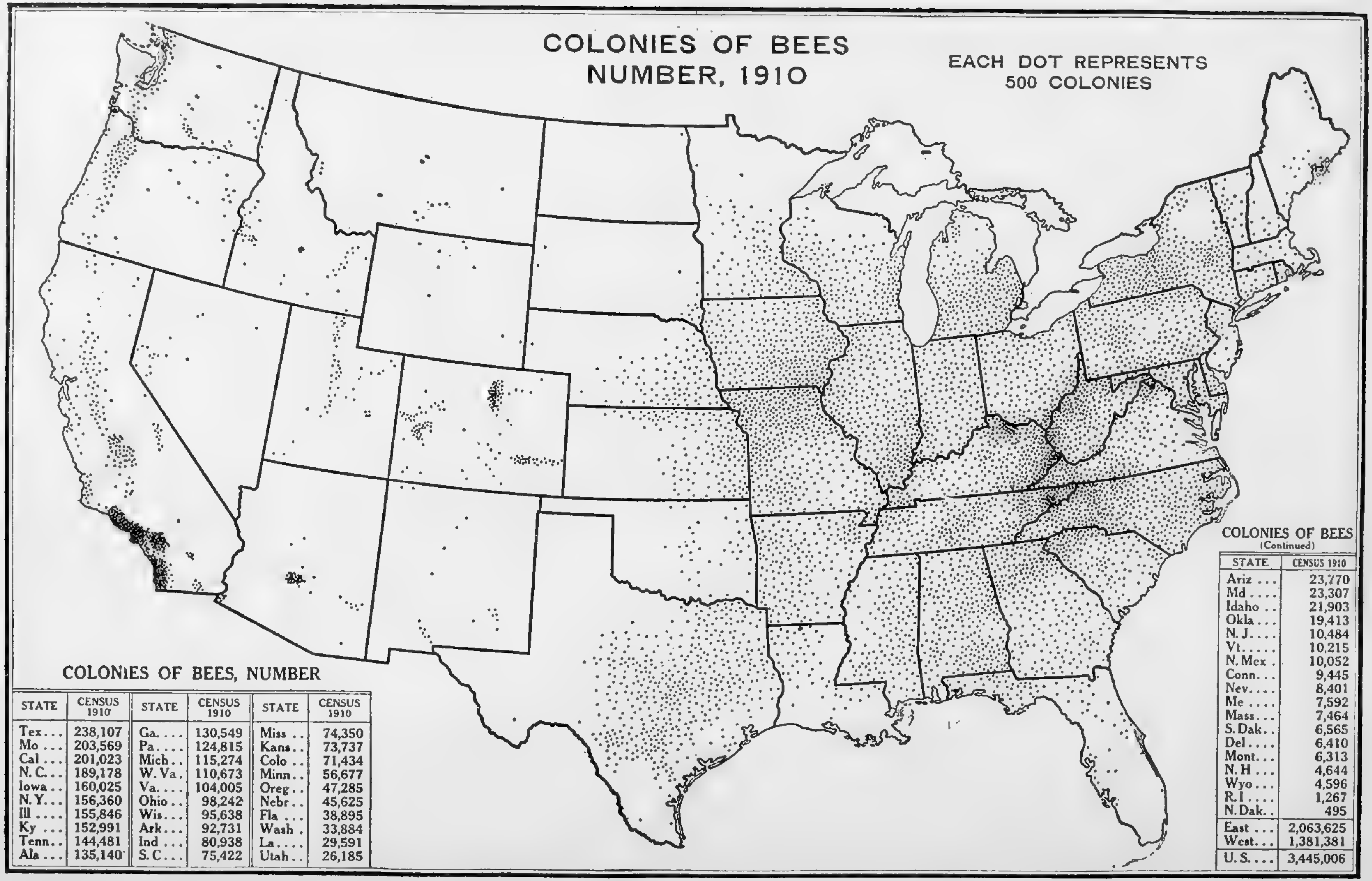
PRESENT DEVELOPMENT OF BEEKEEPING IN THE REGION.

The area where the tulip-tree is abundant enough to constitute an important source of honey is not, as has been stated, one where beekeeping is well developed. This is due in part to a failure by the beekeepers to recognize the value of this tree, but especially to a failure to practice those methods which will permit the bees to be in the right condition to get a full crop from this species. Furthermore, beekeeping has not developed so rapidly in the Southern States as in the North and West, and there are still many colonies of bees kept in box-hives and "gums" in this territory, probably the majority of the colonies being so housed. While bees are more abundant in this area than in any other large area of the United States (fig. 2), beekeeping is not so progressive, and there are few commercial beekeepers devoting their chief attention to this branch of industry. According to Jones,[7] the tulip-tree now supplies only 2.8 per cent of the total honey-crop of the country, whereas if the region were adequately developed it could produce as much honey as the clover region now produces. Especially in those places where the honey resources are augmented by nectar from sourwood or some other plant which furnishes nectar later in the season, there is opportunity for the development of extensive beekeeping operations, and wherever the tulip-tree secretes nectar as freely as it does near Washington, D. C., commercial beekeeping could be conducted profitably, even if this were the only major source of nectar.

PECULIARITIES OF THE REGION.

One of the difficulties encountered in the tulip-tree region is that practically nothing has been published concerning this plant from the standpoint of the beekeeper and there is little to guide the prospective honey-producer except his own experience. Under such circumstances it is little wonder that so small an amount of honey from this source is now produced. The usual beekeeping practices of the

[7] Department Bulletin 685.



COLONIES OF BEES, NUMBER

STATE	CENSUS 1910	STATE	CENSUS 1910	STATE	CENSUS 1910
Tex...	238,107	Ga....	130,549	Miss ..	74,350
Mo ...	203,569	Pa....	124,815	Kans..	73,737
Cal ...	201,023	Mich..	115,274	Colo ..	71,434
N.C...	189,178	W. Va..	110,673	Minn..	56,677
Iowa ..	160,025	Va....	104,005	Oreg..	47,285
N.Y...	156,360	Ohio ..	98,242	Nebr..	45,625
Ill	155,846	Wis...	95,638	Fla ...	38,895
Ky ...	152,991	Ark...	92,731	Wash .	33,884
Tenn..	144,481	Ind ...	80,938	La....	29,591
Ala ...	135,140	S.C...	75,422	Utah..	26,185

COLONIES OF BEES (Continued)

STATE	CENSUS 1910
Ariz ...	23,770
Md	23,307
Idaho ..	21,903
Okla ...	19,413
N.J....	10,484
Vt.....	10,215
N. Mex .	10,052
Conn...	9,445
Nev....	8,401
Me	7,592
Mass...	7,464
S. Dak..	6,565
Del	6,410
Mont...	6,313
N.H ...	4,644
Wyo ...	4,596
R.I....	1,267
N. Dak..	495
East ...	2,063,625
West...	1,381,381
U.S....	3,445,006

FIG. 2.—Map showing distribution of colonies of bees according to data furnished by the census of 1910. The tulip-tree region is abundantly supplied with bees.

clover region will not serve to bring full results where the tulip-tree is the chief source of honey, although the later and better methods applicable to the clover region are suitable for maximum honey-crops from the tulip-tree, or, in fact, from almost any early honey-source whatever. Beekeeping methods applicable to the wild raspberry region of the North perhaps most nearly approach those needed for the tulip-tree region. The lack of literature concerning the tulip-tree as a honey-plant is a serious one and the chief object of this bulletin is to make up this deficiency.

As the tree blooms so early in the spring, there is little time for the bees to get in proper condition for the gathering of the tulip-tree honey-crop. In this region brood-rearing normally begins between February 15 and March 1, although in unprotected and poorly protected colonies it may begin as early as January. The reason for the earlier beginning of brood-rearing in poorly protected colonies is fully explained in the bulletins of the Department of Agriculture devoted to the wintering of bees. Those colonies which begin brood-rearing too soon are usually so weakened by this unseasonable work that they are not able to get to full strength by the time the tulip-tree blooms, and it is therefore advantageous to retard brood-rearing by protection until the normal time. After it is once started it is to the advantage of the bees and of the beekeeper that it progress as rapidly as possible. A failure to have colonies strong at the beginning of the tulip-tree bloom is the cause of the loss of tons of honey from this source annually.

It will be seen that the proper protection of the bees during the winter becomes a serious problem in this section; in fact, it is more important here than in many parts of the country much farther north. Adequate stores must be provided in the spring, and this is frequently not done. It is also evident that after brood-rearing begins it must progress rapidly, and only a good, prolific young queen can lay the eggs necessary for such a rapid development of the colony strength. Since beekeeping has not been so advanced in this region, it is not surprising to find that most of the bees are inferior blacks or hybrids with but a small amount of Italian blood. These scrub queens may begin egg-laying at the right time and at a good rate, but they often fail and are unable to keep up the pace of egg-laying demanded to get the tulip-tree honey-crop. More detailed methods for remedying these defects will be discussed later.

From what has been said it is evident that the production of a full crop of honey from the tulip-tree demands a high degree of skill on the part of the beekeeper. The chief reasons for failure in this region are poor wintering, inferior queens, and generally poor beekeeping, with box-hives.

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TYPE OF HONEY TO BE PRODUCED.

It has been pointed out that the honey from the tulip-tree is dark amber in color and of strong flavor. Such a honey should not be put on the market in the form of comb-honey; extracted honey alone should be produced from this source. Some beekeepers now produce bulk comb-honey ("chunk honey") in this region, but as beekeeping advances there will be a tendency for this type of product to disappear. The honey-flow from the tulip-tree is short, and, as it comes so early in the season, comb-honey production with profit would tax the beekeeper's skill. Unfortunately most beekeepers when taking up modern beekeeping with movable-frame hives get equipment suitable for comb-honey production. Profitable comb-honey production requires more skill than does the production of extracted honey, and it may therefore better be left to the skilled beekeepers. Dark honeys should be extracted, as the general honey markets demand light-colored comb-honeys. There is no demand for bulk comb-honey in the larger honey markets.

OTHER PLANTS IN THE REGION WHICH FURNISH NECTAR.

Throughout the range of the tulip-tree other plants add to the beekeeper's profits. The black locust [8] is found in open fields throughout the area, blooming at the same time or a little later than the tulip-tree. Sourwood,[9] which does not bloom until July, is abundant in the foothills of the Southern States. In a few localities the clovers contribute somewhat to the honey resources, blooming soon after the tulip-tree has ceased. Asters [10] and goldenrods [11] are usually abundant in the fall, in some localities furnishing surplus honey. The linden or basswood [12] is occasionally encountered in the mountains, blooming after the tulip-tree has ceased. Viper's bugloss or blueweed [13] is valuable in the Shenandoah Valley and in the surrounding hills, blooming in August. Buckwheat [14] is grown to some extent in the mountain regions of West Virginia and North Carolina and offers a supply of nectar for the bees long after the tulip-tree has ceased; it usually blooms in August. Fruit bloom, red-bud,[15] persimmon,[16] sweet clover [17] in limited areas, willowherb,[18] holly,[19] sumac,[20] smartweed [21] and Spanish needle [22] are also sources of honey in the chief range of the tulip-tree. In some parts of the tulip-tree region cotton contributes some nectar.

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[8] *Robinia pseudacacia.*
[9] *Oxydendrum arboreum.*
[10] *Aster* spp.
[11] *Solidago* spp.
[12] *Tilia* spp.
[13] *Echium vulgare.*
[14] *Fagopyrum esculentum.*
[15] *Cercis canadensis.*
[16] *Diospros virginiana.*
[17] *Melilotus officinalis.*
[18] *Chamaenerion angustifolium.*
[19] *Ilex opaca.*
[20] *Rhus* spp.
[21] *Polygonum* spp.
[22] *Bidens* spp.

Little modification in beekeeping practices is necessary where the beekeeper has one or more of these plants as important honey sources in addition to the tulip-tree. Some beekeepers in the mountains utilize honey from the tulip-tree for brood-rearing, because the honey is dark and brings a lower price than does that from sourwood. Since to get a crop from the tulip-tree requires that the colonies be strong unusually early, the chief difficulty is in keeping the bees from swarming during the tulip-tree bloom and in keeping up the colony strength until July by continued brood-rearing. Swarm-control methods are given farther on. The continuation of egg-laying may best be insured by frequent requeening from prolific stock. If it is desired to use the tulip-tree honey for brood-rearing, it should be taken from the hives before any lighter honey is gathered and should especially not be in the hives during the blooming period of the sourwood, for if the light honey is mixed with the dark the market value is reduced. The black locust is a valuable source of white honey when the weather is good during the blooming period of a few days, but its secreting period so nearly coincides with that of the tulip-tree that it is rarely possible to get that honey separately.

EQUIPMENT RECOMMENDED.

Many beekeepers in the region where the tulip-tree thrives have their bees in "gums" and box-hives, and it can not be too strongly recommended that these be transferred as rapidly as possible to modern movable-frame hives. For methods of transferring, see Farmers' Bulletin 961. The complaint is often heard in this region that the "patent gums," as movable-frame hives are often called, are too expensive, but it will pay any thoughtful beekeeper to borrow the money to buy the better hives if this is necessary. The advantage of being able to handle the bees far outweighs the cost of equipment. The 10-frame Langstroth hive, now manufactured by all factories making beehives, is the one best suited to the practices here given for beekeeping in this region. This hive is not patented. Care should be exercised to get accurately made hives and frames. The spacing of the frames should be accurate and the parts of all hives should be interchangeable. It should be emphasized that transferring bees to modern hives will not be profitable unless the bees are then properly cared for. If neglected, they will probably not do so well in new hives as they did in the "gums."

The combs of the brood chamber should be all of worker-sized cells. This condition may be obtained best by the use of full sheets of comb-foundation, and no beekeeper of this region can afford to use merely starters of foundation. The frames should be carefully wired to strengthen the combs. Detailed directions for arranging the sheets of foundation in the frames and for wiring are given in Farmers' Bulletin 447 and in still greater detail in the books on beekeeping. Even when full sheets of worker foundation are used, there will be a tendency for the foundation or the combs to sag, leaving several rows of imperfectly formed cells at the top of the frame. The beekeeper should constantly sort out imperfect combs and use them for the supers. Extra care should be exercised to see that only perfect combs are placed in the lower one of the two hive-bodies during the winter, in order that the queen may pass easily from the second to the first story during the period of brood-rearing previous to the time of unpacking.

As has been stated, most of the bees of this region are of the inferior German or black stock, and this race should be eliminated as rapidly as possible. It has no desirable quality, except that the capping on the combs is whiter as a rule than that made by Italian bees. This is not a matter of moment in the production of either extracted honey or bulk comb-honey. It is common to hear beekeepers of this region state that their bees are Italians, this opinion being based on the common supposition that any bee which shows the least yellow color is Italian. It is, however, rare to find good Italian stock in this region, and it is safe to recommend to all beekeepers that they get new blood in their apiaries unless this has been done within a few years. The German queens of this region are not prolific and are unable to get the colony strength up rapidly, and, as has been shown, this is the most important step in preparation for the gathering of a crop of honey from the tulip-tree. It would pay the better beekeepers of this region to buy young queens every year if there were no other way to get young stock of the Italian race, in order to have colonies of the right strength. This is not necessary, for the beekeeper can rear his own queens as needed, after he becomes familiar with the work. It is, of course, necessary in almost every apiary to buy queens from queen-breeders in order to get better stock. The best plan is to buy several untested queens from each of several breeders, to select as a breeding queen the best one from among these, as indicated by the honey-crop, and then to rear one's own queens. No one queen-breeder can be recommended as better than any others and the best plan is to buy from queen-breeders who have been in the business long enough to have a well-defined strain and have the skill necessary to select and raise good stock. The names and addresses of queen-breeders may be obtained from advertisements in the journals devoted to beekeeping.

ADAPTATIONS OF BEEKEEPING PRACTICE FOR THIS REGION.

To obtain a crop of honey from the tulip-tree it is of the highest importance that the beekeeper begin the work of preparation early. It will not do to wait until the trees are in bloom and then make the most of what the bees are able to do. This results in a reduction of the crop, sometimes to the point where no surplus honey is obtained from the tulip-tree.

OUTLINE OF THE ANNUAL CYCLE IN THIS REGION.

To have a good colony of bees at the beginning of the tulip-tree bloom, it is necessary that the beekeeper begin his preparations about August 15 of the previous year. In most cases there will be honey coming to the hives then or later, and it may still be desirable to extract some honey, but from this time on the beekeeper should have constantly in mind the prosperity of the colony for the coming winter period, giving them during the ensuing six or eight weeks conditions favorable for the rearing of brood for the winter colony. During the winter he should in every way aid the bees in the conservation of their energy, so that they will not begin brood-rearing too early and so that they may also be able to do the work of brood-rearing to the fullest extent in the spring. During the spring before the tulip-tree blooms he should be sure that at all times the bees have abundant stores for brood-rearing or it will be curtailed at this vital time. These helps will bring the colonies to full or approximately full strength at the time the tulip-tree blossoms open, enabling the beekeeper to get the full crop from this source. Having done these important things, his work now lies in preventing the division of the strength of the colonies by swarming before or during the honey-flow and in supplying the bees with abundant room, so that they may ripen and store the honey properly. His plans for increasing his colonies and for requeening will depend on whether there are later honey-flows from which he expects to get a heavy yield, but the essential points of the active season are to prevent division of the strength of the colonies when it would decrease his crop, and to keep the bees contented and working hard whenever there is nectar available.

FALL PREPARATION.

In this region brood-rearing usually ceases for the winter about October 15, and during the period of eight weeks before that time, that is, beginning about August 15, the bees that are to live through the winter to perpetuate the colony must be reared. The bees that constitute the colony on August 15 will practically all have died before October 15, and any that then remain will be too old to do much of the work of keeping up the colony temperature during the winter season. These old bees will certainly die during the winter, and it will be only those bees which are reared after August 15 that will remain to do the work when normal brood-rearing begins about March 1 of the next year. Brood-rearing naturally decreases in late summer and it is necessary that favorable conditions be provided or the bees may almost cease raising brood, and thus endanger the very life of the colony. The common German bees found in this region are especially likely to stop brood-rearing too soon. As will be explained later in more detail, every colony should have a young queen introduced and laying just before the period of preparation for the winter begins. Room for the rearing of brood must be present. Stores must be present in plenty, and at no time between August 15 and October 15 must there be less than 15 pounds of honey in each hive, for with less honey the bees will almost certainly not rear enough bees for the winter cluster. It will be found advantageous to provide each colony with at least two 10-frame hive-bodies at this time, the brood being reared in the lower hive and the upper one being practically full of honey. This is more than the bees actually need at this season, but, as will be shown later, they will need it during the winter and spring, and if it is provided in late summer, nothing further need be done as to stores. It is a serious mistake, especially in this region, to extract too closely, to reduce the bees to a single hive-body, and to depend on the fall flowers to provide stores for winter, and these are perhaps the most common mistakes of the beekeepers of the region. The requirements of the colonies for the late summer are, therefore, a young queen, two stories for the hive, the upper hive-body full of honey, and enough empty cells in the lower hive-body for the small amount of brood which will then be reared. Nothing else that the beekeeper can then do will contribute to the well-being of the colony.

WINTER CARE.

Throughout this region the winter losses are as high as those experienced by beekeepers much farther north. In the tulip-tree region bees should be wintered out of doors, as cellar wintering is unnecessary and would be fatal with tulip-tree or aster stores. *There is no place in the region where winter packing is not needed*, and it is impossible to get the full crop of honey from the tulip-tree with colonies that have been left without added protection in winter. Detailed directions for the making of one type of winter packing-case are given in Farmers' Bulletin 1012, to which the reader is referred. The quadruple winter-case (fig. 3) therein described is one of the best for this region. In western Maryland, western Virginia, eastern Kentucky, and all more northern sections where the tulip-tree is a main source of honey the bees should be packed on or before October 15. (See map, fig. 4.) In the more southern sections the packing may be delayed until November 1, but it should not be delayed beyond these dates. Early packing is important in preserving the vitality of the bees which will start the work of the colony the following spring. Throughout the tulip-tree region 4 inches of packing are needed below the bottom of the hive, 6 inches (8 inches in more northern localities) on all sides, and 8 inches or more on top. Dry saw-

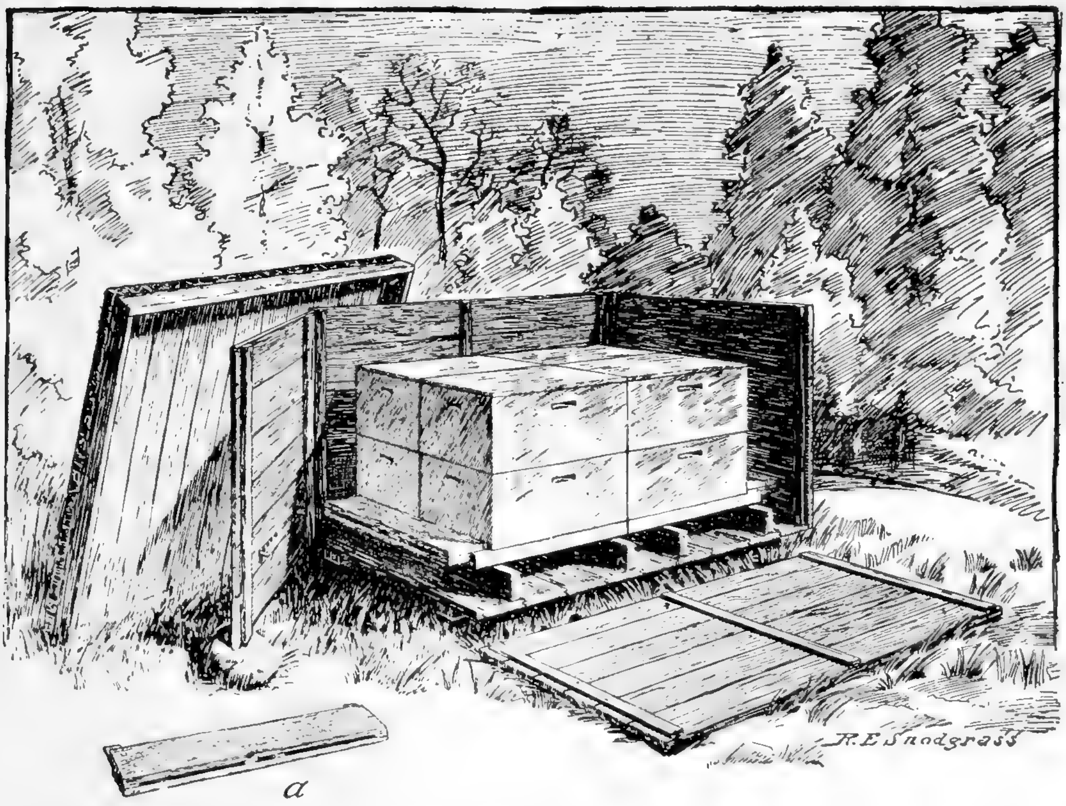

FIG. 3.—The quadruple winter packing case; *a*, Detail of tunnel to hives. Any type of packing case which gives equivalent insulation on bottom, sides, and top may be used.

dust, fine planer shavings, well-dried leaves, or any other finely divided packing material may be used. It is not safe to wait until the leaves fall before packing, for this is often more than a month too late. The entrances to the hives must be reduced as described in the bulletin on wintering above mentioned.

The bees should be wintered in two hive-bodies, just as was described for the late summer (p. 14). It is not safe in this region to put bees into winter quarters outdoors on less than 45 pounds of stores, for while a considerable quantity of nectar may come in during the early spring, occasionally this does not happen in this region, and it is necessary that the beekeeper leave the amount specified in order to insure the proper building up of the colony after March 1.

It is much safer to leave the entire amount all winter than it is to give more before the time of unpacking in May.

SPRING CARE.

If the bees have been wintered as described, and if a young, vigorous queen has been introduced to each colony the preceding August,

FIG. 4.—Map showing average date of first killing frost in fall in tulip-tree region. From these data the beekeeper determines when to pack bees for winter. Feeding to improve quality of winter stores is done after a killing frost.

there is little that the beekeeper can do that will add to the prosperity of the bees after spring brood-rearing begins and until time to unpack the bees. The entrances to the packing cases should be enlarged soon after brood-rearing begins. There will be plenty of stores, plenty of room for the rearing of all the brood possible, and plenty of protection, for the bees will not be unpacked until just in time to handle them in preparation for the gathering of the honey-crop from the tulip-tree. If the beekeeper knows that he has not done all of the things that he should in advance, he may then add any of the three necessary factors in the spring, but this is dangerous practice, for too often it is done too late. The practice of clipping the queen's wings during the early spring can not be followed, as often advised, for the queen can not well be found while the bees are in their winter cases.

FIG. 5.—Map showing average date of last killing frost in tulip-tree region. From these data the beekeeper determines when to remove the winter protection and estimates the time of the beginning of nectar secretion of the tulip-tree.

The time to unpack the bees will be four or five days before the tulip-tree is in bloom, usually the first week in May, perhaps a little earlier in the more southern limits of this plant. (See map, fig. 5.) It may happen that a few colonies will cast swarms, especially if they have defective brood-combs, before the scheduled time for unpacking, in which event the swarm should be placed in a new hive directly beside the colony from which it came. In the event that a swarm issues, the packing case containing the parent colony should be removed within a week. On the seventh day the parent colony is set to one side and the swarm is put in its place, with such supers as are necessary for receiving incoming nectar. The hive containing the parent colony is now gently set on top of the hive containing the swarm, thus placing the entire field force with the swarm. Ten days after this operation the parent colony and the swarm are united. If the tulip-tree honey-flow is heavy and if the weather is good, simply set the hive bodies of the parent colony as supers on the swarm. If the honey-flow is light, place one thickness of newspaper between the parent colony and the swarm.

As a rule there will be no swarming until after unpacking, but this will then come on with great rapidity unless the beekeeper takes the precautions later described. With the methods herein described the spring work of the apiary is reduced almost to zero, but the beekeeper should take this time to get everything in readiness for the honey-flow, for it will come on almost immediately after the bees are unpacked.

ADDITIONAL ROOM FOR HONEY.

In the production of extracted honey, which is strongly advised for this region, the placing of extra hive-bodies for the honey is not a complicated process, as in the production of comb-honey. As a rule the honey-flow from the tulip-tree begins suddenly on a bright warm day and the incoming nectar comes with a rush. It is, of course, necessary that plenty of room be provided for this honey, and a common fault in the region is a failure to provide enough room. At least two additional 10-frame hive-bodies will be needed for every colony that is in normal condition, and one of these should be added as soon as the bees are unpacked from the winter cases. If the honey-flow is good the beekeeper should examine the colonies every few days, for it will be necessary to give most of them more room. Because of the amount of water in nectar from the tulip-tree, considerable room is needed for ripening honey as well as for storage, and a failure to provide this often greatly reduces the crop. It is quite possible in this region for good colonies to require a total space of six 10-frame hive-bodies before the close of the honey-flow from the tulip-tree, and there will be colonies that need seven. The measures advised for swarm control influence the arrangement of the supers, as will be described further on.

SWARM CONTROL.

After taking all the precautions to have a full-sized colony, it would be the height of folly for the beekeeper to allow the bees to divide their working force by swarming during the short time when tulip-tree blossoms are pouring out nectar, and this is just the time when they will swarm normally unless steps are taken to prevent this. Too many beekeepers of the region still look on swarming as indicating a prosperous condition of the bees, failing to realize that this phenomenon, if unchecked, destroys all chance of a further crop from any short early honey-flows. Every precaution should be taken, therefore, to prevent swarming, and if any increase in the number of colonies is desired, this should be made by artificial division after the honey-flow, but before August 15.

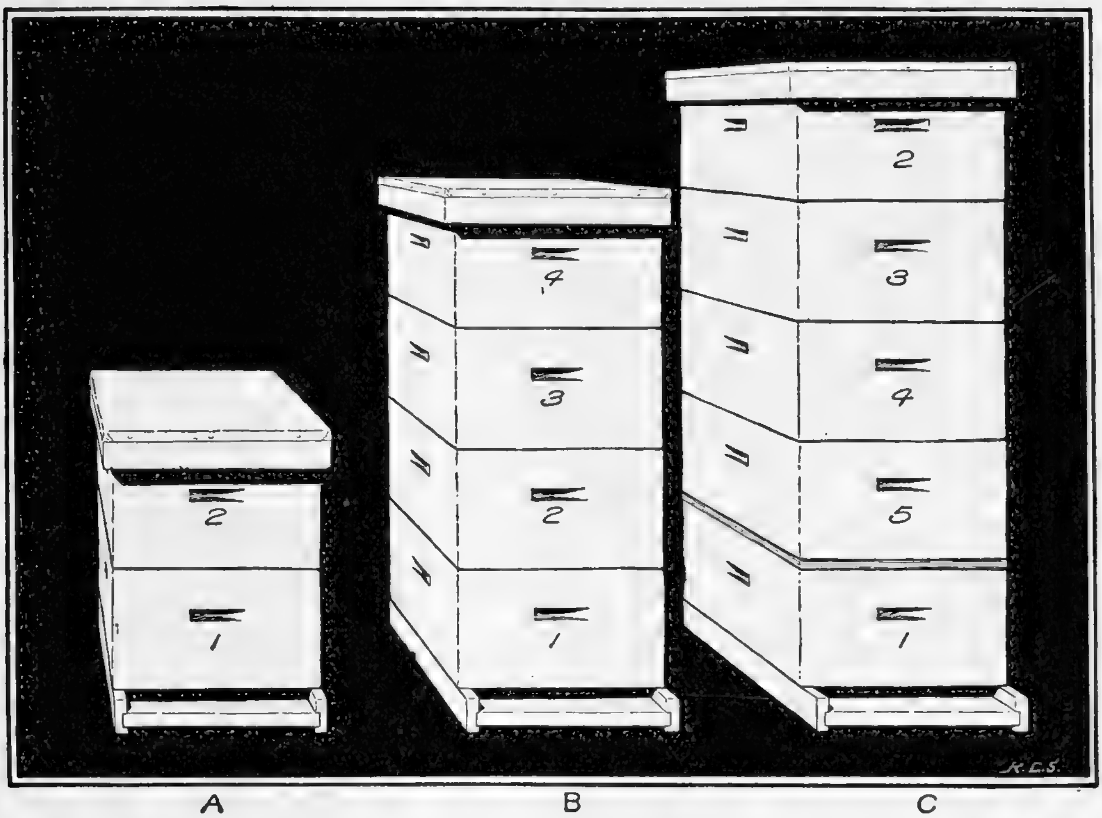

FIG. 6.—Diagram of swarm-control method for extracted honey production. *A*. Brood in both hive-bodies in the spring. *B*. Supers 3 and 4 are added as more room is needed, queen usually abandoning lower brood-chamber. *C*. Queen placed below queen-excluder in (1) after all brood in this hive-body has been sealed. Empty super (5) is added and brood-chamber (2) is placed on top.

Before the bees are unpacked there will be brood in both of the hive-bodies (fig. 6, *A*), unless the queen has been prevented from going from the second story to the first by imperfection of the combs (see p. 12). As soon as they are unpacked and additional hive-bodies are given, the queen will almost invariably desert the lower hive-body and will then lay eggs in combs in the second and third bodies (fig. 6, *B*). In a short time the lowest hive-body will contain only sealed brood, but in the meantime the bees will have filled many cells in this hive-body with pollen and there may be a little honey there. Ten days after the bees are unpacked, if any queencells are started in preparation for swarming, these queencells should be cut out and the queen should be removed from the brood on which she is found and placed in the first or lowest hive-body (fig. 6, *C*). A queen-excluder should then be placed over this lowest hive-body. On top of this should be placed two supers or hive-bodies for the storage of honey and above these the hive-bodies containing brood. This operation separates the queen and the brood by the space of two hive-bodies and this will act as a preventive to further efforts to swarm, at least during the short time of the honey-flow from the tulip-tree. Ten days later it may be necessary to remove queencells from the brood on top of the hives, although this is not always necessary even if queens are reared so far above the new brood-chamber. The hive-body which was formerly the second story will contain ten frames and not eight as in the supers, and this is the hive-body which should be left with the bees after the removal of the supers.

In producing comb-honey or bulk comb-honey, the control of swarming must be by other means than the one here given. For methods applicable for such cases the reader is referred to Farmers' Bulletin 1039, "Commercial Comb-Honey Production," in which swarm control in comb-honey production is discussed. Methods in producing bulk comb-honey will be the same as for comb-honey. For a general discussion of swarm-control methods, the reader is referred to Farmers' Bulletin 1198.

REMOVAL OF THE HONEY-CROP.

The outfit needed for extracting and the methods to be employed will depend on the size of the apiaries maintained. Special attention should be called to the necessity of having abundant supers to hold the heavy honey-flow from the tulip-tree and to provide room for ripening before extraction. A failure to provide these may result in a loss of half the crop. It is customary to use eight frames with wider spacing in a 10-frame super. If foundation is being drawn in the supers not less than nine should be used. While efficiency in methods of extracting is important in enabling the beekeeper to maintain a large number of colonies, this phase of the work has been so fully discussed in the books devoted to beekeeping that it does not seem best to attempt to include it in the present bulletin. This part of the work in the tulip-tree region will be the same as in other beekeeping regions, and the consideration of first importance is the production of honey to extract.

PREPARATION FOR LATER HONEY-FLOWS.

If following the honey-flow from the tulip-tree there is reason to expect a honey-flow from another species of plant, as from sourwood in part of this region, the beekeeper must leave the bees in condition after the tulip-tree ceases to bloom so that brood-rearing will be continued almost without interruption. The honey should not all be taken from the bees at this time, but they should be left with at least two hive-bodies, the upper one well filled with honey. Since honey from the tulip-tree is dark and strong, some beekeepers prefer to use it for brood-rearing and to take away all the honey from sourwood or other light honeys. Large quantities of stores will be needed for the proper maintenance of the bees during the interval until sourwood blooms and there could be no greater mistake than to confine the bees to one hive-body with only a small amount of honey.

As a further aid to maintaining the rearing of brood, it might be desirable to requeen all colonies during or just at the end of the honey-flow from the tulip-tree. This should not be done at this time unless there is an interval of at least six weeks before the next honey-flow is expected. The best time for requeening is discussed elsewhere.

DISEASE CONTROL.

Bees are subject to two infectious diseases of the brood which sometimes cause serious loss to the beekeeper. American foulbrood is found in a few localities in the tulip-tree region, and the shaking treatment which is necessary for this disease is described in Farmers' Bulletin 1084, to which the reader is referred. In case this disease is encountered, the best time to treat it will be during the tulip-tree honey-flow.

A few cases of European foulbrood have been found in this region. With the methods of beekeeping practice herein described, however, there will be no danger of loss from this disease, for the things here advocated are exactly the practices which are used for the prevention of the disease. For details the reader is referred to Farmers' Bulletin 975. Young, vigorous Italian queens and conditions favorable for the rapid building up of the colony in early spring are the two factors in preventing this disease, and in this region they are the two factors which bring the honey-crop. The good beekeeper of this region need not, therefore, fear this disease. In case it is discovered, this is conclusive proof that the methods of the apiary are not the best for the region. Steps should then be taken to get the disease under control by remedial measures and from that time on the beekeeper will find it greatly to his advantage to follow the plans for beekeeping herein set forth. In the Shenandoah Valley there is a great deal of European foulbrood. This valley lies within the limits here given for the tulip-tree but this species does not thrive on the valley floor, and this gives a better chance for the disease to develop and spread. The chief source of honey in the valley is the blueweed or viper's bugloss, which blooms later in the summer. Beekeepers in the valley will find it helpful to practice the methods of wintering herein described and especially important to introduce young Italian queens frequently.

TIME AND FREQUENCY OF REQUEENING.

It will be evident that there must be no interruption of brood-rearing during the period of rearing bees for the winter colony, and it is also obvious that nothing should be done which will stop egg-laying for even a day during the time between March 1 and May 10. During the spring it is difficult to rear queens and in the winter packing-cases it would be practically impossible to find the old queens and introduce new ones. Clearly, then, requeening should be done between May 10 and August 15. The exact time will depend on whether or not there is any honey-flow other than that from the tulip-tree. If there is a honey-flow following this, then the beekeeper will wish to continue brood-rearing without interruption. The best time to introduce new queens, so far as preparation for winter is concerned, is just in time for them to be mated and laying by August 15. If the beekeeper rears his own queens, as he should if he is heavily engaged in beekeeping, then he may start a lot of queencells in late July. About three days before the young queens are due to emerge, the beekeeper should remove the old queen from each colony. Two days later he should give a queencell to each queenless colony. In due time after emergence the young queen will fly from the hive and mate with a drone. After an interval of about two days after mating she will take up the work of egg-laying, and the young queen will be more able to lay a goodly supply of eggs in the late summer than will an old one. Since some queens may be lost in matings it is well to have additional queencells for this emergency. For methods of rearing queens the reader must be referred to the books on beekeeping, but it may be said that the successful beekeeper should make himself familiar with this branch of the work as soon as possible and should not depend on the purchase of all of his queens from queen-breeders.

With the methods of beekeeping herein described, it will be found almost necessary to requeen every August. Many beekeepers practice requeening every second year, but if this is done it will be observed that a considerable number of the two-year-old queens will not be able to lay enough eggs to build up the colony properly during the spring, and obviously this failure will result in a great reduction of the honey-crop. Good queens are the most important single item in the apiary management, and they are worth all the time and expense required to get them. Those beekeepers who leave the matter of rearing queens entirely to the bees must expect in the tulip-tree region to suffer a loss of at least half the honey-crop.

INCREASE.

It will be evident from what has been said that any increase in the number of colonies by division before or during the honey-flow from tulip-tree will result in a decrease in the honey-crop, except when such increase is made from brood which will emerge too late to take part in gathering the crop (p. 18). It is also detrimental to make increase after August 15, when bees for winter are being reared. Increase is therefore limited in time, just as is requeening.

When a permanent increase in the number of colonies is desired, the large colonies may be divided at the time of requeening, thus utilizing the workers that would not live through winter and that will not be serviceable in gathering a honey-crop. No new colony should be started with less than enough bees to care for four or five frames of emerging brood. The brood should chiefly be placed in those colonies which are moved away from the old stand. Queen-cells should be furnished within two days to all queenless colonies, and under no circumstances should the beekeeper allow these small colonies to rear their own queens, as such queens are almost always inferior.

A simple way to make increase at this time, when each colony is to be divided into two and when the beekeeper has only one apiary, is to remove the lower hive-body containing the queen and brood to a new location. On the old stand is placed a hive containing empty combs, and a queencell is placed between the combs in a cell-protector, the second story being put in place, A hive-body containing full combs of honey is placed on the removed hive containing the queen, for their winter food supply. To prevent the return of too many of the bees of the new colony to their old location, the entrance of the new hive should be closed with green grass. As this dries the bees are released. When outapiaries are maintained the original hive can be divided into two equal parts, the queenless portion given a queencell, and one part moved to another apiary to prevent return to the old stand.

MARKET FACILITIES AND METHODS OF MARKETING.

The tulip-tree grows in a part of the country where the people are accustomed to eat considerable honey, and there is rarely any difficulty in selling the crop near the point of production. Because tulip-tree honey is dark and rather strong in flavor, there is little present demand for it on the larger honey markets of the country, except sometimes for the baking trade. It should therefore be the plan of the beekeepers of this region to sell their honey locally, at least until a larger market may be developed. The Southern States are now considerable producers of honey, yet honey is sent into these States every year in large quantities from the North and West. With the vast resources from the tulip-tree and other nectar-producing plants this is an unfortunate condition, and it will be found that honey is a vastly superior food to the sirups and molasses so much used.

Bulk comb-honey is perhaps the most common form of honey now on this market, but it will be better for the beekeeper and for his customers if tulip-tree honey is extracted. It may take a little time for the beekeeper to acquaint his customers with honey in this form, and perhaps for a time some beekeepers will find it profitable to produce some bulk comb-honey for their trade, but as rapidly as possible the change to extracted honey should be made. This may be marketed locally in special glass jars, quart fruit jars, tin cans of 2½, 5, and 10 pounds capacity, or in any other form which seems best to appeal to the trade. Each package should be labeled to conform with Federal and State laws. The mistake should not be made of marketing the honey only in small jars, for this does not suggest to customers the possibility of buying honey in the larger quantities. Owing to its dark color tulip-tree honey is preferably marketed in tin cans.

Tulip-tree honey may be used for the manufacture of fine honey vinegar. One and one-half pounds of honey should be diluted with sufficient water to make 1 gallon. To this a small quantity of yeast is added and it is then placed in jugs or barrels during the process of fermentation. A small opening for the admission of air is necessary, but this opening should be plugged with cotton to prevent the entrance of dust, dirt, and insects. The time needed for the entire fermentation will depend on the temperature, but it may be expected to require several months. Such vinegar may be made for home use and with the amount of honey specified it will be found that the vinegar is quite strong. A market should be developed for some of this product, because of its superiority over other vinegars. Tulip-tree honey is especially valuable for this purpose because of its strong flavor and dark color, the milder honeys producing vinegar with little characteristic flavor.

OPPORTUNITIES FOR THE DEVELOPMENT OF THE REGION.

With the tons and tons of nectar going to waste every year in the tulip-tree region because the colonies of bees are not strong enough to get the full amount of surplus, there is no question that this area may furnish many times more honey than it does at present. That this honey can be marketed at a profit is attested by the fact that this section now sends to outside regions for part of its honey supply. There is not the local prejudice to dark honey which exists in the clover region and in the West. All of these factors taken together make the region one of promise. The enormous number of colonies of bees in this region is proof of the great nectar resources, and if these colonies are given proper care vast quantities of honey can be produced.

If the beekeepers of the region will abandon the "gums" and box-hives for modern equipment, and if they will adopt the practices for their beekeeping which are herein set forth in brief, they will find it possible to engage in beekeeping to a much greater extent than has been customary in the past. The region needs, more than anything else, more men engaged in beekeeping on a commercial scale, men who make it their chief or only occupation. The possibilities of the region are such that this procedure can be recommended and it is evident that it will be impossible for the man with only a few colonies to make the study of the business which will insure success under the peculiarities of this region. Careless beekeeping is entirely unprofitable, especially in a region where the main honey-flow comes so soon after the last killing frost of the spring. Only the beekeeper who studies his work and who takes the proper care of his bees can hope to make beekeeping a success in this region.

In connection with this bulletin the reader should refer especially to the following publications, all of which may be obtained without charge from the Department of Agriculture, Washington, D. C.:

Farmers' Bulletin 447, Bees.
Farmers' Bulletin 653, Honey and Its Uses in the Home.
Farmers' Bulletin 961, Transferring Bees to Modern Hives.
Farmers' Bulletin 975, The Control of European Foulbrood.
Farmers' Bulletin 1012, Preparation of Bees for Outdoor Wintering.
Farmers' Bulletin 1084, The Control of American Foulbrood.
Farmers' Bulletin 1198, Swarm Control.

Semimonthly reports of market conditions and prices prevailing in the principal producing areas and on the leading commercial honey markets of the country may be had free on request from the Bureau of Markets and Crop Estimates, Department of Agriculture, Washington, D. C.

How To Do It

DO YOU WANT practical suggestions on how to build a silo, a hog house, a poultry house, a potato-storage house, or how to make a fireless cooker or other farm home convenience? Are you seeking ideas on how to prepare vegetables for the table, how to care for food in the home, how to bake bread and cake and other appetizing foods in an efficient and economical manner? Is there some practical question about your corn or wheat or cotton or other crops, or about your poultry or live stock, to which you are seeking an answer? The answers to thousands of such questions and practical suggestions for doing thousands of things about the farm and home are contained in over 500 Farmers' Bulletins, which can be obtained upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C.

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1862
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UNITED STATES DEPARTMENT OF AGRICULTURE

THE CHINCH BUG AND ITS CONTROL

J. R. HORTON and A. F. SATTERTHWAIT
Scientific Assistants
Cereal and Forage Insect Investigations

Corn Plants Killed by the Chinch Bug

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. February, 1922

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1922

CHINCH BUGS destroy fully $46,000,000 worth of corn, wheat, oats, and forage sorghums in the United States every year.

Aggressive work against these insects is more profitable than defensive work. There are three periods when they may be destroyed most effectively: In November and December, by burning or plowing down their hibernating places; in May and June, by spraying in wheat fields and trapping in barriers, followed by spraying in marginal rows of corn if necessary; and in September, by plowing corn stubble deeply before the bugs have gone to winter cover.

Chinch bugs spend the winter largely in bluestem and other bunch grasses, in pastures, neglected fields, roadsides, sunny hill slopes, and similar uncultivated places. The grasses should be burned in November and December, and unused areas kept as clean as possible. The bugs leave their winter quarters in early spring, migrating to fields of wheat, oats, etc., feeding until the grain is nearly ripe and then attacking the corn and other row crops. Serious damage to row crops can be prevented by spraying the bugs themselves with oil-emulsion nicotine sulphate as described in this bulletin. Countless millions more may often be destroyed by using these same means in the wheat stubble, immediately following the binder.

Cooperation in conducting chinch-bug control measures in neighborhoods or larger blocks is of vital importance.

THE CHINCH BUG[1] AND ITS CONTROL.

CONTENTS.

AMOUNT OF DAMAGE.

ABOUT the year 1783 wheat crops were destroyed by the chinch bug in Orange County, N. C. In 1785 it had so spread and increased that the total destruction of wheat was threatened. For four or five years it spread and increased in North Carolina and Virginia, causing great loss both to wheat and corn. About 1809 the damage was so intense in Orange County, N. C., that wheat growing was abandoned for two years, with the result that the pest was subdued.

In 1839 it was again very destructive in Virginia and the Carolinas, completely wiping out oats and wheat, except an especially early maturing variety, and severely damaging corn. In 1840 it became destructive to wheat and corn in Illinois, breaking out again in 1844 and 1845. It was destructive in Iowa in 1847 and in Indiana in 1848. In 1854 it was a scourge in Illinois, Indiana, and Wisconsin, and continued to be destructive in Illinois till 1858.

The outbreak of 1863–1865 in Illinois was estimated to have caused the loss of about 30,000,000 bushels of wheat (three-fourths of the crop) and 138,000,000 bushels of corn (one-half of the entire crop), the cash loss being computed at $73,000,000.

[1] *Blissus leucopterus* Say; order Hemiptera, family Lygaeidae (Myodochidae).

Two other outbreaks for which the losses were estimated were those of 1871 and 1874, in which the ravages of the insect were enormous and widespread throughout the States of Indiana, Illinois, Wisconsin, Missouri, Iowa, Nebraska, and Kansas. The loss in 1871 in these seven States has been computed at $30,000,000. In Missouri alone the loss in 1874 was computed at $19,000,000, and for the seven States at upward of $60,000,000.

The next serious outbreak for which the losses were estimated occurred in 1887 in Kentucky, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, and Kansas. The damage in this year amounted to $60,000,000, the greatest loss occurring in Illinois, Iowa, Missouri, and Kansas.

In the years 1892 to 1897 an outbreak in Kansas, Iowa, Minnesota, and Illinois, reaching its maximum in Ohio in 1896, caused a loss estimated at not less than $2,000,000 for the last-named State alone.

The total estimated loss in the United States for the period from 1850 to 1915 is placed at fully $350,000,000. In round numbers this is at an average yearly rate of $5,385,000 during the entire period of 65 years.

The average annual loss sustained by the most heavily infested States taken as a whole has been estimated at 5 per cent of the wheat crop and 2 per cent of the corn crop. On the basis of the average farm value of the foregoing crops for the years 1912, 1913, and 1914, at normal prewar prices, the annual loss in the wheat crop would be $20,000,000; in the corn crop, $24,000,364; in the grain sorghums, $2,009,985; and in broom corn, $94,000. The total annual loss to the farmers of the United States from chinch bug depredations in these crops would, therefore, run upwards of $46,104,349.

HOW THE CHINCH BUG INJURES CROPS.

The chinch bug feeds upon growing crops throughout its entire life. It is armed with a four-jointed beak, equipped with lancets for piercing the plant and starting the flow of sap, which is sucked into the stomach. In feeding it imparts a reddish stain to the plant parts attacked and causes the death of plant cells. The feeding of a large number of bugs on growing plants prevents normal growth and brings about a dwarfing or falling of plants and a reduction of yields. A concerted attack such as often occurs in young corn and forage sorghums may kill the plant outright or so weaken it that it remains small and fails to yield at all.

WHERE THE CHINCH BUG OCCURS.

The principal distribution (fig. 1) of the chinch bug in North America extends from the Rocky Mountains eastward to the Atlantic Coast, and from Manitoba to Texas. The States in which destructive outbreaks occur are: Texas, Arkansas, Oklahoma, Kansas, Nebraska, Wisconsin, Iowa, Minnesota, Illinois, Missouri, Kentucky, Indiana, Ohio, South Carolina, North Carolina, and Virginia. In the following localities in the mountain district it is known to be present, but does not occur in destructive numbers: New Mexico and Arizona; California, in the Sacramento, San Joaquin, and southern Imperial Valleys; and Washington. It has recently been reported from the Missouri River Valley in northeastern Montana. It has been found in Connecticut, Maine, Massachusetts, Tennessee, South Dakota, Louisiana, Florida, New Jersey, Pennsylvania, and New York. It has also been discovered in places in the West Indies, Cuba, Panama, Guatemala, Lower California, Mexico, Cape Breton, and Canada.

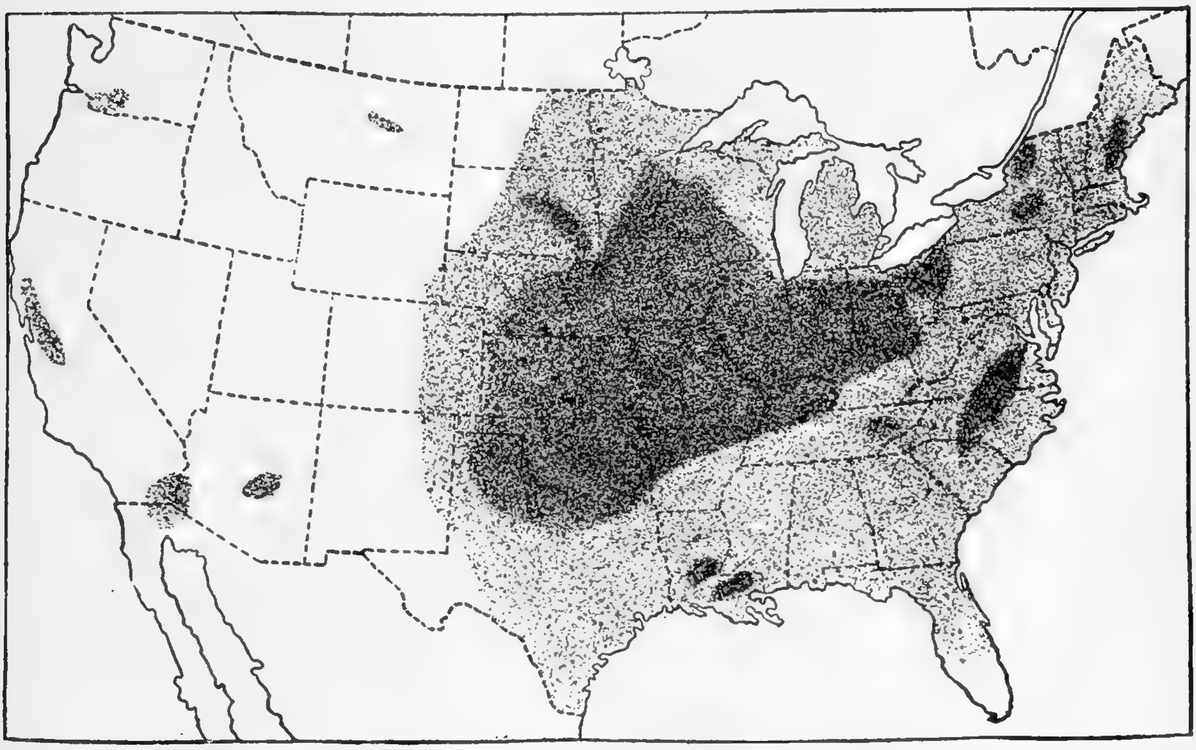


FIG. 1.—Map showing distribution of the chinch bug and areas most often devastated by it.

HOW TO KNOW THE CHINCH BUG.

THE ADULT.

The full-grown or adult chinch bug (figs. 2, *f;* 3) is the first form of this insect to be found in the spring. At first very few are seen, as they resume activity gradually, leave their winter quarters, and attack the growing crops. They fly and crawl to the young wheat and may be found well down in the wheat stools almost any time during April and May.

Two forms of adult occur, one having short wings which reach only from one-half to two-thirds the length of the abdomen, the other having long wings which reach almost to the tip of the abdomen. The long-winged form (fig. 2, *f*) occurs over most of the country between the Rocky Mountains and the Allegheny Mountains.

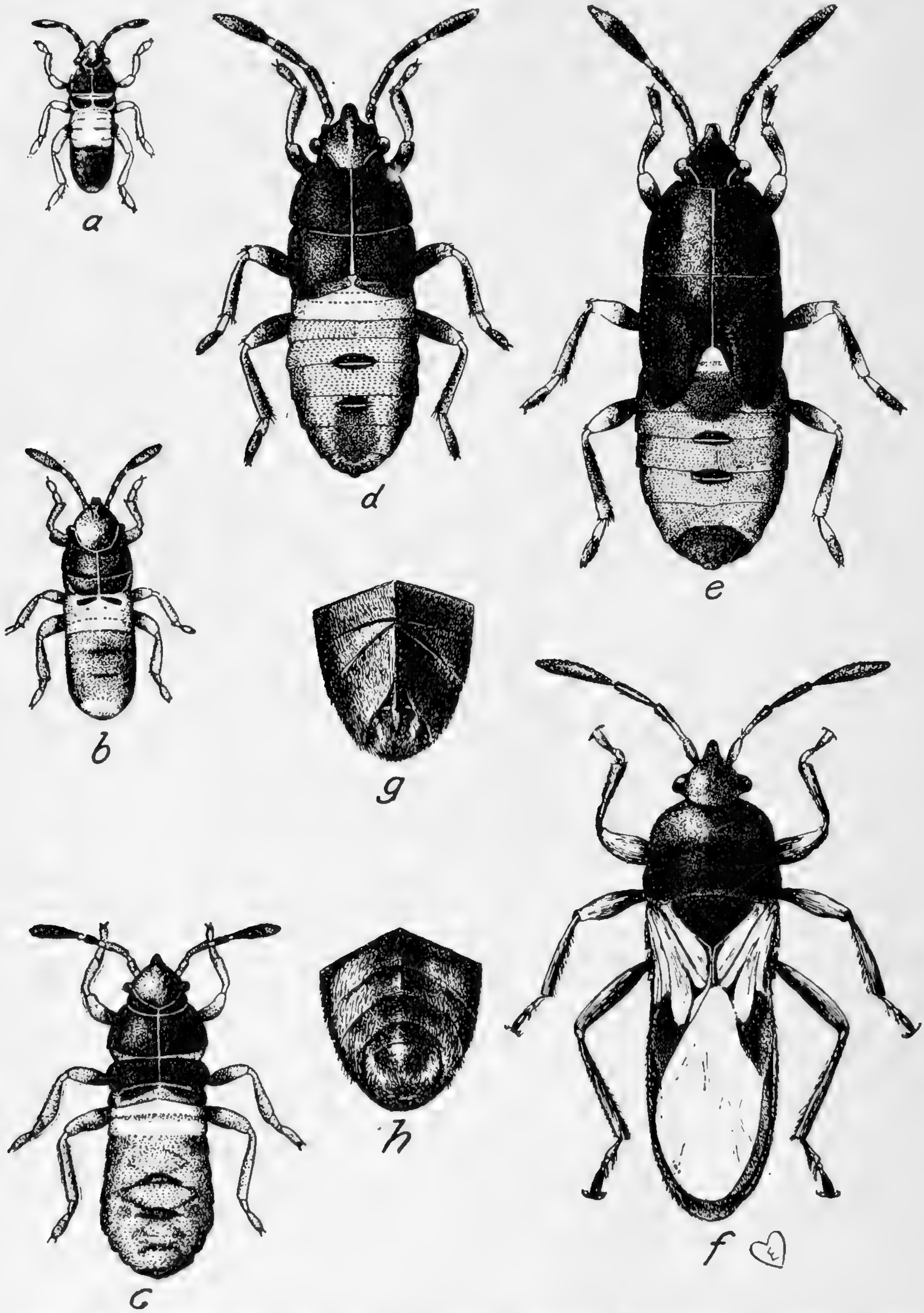


FIG. 2.—The chinch bug: *a–d*, First to fourth instars, respectively; *e*, pupa; *f*, adult female, long-winged form; *g*, genitalia of the female; *h*, genitalia of the male. Greatly enlarged. (Luginbill.)

The short-winged form (fig. 3) has been found to exist principally along the seacoast, and in the East extends inland along the lower Great Lakes to Northern Illinois. It is not abundant, however, west of a line drawn from Toledo, Ohio, to Pittsburgh, Pa. The long-winged form mingles with the short-winged form throughout the territory occupied by the latter. Both forms are white immediately after the skin is shed, but soon become black. The upper wings are whitish at the base, white at the tips, and bear a black spot about the center. The under wings are whitish, folded membranes. The insect is about one-fifth inch or less in length.

The adult may be easily distinguished from the young or nymph by its larger size, the possession of four wings, and the absence of pink or red coloration. It does not differ greatly in size and color from the large nymphs in the last stage of growth, but its whitish upper wings make identification easy.

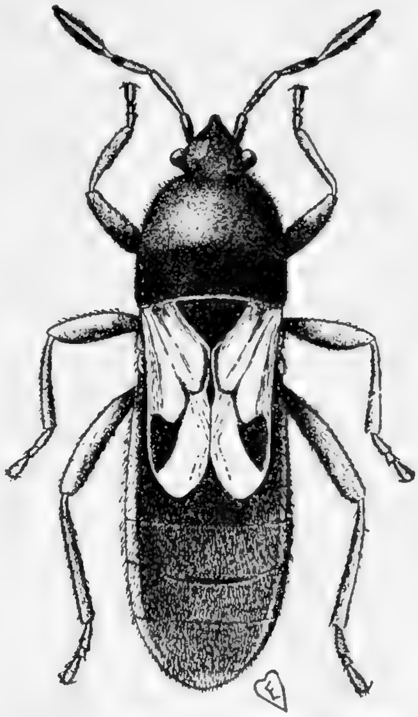
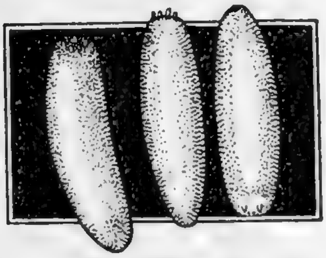


Fig. 3.—Chinch bug adult, short-winged individual. Greatly enlarged.

THE EGG.

Soon after transferring to the wheat fields in the spring the bugs lay their eggs (fig. 4) in the soil about the roots and on the roots and stems of the wheat, also particularly on the lower leaves of the wheat. During the summer the eggs can be found in the soil around the roots of corn, kafir, and similar crops, and on the roots and basal leaves.

The average egg length is about 0.033 inch, the average width about 0.012 inch. It is shaped somewhat like a navy bean. One end is flattened and bears from three to five minute projections. When first laid the egg is pale yellowish, but within a day or two it darkens to an amber color, and finally shows the red coloring of the little insect within. The size sometimes increases to nearly 0.04 inch before hatching.



4.—Eggs of the chinch bug. Greatly enlarged.

THE YOUNG.

The chinch bug undergoes six transformations or stages after emerging from the egg, at least in South Carolina, where it has been studied most carefully. Almost immediately upon issuing from the egg, the little reddish nymph (fig. 2, *a*) starts feeding and locates where it is sheltered from the sun, rain, and its natural enemies. The insect moves about from place to place throughout its life, and hence may be found in various positions, ranging from the tip to the roots of the food plant upon which it lives. During the summer the bugs may be found among the roots just beneath the surface of the soil, under leaf sheaths, in the leaf curls, and in the heads of such crops as corn, kafir, milo, feterita, Sudan grass, etc. They may also often be found under clods of earth, fallen leaves, and almost any other shelter existing between the rows of corn or other crops.

Immediately after hatching, the young chinch bug is about 0.04 inch in length; the head and thorax are brown; the eyes are dark red; and the abdomen ranges from yellowish white to light red in color. The tip of the abdomen is black. The second, third, and fourth stages of the insect are similar to the very young bugs (fig. 2, *b*, *c*, *d*), except that the abdomen becomes a darker red in color and spotted with black. The wing pads appear in the fourth stage or instar, and the abdomen becomes banded with red and black. The fifth instar or pupa (fig. 2, *e*) is about one-sixth of an inch in length, the head and thorax are black and polished, and most of the abdomen is dark red, with the exception of the tip, which is black. At a little distance the entire abdomen appears black. The sixth stage is the fully developed insect or adult.

FOOD PLANTS.

Over the western part of the country, from Indiana to Texas, the principal crops damaged are wheat, field and garden corn, the millets (including Hungarian grass),[2] and the sorghums,[3] including cane, kafir, milo, broom corn, shallu, feterita, Sudan grass, kaoliang, and durra. An outbreak usually originates in wheat, rye, or barley fields, from which the bugs migrate to near-by fields of corn and sorghum, beginning shortly before the small grain is ripe and passing over in great numbers shortly after it is harvested. In the northeastern part of the country, where the forage sorghums are replaced by timothy, the migrating bugs are quite as likely to be attracted to the timothy meadows as to corn, where both are within equally easy reach. Rye, barley, and oats are less subject to severe damage than wheat. The chinch bug is said to attack sugar cane in Mexico.

Among its less important food plants may be mentioned such forage grasses as Johnson grass,[4] emmer,[5] spelt,[6] bluegrass,[7] and prairie grasses. The bugs also develop to some extent on such wild grasses as bottle-brush grass,[8] little bluestem,[9] big bluestem,[10]

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[2] *Chaetochloa italica,* ssp. *nigrofructa* v. *atra* Hubb.

[3] *Holcus sorghum* L.

[4] *Holcus halipensis* L.

[5] *Triticum sativum dicoccum* Schrank.

[6] *Triticum sativum spelta* Hackel.

[7] *Poa pratensis* L.

[8] *Hystrix patula* Moench.

[9] *Andropogon scoparius* Michx.

[10] *Andropogon provincialis* Lam.

forked beard grass,[11] barnyard grass,[12] oat grass,[13] bur grass,[14] crab grass,[15] Burmuda grass,[16] green foxtail,[17] yellow foxtail,[18] St. Augustine grass,[19] reed,[20] and old witch [21]. It is also said to feed upon a so-called wild buckwheat. It has recently been reported as feeding upon the leaves of the currant in Christiania, Norway.

In Kansas, Oklahoma, and some other Middle Western States, the big bluestem, little bluestem, Johnson grass, and some other bunch-forming grasses are utilized largely for shelter during the winter and as food on the warmer days of early spring.

The insect has therefore an ample food supply outside of the cultivated fields, although when limited entirely to its wild host plants it does not often increase excessively.

LIFE HISTORY.

WINTER QUARTERS.

It is vital to know where the chinch bug passes the winter, because important means of destruction are based on its hibernating habits, and furthermore this knowledge suggests the need of certain farm practices which tend to discourage the insect.

The bugs are most abundant at the bases of bunch-forming grasses, such as bluestem and prairie grass, along hedges, brushy fence rows, ditch banks, roadsides, and woodlands, in meadows, pastures, and ravines, preferring southern slopes and areas south of protecting woodlands or hedges. Where more suitable shelter is not at hand, they sometimes remain in dead and partly decayed stubbles left in the field after plowing, in corn and sorghum shocks, and in standing corn.

Their destructive work usually begins along the edges of fields bordering such places. Again and again serious destructive outbreaks of the pest in wheat fields have been traced directly to the excellent hibernating quarters furnished by shocks of corn, kafir, cane, Sudan grass, and other fodder allowed to stand in the field through the winter. The bug also hibernates in weeds, grass, and leaves along roadsides and edges of cultivated fields, in the angles of worm fences, under loose stones and logs, in rotting stumps, and under newly spread manure, bits of boards, and sacks.

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[11] *Andropogon furcatus* Muhl.
[12] *Echinochloa crusgalli* (L.) Beauv.
[13] *Arrhenatherum elatius* (L.) Mert. & Koch.
[14] *Cenchrus tribuloides* L.
[15] *Syntherisma sanguinalis* (L.) Dulac.
[16] *Capriola dactylon* (L.) Kuntze.
[17] *Chaetochloa viridis* (L.) Scribn.
[18] *Chaetochloa lutescens* (Weigel.) Stuntz.
[19] *Stenotaphrum secundatum* (Walt.) Kuntze.
[20] *Phragmites* sp.
[21] *Panicum capillare* L.

50663°—21——2

In the Middle West destructive outbreaks are most frequently traced to the abundance of thick, bunch-forming grasses and to the matted grass and leaves bordering osage-orange hedges. In the timothy meadows of New England, New York, and northern Ohio these conditions are of less importance, because there the insects pass the winter largely in the meadows and do not migrate to and from these places, except on foot.

While all sizes of nymphs, as well as adults, go into hibernation places in the late fall, it appears that (except for one record from Montana) only the adult bugs survive the winter.

MIGRATIONS.

The chinch bug always seeks the nearest suitable hibernating place in the fall, and its choice is determined by the necessities of shelter and food. While some bugs may be found at any time in scattered locations where there is no food, as a rule they prefer, especially in the southern part of the range, to get down in the midst of plants such as bunch grass, Johnson grass, or in green fodder stubbles or shocks where some of the plants remain green. They then have food on the warm days occurring after hibernation begins and before they leave their winter quarters in the spring. In the spring the insect moves only as far as is necessary to assure an abundant food supply. In situations such as the timothy fields of northeastern Ohio, it spends the winter in the fields, merely continuing its ravages in the spring. In the fodder fields of southern Oklahoma and Texas it does likewise, when the fields are left in stubble or shocks are left on the ground. In Kansas it often migrates by flight for considerable distances to secure good hibernating quarters in the prairie bunch grass in fall, and from such quarters to the fields of growing wheat in the spring.

In the northern part of its range, the spring movement usually begins in April and continues until the latter part of May. In the southern portion, i. e., Oklahoma and Texas, it begins in the latter part of March or early part of April and continues until the latter half of May, or, in some seasons, until the first part of June. The migration is spread over several weeks, the earliest individuals having deposited eggs before the latest ones have left winter quarters. In their spring search for food they usually attack fields of grasses, wheat, oats, or barley. The adults find feeding places well down in the plant stool, and, as the days grow warmer, along in April or May, earlier in the South, later in the North, begin to deposit their eggs in these situations.

A single chinch bug deposits from 100 to 500 eggs in the course of her life, the average probably being between 100 and 200. The eggs begin to hatch in late April, from 10 to 25 days after being laid, and continue hatching until June, varying with the locality.

The young bugs, hatching in large numbers in May and June, live in the wheat until it begins to ripen and dry, when they leave it, sometimes in armies, crawling on foot to the nearest corn, kafir, or sorghum field. Here they gather on the first rows in dense masses and do the greatest damage of the year. Their habit of remaining together in populous colonies is responsible for the more severe injury such as the killing of the plant outright. A favorite location for the bugs is on the brace roots of corn, which they sometimes weaken so much that the corn falls down. They grow and feed from the latter part of April until July, or for about 3 months, during which time they outgrow and shed their skins several times. Collections of these gray cast skins may often be found upon corn and other crops where the young chinch bugs have occurred in numbers.

GENERATIONS.

The young usually are accompanied in their migrations by some of the overwintering adults and some adults of the first summer generation. The last of the overwintering adults usually die by early July. The adults of the first summer generation usually mature from the first half of June to the latter half of August and deposit eggs throughout most of this period. The eggs develop into second-generation adults from the middle of August to the last of October. The second generation of adults deposits eggs in August, September, and October, many of which hatch, thus beginning a third generation which, however, appears never to develop beyond the nymph stage and not to survive the winter. Thus it is seen that, at least over most of the range of the long-winged form, the chinch bug has but two full generations, and in the southern portion of its range a partial third generation annually. In the eastern portion of the country, where the short-winged form prevails, it is not certain that there is more than one generation annually.

Throughout the Middle West, where the chinch bug does its greatest damage, crops suffer from two attacks annually, although the second attack is not usually noticed. It must be remembered, however, that this later attack is of the utmost importance, for if there are but few of the second generation developing to adults there can be no serious outbreaks the following season.

Oviposition ceases toward the end of August in the northern part of the chinch bug's range and the latter part of October in the southern portion. The insects congregate in October or early November in temporary shelter in corn and fodder shocks and in the stubble, where they feed until the first few cool days of fall. The young gradually die off during October and November; the remaining adults then finally seek permanent hibernating quarters for the winter.

CONDITIONS FAVORING OUTBREAKS.

If growers will take the trouble to watch certain field and weather conditions they usually will be able to tell when an outbreak of chinch bugs threatens. The most important among the conditions favoring outbreaks are: (1) Suitable hibernating places, and (2) warm, fairly dry weather during the two critical hatching periods, May to June and August to September.

In the northern and middle range of the insect, it must have hibernating places capable of harboring large numbers of adults in a position well sheltered from natural enemies and disease. Its winter shelter must be dry and must contain sufficient green plant food to tide it over the periods of warm weather that may occur after it has begun hibernating and before the advent of cold weather, and in the spring before conditions are right for migration to its regular food plants. In its southern range its hibernating quarters must supply food for these periods and must be of a sort that will protect it from a succession of warm, thawing days followed by freezing.

Even if these conditions are met and a fairly good percentage of the bugs get safely through the winter, transfer to the grain crops, and have favorable, warm, dry weather for depositing their eggs, a severe outbreak may still be prevented by a series of drenching rains and prolonged wet, humid weather during the hatching periods. These periods are, for the first generation, throughout May, overlapping into June and extending slightly into July, and for the second generation August, overlapping into September, and in the south extending into October.

NATURAL CONTROL.

NATURAL CONTROLS NOT DEPENDABLE.

That the chinch bug can withstand almost every conceivable climatic variation is shown by the fact of its distribution from little north of the equator to nearly 50° north latitude, and from more than 200 feet below sea level, in the Imperial Valley of California, to upwards of 6,000 feet above sea level in the mountain regions. So far as the influence of cold is concerned it is only in the least protected situations that severe winter weather has much effect in reducing the abundance of the pest. Chinch bugs have been known to withstand temperatures of from 15° to 20° F. below zero, even when incrusted with a coat of ice. Undoubtedly they must have hibernating quarters that will afford protection, and they are usually able to find such quarters. Likewise, the insect can withstand the most severely hot summers, provided it is not long exposed to the direct rays of the sun. In Kansas and Oklahoma large numbers of the bugs are occasionally killed by being knocked from the plants by harvesting when the soil temperature is as high as from 125° to 135° F. In such cases the bugs perish before they are able to travel the 6 to 12 inches to shelter. Most of the bugs escape exposure to such conditions by remaining behind leaf sheaths of corn, kafir, and other crops, or by staying among the roots in soil shaded by the plants, moving from one plant to another only in the late afternoon or early forenoon.

The amount of moisture in the air apparently has no appreciable effect in reducing the abundance of the pest, and it can withstand not only the humidity of the tropics but the continuous drenching rains of more northern latitudes. While it is true that the years of greatest devastation by the chinch bug have largely followed a succession of years of deficient rainfall, the amount of annual rainfall can not be depended upon in predicting outbreaks. Chinch bugs have sometimes been exceedingly numerous and destructive in years of more than normal rainfall. Even if the precipitation occurring only during the active season of the bugs (April to October) is considered, it may fail to give us a basis of prediction. Much depends upon the character of the rainfall.

DISEASES.

The abundance and consequent worth of fungous diseases known to attack the chinch bug are entirely dependent upon the occurrence of wet, cloudy, and cool weather during most of the hatching and growth period of the young bugs. This dependence upon a particular kind of weather ordinarily prevents these diseases from destroying the bugs in large numbers.

The principal disease, known as the chinch-bug fungus,[22] has been purposely introduced among the bugs in Kansas, Nebraska, and Illinois, without practical commercial benefit in preventing damage. Its efficiency depends very largely upon exceptional seasonal precipitation, just the conditions which of themselves alone are most unfavorable to the chinch bug. In seasons when the bug can thrive best least can be expected of the fungus. The disease attacks many other insects, and is present every year throughout most of the chinch-bug territory. Therefore, it would become exceptionally abundant in unusually favorable weather without artificial introduction, whereas cultures introduced in unfavorable weather would be held to the normal level of the disease. The control of the chinch bug by introducing fungous disease has so far failed. Where the

[22] *Beauveria globulifera* (Speg.) Picard.

disease is already present, its destructiveness can not be increased by introducing more diseased material; and where not present, introduced disease has no noticeable effect, as its absence means conditions unfavorable to the fungus.

Another disease[23] which probably attacks the chinch bug has been known since 1888, when it was first discovered in cutworms. In the last three years it has been found attacking a number of different kinds of insects, and its possible usefulness is still under investigation.

PREDACIOUS AND PARASITIC ENEMIES.

While the chinch bug has a considerable number of enemies belonging to the animal kingdom, it is more fortunate than most other insect pests in escaping attack, and, for an insect of such great abundance and wide distribution, has comparatively few natural enemies. None of them appears to prey wholly or even to a large extent upon it alone; none of them appears to be of any great importance in suppressing serious outbreaks. The birds and other higher animals which have been known to eat chinch bugs feed upon almost all kinds of insects, and thus destroy only an occasional individual of this kind.

Its most important natural enemies are undoubtedly other insects, twenty or more kinds of which are known to attack it occasionally or habitually. The most important of these are lady beetles, ground beetles, true bugs, the young of the lace-winged flies, and ants. A great majority, if not all of them, feed widely upon many kinds of insects, and are by no means especially destructive to chinch bugs. The most important predatory enemies are probably the insidious flower bug,[24] the many-banded assassin bug,[25] and several kinds of ants. Both the insidious flower bug and the assassin bug, however, have a multitude of other victims, and even when numerous among the chinch bugs have never been seen noticeably to reduce their numbers. The false chinch bug,[26] which often occurs on field and garden crops in extremely large numbers, also feeds occasionally on young chinch bugs, but it is almost entirely a plant-feeding insect. Ants are more numerous than all other animals put together and probably cause the death of more chinch bugs than any other enemy.

Only two truly parasitic insects, living within the body of their host, assail the chinch bug. One of these is known as the chinch-bug egg parasite,[27] and has been credited at one time with annihilating from 16 to 50 per cent of the eggs in Kansas. The other is a wasp-like insect,[28] whose habit of parasitizing chinch-bug eggs has been discovered, but of which little further is known.

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[23] *Sorosporella uvella* (Krass.) Gd.
[24] *Triphleps insidiosus* Say.
[25] *Milyas cinctus* Fabr.
[26] *Nysius angustatus* Uhl.
[27] *Eumicrosoma benefica* Gahan.
[28] *Abbella subflava* Gir.

One of the group of round worms, commonly known as "hair snakes," occasionally destroys a few chinch bugs, but it is not numerous enough to be important.

At least 24 of the insect-feeding species of birds destroy chinch bugs along with many other kinds of insects. Quails and meadowlarks have been rated as the most important of the chinch-bug destroying birds. While these birds seldom occur in large numbers in the midst of outbreaks of chinch bugs and do not especially seek this insect in preference to others, they are a valuable enough factor in destroying this and other injurious insects to deserve the fullest possible protection.

Lizards, frogs, and toads make the chinch bug an occasional though unimportant addition to their ration. In the southwestern range of the chinch bug the so-called horned toad[29] is sometimes found with more chinch bugs than all other insects together in its stomach. Like all of the foregoing, however, it is not numerous enough seriously to reduce the chinch bug.

CONTROL MEASURES.

MEASURES MUST BE ADAPTED TO THE CONDITIONS.

Many methods for destroying chinch bugs and for limiting or preventing damage by them are given in the following pages on the basis that each may be practical at some time or place, although no one method will always be practicable. Each farmer is obliged to adapt his protective measures to weather conditions, location of field, variety and condition of crops infested and likely to become infested, available equipment, chemicals, and labor. The various methods of control are arranged on the basis of a season's campaign, beginning in the fall, as preventive measures of great importance may be started then.

Something may be done toward controlling the chinch bug during almost every month of the year, either by direct attack or by preventive measures. Continued attack on the pest at every opportunity throughout one season insures against loss the following season. Although control measures should be under way almost every month in seasons of outbreak, there are three periods during the year when the chinch bugs may be most effectively destroyed. These are: First, when they are just firmly established in winter quarters in November and early December; second, from the time the overwintering adults have concentrated in fields of wheat and other small grains until the wheat is harvested and the bugs have begun to migrate to fields of corn and sorghum; and third, from the time the corn and sorghum fields are harvested until the bugs are driven by cool weather into winter quarters.

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[29] *Phrynosoma cornutum* Harlan.

EQUIPMENT.

The equipment for such work is varied and may be divided into five groups: Ordinary farm implements, sprayers and chemicals, special drags, oil-pouring devices, and gasoline torches or other heat.

FARM IMPLEMENTS.

The plow appears to be the most fundamental piece of equipment, is always available on every farm, and remarkably efficient when used to bury the bugs 7 or more inches under the surface. Following the plow closely in time of application are the harrow, drag, clod crusher, and roller. The plow is required for preparing the soil for the trench, double trench, and ridge-groove drags. In case the plow is used for making a furrow-barrier, it is followed by a log or a barrel for pulverizing the soil in the furrow. The lister may be substituted for the plow in making the furrow barrier. The post-hole auger (fig. 5) in favorable soils is the most desirable type of implement for making holes along barriers for trapping the migrating bugs. In stony ground a digging iron and a shovel will serve the purpose. The shovel, hoe, and perhaps grubbing hoe will be needed in some methods of laying oil barriers.

FIG. 5.—Desirable type of post-hole auger.

SPRAYERS AND INSECTICIDES.

The high-pressure, gasoline-power sprayer, though expensive, stands first in the equipment for saving an infested crop. Great care is required in selecting this outfit. Best spraying results are secured with a sustained power of 250 pounds pressure operating two leads of hose and four large-chambered nozzles (see fig. 6). This insures the largest kill of bugs, greatest economy of labor and insecticide, minimum of chemical injury to the crop, and greatest speed in saving the crop-acres. It is highly important to select a sprayer with a large pump and air chamber and good leverage or gearing system, with all valves and wearing parts easy to remove and replace. These features should be insisted upon regardless of other considerations, whether ordering a gasoline or a man-power outfit.

If the amount of spraying is large, a gasoline-power sprayer of the type shown in figure 7 should be used. For smaller areas and for spraying row crops too large to allow a gasoline-power sprayer to pass over them, a hand-power outfit of the type shown in figure 8 is entirely suitable, provided it has the capacity to maintain a pressure of 125 pounds. Smaller outfits than this are not advisable for this work, as the value of the spraying depends upon hitting the bugs, many of which occupy relatively sheltered places. The lower pressures are suitable for young wheat, or until the crop is half grown,

Fig. 6.—Spraying chinch bugs in wheat.

or under very thorough application; the higher pressures are efficient everywhere, and are especially necessary for high wheat and rapid work.

Fig. 7. Gasoline power sprayer in operation.

50663°—21——3

The spray-delivery system should consist of 25-foot leads of high-pressure hose, fitted with 12-foot bamboo-covered extension rods, which enable the operator to cover wide areas, thus reducing the number of trips of sprayer and horses. The rods should be, and usually are, fitted with cut-offs, by which the spray may be at once stopped when it is desired to change position, avoiding waste of material. The large chambered type of nozzle, illustrated in figures 6 and 7, will give the widest sweep of spray. It is of advantage to increase the nozzle capacity to an even greater extent by placing two of these nozzles on a Y. The nozzles must be angled, not straight, and this should be specified in ordering equipment. The hose should be trussed to wagon bed or engine cover (see fig. 7) to keep it from dragging down the wheat, especially when spraying high wheat.

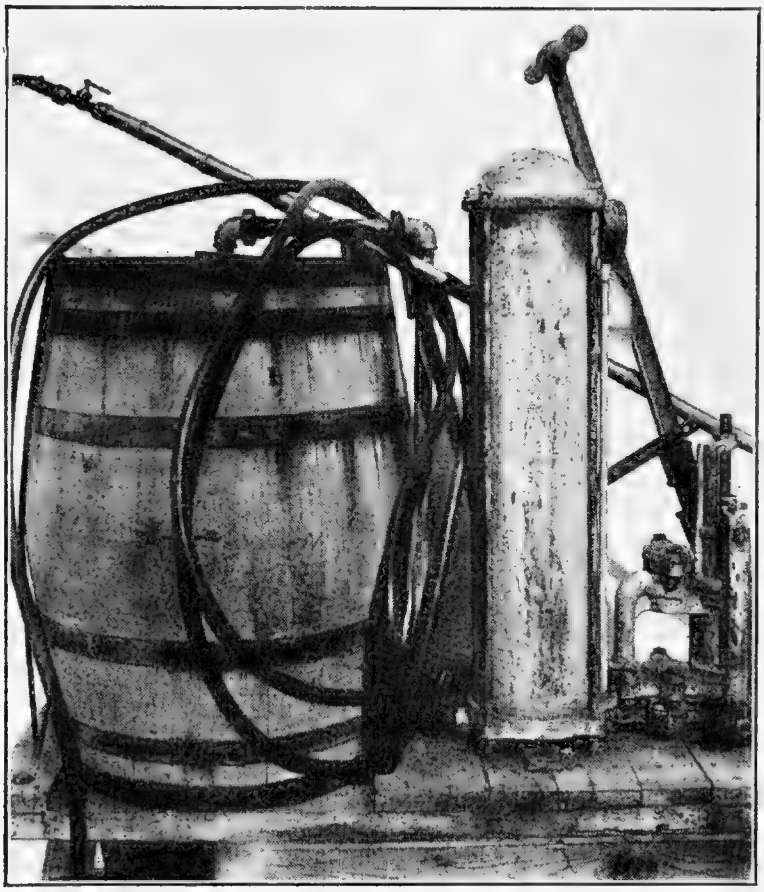

FIG. 8.—Desirable type of hand sprayer.

For mixing spray preparations, especially where an emulsion is required, a good mixer is of the utmost importance. It is possible to obtain an emulsion (a uniform suspension of oil in minute particles in water) by stirring with a loop-wire, hotel-size egg-beater, or even a wooden paddle. There are, however, two or three types of moderately priced churns on the market which are so far superior to the beater as to warrant their purchase even when only a small quantity of insecticide is to be prepared. One of the best types of churn for this purpose is illustrated in figures 9 and 10. This type may be had in sizes from 3 to 25 gallons. All may be run by hand, at least up to the 16-gallon size. The larger sizes may be connected with a gasoline engine, as shown in figure 11, when a large quantity of insecticide is to be made. The churn is equally convenient for making both soap and emulsion. It may be cleaned and turned to other uses after this work is completed.

Other items of equipment incidental to spraying are a strainer with the gauze in a more or less vertical position, a pair of scales for weighing, a 1-gallon measure, and several good, clean barrels, and metal

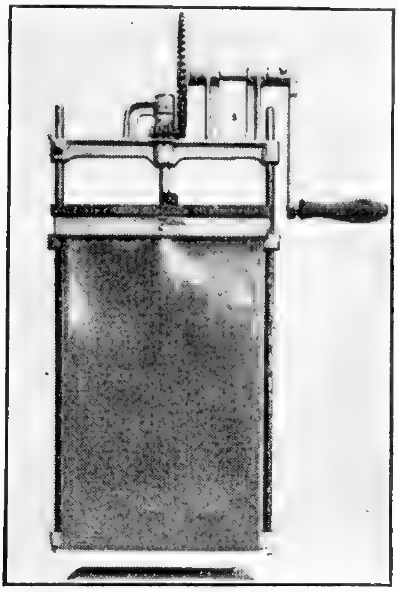

FIG. 9.—Efficient type of insecticide mixer.

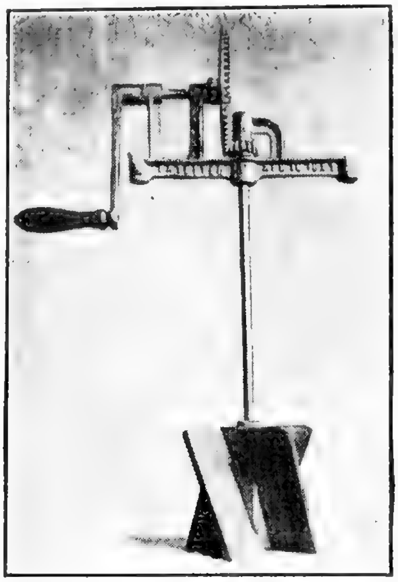

FIG. 10.—Dasher removed from insecticide mixer.

drums or grain cans for storage purposes. A strainer with fine wire gauze set in as a cone is a very satisfactory type of strainer.

The insecticides required will be lubricating oil, soap, and nicotine sulphate. If the modified formula is used the nicotine sulphate may

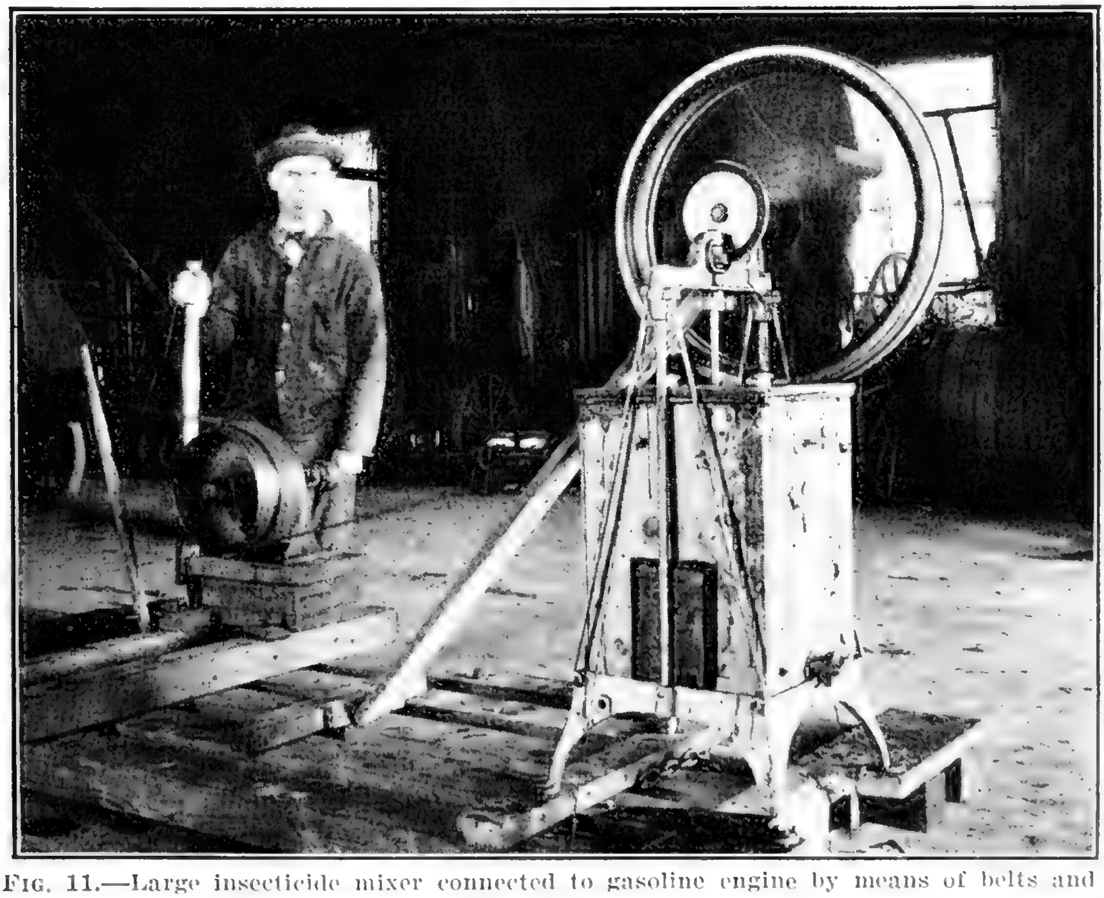

FIG. 11.—Large insecticide mixer connected to gasoline engine by means of belts and pulleys.

be omitted. The quantity of insecticides must be estimated and the orders placed early in the year to avoid delay due to heavy sales and slow transportation.

Lubricating Oil.

All of the principal oil-refining companies market an oil suitable for this purpose. The cheapest and usually lightest grade of oil is required. Its specific gravity is usually from 24° to 32° Baumé and its viscosity 200 or over. The present cost is from 38 cents to 50 cents per gallon, depending upon the quantity purchased.

Soap.

For the sake of securing an article of known strength and purity, as well as reducing the cost, the soap should be made at home. A very satisfactory soap may be made of crude corn or cottonseed oil and caustic soda, after the following formula. Cottonseed oil may be purchased of any of the cotton oil refining companies. Off-grade refined oil can sometimes be purchased as cheaply as the crude oil and is highly satisfactory. The corn oil can be purchased of manufacturers of corn products. The technical grade (78 per cent pure) of soda is satisfactory and can be purchased of wholesale drug houses.

Soap Formula.

Caustic soda	pounds	4
Water	gallon	1
Crude corn oil or cotton oil	do	2½

Directions for preparation.—Place the water in the mixer already described, sprinkle the soda in the water to avoid danger of an explosion from suddenly generated heat, and rotate the agitator slowly. *While still hot* pour the oil slowly in, meanwhile churning as vigorously as possible without splashing. *The heat developed by dissolving the soda in the water is very necessary for the formation of the soap; therefore add the oil before the mixture begins to cool.* The oil should be poured in a thin stream from a sprinkling can from which the cap has been removed, or slowly pumped in with a tin gasoline pump. Continue churning slowly until the mixture is of uniform color throughout and begins to thicken and the dasher to turn hard. Then pour into a clean barrel or other receptacle and cover for storage. Further batches may be poured directly upon the first. If properly made and stored in air-tight containers, this soap will keep for years. Evaporation should be prevented, otherwise the soap will become very hard. Galvanized-iron grain cans, with fitted lids, are excellent for storing the soap for a period of several months to a year.

Soap Liquid.

This soap, like all other hard soaps, will take time to dissolve perfectly for use in making the spray emulsion. Therefore enough should be dissolved in advance of need to make up all the stock emulsion required for the season's work. This *soap liquid* may be made by dissolving the required amount of soap in three times its weight of hot water. It should be kept in tightly covered barrels or grain cans.

Nicotine Sulphate.

This product is a highly concentrated tobacco extract, containing 40 per cent of the pure form of nicotine. It may be purchased at seed stores, drug stores, or of the manufacturers.

SPRAY FORMULA.

Either the following spray mixture or its modification will give excellent results if properly applied. Spraying may be followed by a slight amount of injury, but the wheat will recover from these apparent ill effects in a week or 10 days, and where the spraying is fully warranted will be as nothing compared with the damage the bugs would have done.

Lubricating oil	pounds	8
Soap liquid	do	16
Water	pints	7
Nicotine sulphate (40 per cent)	pound	$\frac{4}{5}$
Additional soap liquid	pounds	$3\frac{1}{5}$

To be mixed with sufficient water to make 100 gallons of spray.

Directions for Preparing Stock Emulsion.

Place the oil and soap liquid in the mixer, and stir until they are thoroughly mixed and of uniform color throughout, then add the water and continue the stirring. A creamy emulsion will quickly result, but the stirring should be continued for 15 or 20 minutes, occasionally reversing the direction of the dash, to insure thorough mixture. When the batch is completed it may at once be stored in airtight barrels for future use. It will keep for months if the air is completely excluded. The stock emulsion should be made without heat, thus saving time and annoyance besides obtaining a preparation with good keeping qualities. It must be very thoroughly churned or stirred, so that the oil and soap will be evenly divided into fine particles and thoroughly incorporated with each other.

Directions for Diluting.

For use, first churn again thoroughly, then add water, a gallon at a time, churning after each addition, until the mixture is brought up to 10 gallons. Fill the spray tank about four-fifths full of water, stir in the $3\frac{1}{5}$ pounds of additional soap liquid and the nicotine sulphate, and start the agitator. Then pour in the emulsion while the agitator is running. In case a 50-gallon barrel pump is used this will make two sprayer loads, 5 gallons being added to 45 gallons of water and $1\frac{3}{5}$ pounds of soap liquid previously placed in the sprayer barrel. While pouring the mixture into the sprayer the agitator should be kept moving.

A modification of the formula, in which the strength of the oil is increased by one-third, and the nicotine sulphate omitted, may be used with good results. In that case the stock mixture should be added to sufficient water to make 66 gallons instead of 100 gallons of spray, using additional soap liquid, as before, at the rate of $3\frac{1}{5}$ pounds per 100 gallons.

Cost.

The cost of spraying operations for destroying the chinch bug is relatively high. The following statement of costs is the result of work done during the era of high prices prevailing in 1919.

Cost of oil per 100-gallon tank	$0.368
Cost of soap per 100-gallon tank	.653
Cost of nicotine per 100-gallon tank	.952
Total	$1.97
Cost of insecticide per acre	$29.55
Cost of labor per acre	10–13.00
Total	$39.55–42.55

In view of the considerable expense involved, the use of this method must necessarily be restricted to comparatively small areas, such as the borders or edges of newly infested fields and stubble fields or other small areas from which the bugs are migrating in large numbers.

The grower should consider well, before attempting to spray, the question of whether the expense involved will be justified by the results to be obtained. The price of suitable oils has fallen considerably since the estimate given above was prepared.

SPECIAL BARRIER DRAGS.

A dust path or oil-line barrier, laid about harvest time, between the wheat or other small-grain field which the bugs are about to leave, and the corn or other row-crop field which they threaten to attack, is one of the best means of destroying the bugs. By this means, corn planted near a small-grain field can be protected from destruction by the spring issue of bugs while still under 18 inches in height. This highly important lot of bugs being destroyed, damage from the second uprising may possibly be prevented by unfavorable weather.

THE GROOVE DRAG.

The simplest type of effective barrier, and one of the most easily constructed and maintained, is made by means of the groove drag (fig. 12). This drag makes a combination dust path and shallow ditch or groove, as shown in figure 13, both of which the bugs must cross before reaching row crops. In dry, hot weather, the dust track made by this type of drag is often of itself alone sufficient to check the migrating bugs. In wet weather, or when the bugs travel only in

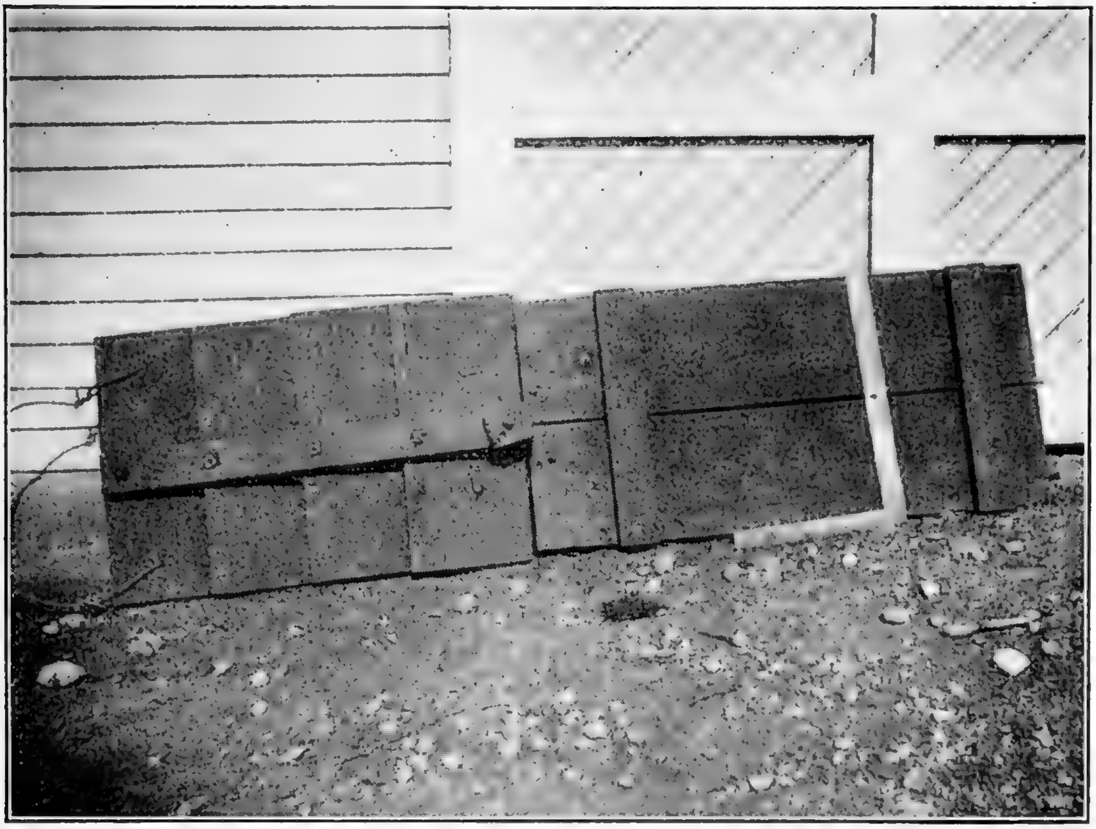

FIG. 12.—Groove drag used for preparing oil-line barriers, etc.

the cool of the morning and afternoon, as they are very apt to do, it may be made impassable by laying a line of road-surfacing oil or crude creosote in the groove.

The groove drag here shown is constructed of 2 by 12 inch oak planks, 2 by 4 inch crosspieces, and an angle iron fence post with most of the base cut away. The front or clod crusher section is made of four 2-foot lengths of the plank spiked together, with the front edge of the second overlapping the back edge of the first about 2 inches, the third overlapping the second, and the fourth the third. This is reinforced by bolting a 2 by 4-inch crosspiece to each section of the plank at the middle of the front edge, and to the back of the fourth plank, a 2-inch support block being placed between the back edge of the fourth plank and the crosspiece. This section of the drag breaks up clods and prepares the way for the smoothing section. To the back edge of this fourth plank is rigidly attached a smoothing drag consisting of two sections of 2 by 12-inch plank 4 feet long cleated together by 2 by 4-inch crosspieces near each end of the planks. To the underside of the fourth plank of the clod crusher is bolted the flanged base of the iron fence post, so placed that the two edges of the angle iron straddle the crack between the two smoothing planks, to each of which the iron is securely attached. Two strips of iron anchor the two portions of the drag together, supplementary to the angle iron. Holes are bored in the front plank of the clod crusher for the attachment of a wire anchor for a singletree for the attachment of one horse.

Fig. 13.—Dust path made by groove drag.

Equally efficient modifications of the groove drag shown in the figure have been made by substituting $1\frac{1}{2}$ inch for 1-inch angle iron, and 1-inch boards for the 2-inch planks in the back or smoothing section, the two sections being fastened rigidly together. Angle iron with 2-inch sides is not satisfactory. One-inch smoothing boards are quite as satisfactory as 2-inch planks, although they are not likely to be durable. An absolutely smooth finish to the undersurface of the rear section of the drag is most necessary so that it will not catch and will produce a perfectly smooth impression. Not only must the boards be perfectly smoothed off, but the front end of the angle iron must be flattened and smoothed, and the bolt heads in it completely countersunk.

The groove drag improves the soil surface wherever used. Its width is such as to permit its use between rows of corn, thus segregating infested rows and preventing the bugs from crossing into noninfested ones. It usually makes a nearly perfect barrier with one round trip on any one trail, and two or more trails may be made between corn rows in a comparatively short time. For laying an oil or creosote barrier, the groove furnishes the most economical trail, holding the oil in a narrow line and limiting any collection of oil strictly to the deepest part of the groove. Oil poured on a natural or a flat surface, a ridge, or the bottom of a plow or lister furrow, will spread out and sink into the soil, leaving a passable surface for the chinch bugs, much sooner than where its spread is limited to a groove as just described. The groove drag reduces the chance of accidentally bridging the oil line by pushing clods into it with the feet when renewing the oil. It also forms a convenient path for a two-wheeled vehicle carrying an oil container from which the oil is allowed to flow through an adjustable cock at the bottom.

OTHER KINDS OF DRAGS.

The trench drag is a special contrivance for pulverizing and compacting the soil in a furrow previously made with plow or lister. It perhaps serves this purpose somewhat better than a log or barrel, in that it fits the furrow more snugly and can be weighted as much as desired with sacks of sand. It is made of two pieces of lumber 2 by 12 inches and 2 by 14 inches, respectively, and 5 feet long; the 12-inch plank being spiked to the 14-inch one flush with one edge and at right angles with it, and the top of the drag being reinforced by a short piece nailed across each end.

A double-trench drag, making a double-barrier path, has also been successfully used. It is made of three 2 by 12-inch planks and one 2 by 14-inch plank, 4 feet long; one 12-inch piece being spiked flush with an edge of the 14-inch piece, a second 12-inch piece to the upper edge of the first 12-inch piece, and the third to the lower edge of the second. It is reinforced by a piece across each end and by two more pieces across the top and weighted as required.

The straddle drag, used for smoothing and compacting an elevated barrier made by plowing a furrow and then back-furrowing to make a ridge, is made by spiking a 2 by 12-inch plank 6 feet long flush with one edge of a plank 2 by 14 inches by 6 feet at right angles to it, the front ends being rounded off. A rectangular piece 7 feet long, cut to fit into the angle, is nailed to the inside flush with the front end, extending a foot beyond the hind end, serving to make a groove for an oil or creosote line on top of the ridge. The inside of the drag is then lined with galvanized iron. A narrow weighting platform, made by nailing three cross braces of 2 by 4 inch plank 1½ feet long across the top and fastening two planks 2 by 4 inches by 6 feet to them, completes the drag.

DEVICES FOR POURING OIL.

When oil barriers are resorted to, it becomes necessary to use containers from which a small stream of oil can be accurately directed onto the line. A 1-gallon coffee pot serves the purpose fairly well. A sprinkling can with the rosette removed is better because of its longer spout. In hot weather, when the oil is so warm as to flow freely, the spout of the watering can may with advantage be partially plugged with a stick of wood. Far more efficient than either of these, especially when the groove drag is used, is a two-wheeled truck with a 20-quart can mounted between the wheels and fitted with a stopcock at the bottom of one side. The wheels should be set about 18 inches apart. The operator walks, straddling the line, behind the truck. The stopcock is set to supply a sufficient line of oil in the

FIG. 14.—Five-torch asphalt heater adapted for burning chinch bugs.

groove. The smoothed path and this method of oiling offer a minimum risk of bridging the oil line by knocking in clods or other matter with the feet. Such two-wheeled trucks are on the market for garden spraying apparatus. Road oil No. 7 or crude creosote is considered best for this work.

TORCHES.

Gasoline torches, of the type known as the plumber's torch, are sometimes used for burning chinch bugs along dust and oil barriers. A special knapsack gasoline torch which has been used in the field for destroying trash, and incidentally the pink bollworm in the infested areas in the Gulf Region, will also be of value for destroying the bugs massed along barriers. Neither of these types of torch is of much value for burning the bugs in growing crops or in stubbles.

A five-torch asphalt heater (fig. 14), generating a temperature of 230° F. at the surface of the ground, also has proved inefficient when applied to green sorghum stubble. It is expensive in its consumption of gasoline and will not kill bugs sheltering under small clods of earth or in the stubbles of kafir or sorghums. Where such apparatus happens to be available, it might be useful in destroying bugs trapped along barriers. It might have a further value in burning the stubble of small grains immediately after the crop is harvested and before the bugs have completed their migration to other crops. The asphalt heater is made for use on paved streets, and to be operated by man power. To make it applicable to cultivated ground, it is necessary to attach shafts to the handle end and to swing the torches 2 or more inches higher on the running gears than would be necessary on the street, in order to avoid clogging them with earth.

Of all heat application, the most effective in destroying chinch bugs is the heat furnished by the sun and absorbed by the soil. The surface of the soil not infrequently registers temperatures so high that the bugs can not survive even a few minutes' direct exposure, soil temperatures from 130° to 150° F. having been recorded in Kansas and Oklahoma. When caught for a few minutes in a dust furrow or groove barrier heated to such temperatures by a bright summer sun the bugs invariably are killed.

THE SEASON'S CAMPAIGN.

FALL CLEAN-UP.

A general clean-up in the fall is important to prevent as many bugs as possible from successfully entering into hibernation. All corn and sorghum stalks and stubble should, where practicable, be plowed under to a depth of at least 7 inches and packed with roller or drag, so that the bugs can not escape. This should be done as promptly as possible after the corn or sorghum is harvested and before the bugs begin to migrate to their final winter quarters. Wherever bunch grasses grow on strips of waste land about the farm which will permit deep plowing, the land should be plowed as above described.

Bunch grasses growing in meadows, pastures, and ravines and along roadsides should be burned, preferably soon after the first freeze.

The trash, consisting of grasses, dead leaves, etc., occurring in hedges, brushy fence rows, brier patches, and woodlands should likewise be put to the torch. This destroys the usual hibernating shelters of the bugs, without which few can survive the winter, and results in the death of from 50 to 90 per cent of them. *Where burning operations are conducted in proximity to woodlands, the most careful precautions should be taken to prevent setting fire to the timberland, as otherwise disastrous forest fires may result.* The fullest possible value of burning can only be secured by concerted action on the part of all the farmers of an infested area in the months of November and December. A good torch for ignition purposes is made by fastening a bundle of soft cloth in the twisted-wire holder of a mop stick and saturating it with coal oil. Either of the types of blow torch previously mentioned will also serve.

FOREWARNED IS FOREARMED.

In March a field-to-field examination of little bluestem and other bunch-forming grasses conducted over a large sheet of newspaper or oilcloth will enable the farmer to form an opinion of his chinch-bug prospects. If he finds several or many bugs in each bunch examined he will do well to defend himself against these wintered-over insects getting into his wheat, and prepare his equipment for spraying or the laying of barrier lines.

TRAP STRIPS BETWEEN WINTER QUARTERS AND WHEAT.

A strip of wheat, millet, oats, or rye placed between infestations in bunch grasses and other wintering places and the nearest fields of small grains will usually attract the bugs and prevent them from scattering widely. In April this trap strip should be watched closely so that it may be destroyed when its infestation is greatest. If such trap strip be not planted in time to attract the bugs, or if not planted at all, the edges of wheat fields nearest to areas of bunch grasses, pastures, roadsides, and ditch banks should be carefully inspected every few days, beginning about mid-April. As impending serious outbreaks are most likely to be first discovered in wheat fields shortly before harvest, when the overwintered adults have their first summer generation well under way, it becomes expedient and decidedly profitable to discover the bugs early.

TRAP STRIPS BETWEEN WHEAT AND CORN.

May is the time for planting any trap crop intended to protect corn and sorghum from the bugs migrating from wheat ripening in June or early July. Occasionally this trap may be planted in June and still make enough growth to have real value. Millet and cane are suggested as the best crops at this time. To be most serviceable, this trap crop should be between the infested wheat and the corn or sorghum to be protected, should be at least one drill-width, and should be seeded early enough to allow a growth of 4 to 6 inches before the bugs begin to migrate. The bugs in the trap strip should be destroyed when the largest possible number is present and while the plants are still succulent. They may be killed by plowing the strip 7 inches or more deep and firming the soil with drag or roller, or they may be killed by spraying.

SPRAYING THE BUGS IN WHEAT.

As soon as mating has become common, it may be assumed that sufficient migration from winter quarters to wheat has occurred to warrant spraying with the formula given on page 21. If at this time the infestation in the wheat extends over only a narrow margin of the field, before spraying is attempted it will be advisable to determine whether it may be less costly to plow the infested strip under to a depth of at least 7 inches, beginning at the innermost infested row, and immediately harrow and roll or drag it. If an efficient type of sprayer and a supply of insecticide are immediately available, however, the bugs may be effectively destroyed by spraying. In May or early June, depending upon locality and season, the bugs developing in the wheat should be sprayed. As already stated, the spraying should be done after the bugs begin mating and before the wheat is in full head. The smaller the wheat is when sprayed the greater the saving in time and spray material and the larger the number of bugs that will be killed. Hence, after the bugs are heavily massed on the wheat, the sooner the spraying is done the better. It is important to remember this fact, that only those bugs hit by the spray will be killed, and therefore thorough application, using plenty of liquid at high pressure, is absolutely necessary. From 1,500 to 2,500 gallons of spray material per acre will be required, depending on the height of the wheat.

Infestations in rye, barley, and oats should be treated the same as those in wheat.

While the bugs usually begin to leave the wheat for the nearest cornfield about 10 days before harvest, it sometimes happens that a vast majority of them remain in the wheat until it is cut. In such cases they may be destroyed and consequent injury to the corn prevented by spraying them in the stubble along the margin of the field immediately following the binder.

SPRAYING THE BUGS IN CORN AND TRAP CROPS.

As soon as the migration from the wheat has ceased, the bugs on the early summer trap-crop standing between wheat and corn, if such trap planting has been made, should be destroyed. One of the most effective ways of doing this is by spraying. As there is no need for saving this trap-crop, the spray mixture may be strengthened up to 3 per cent, or a strong mixture of kerosene and water used. Unless a sprayer and solution are immediately available, however, the trap-crop should be plowed under deeply and the ground firmed immediately thereafter.

To destroy chinch bugs in corn by spraying on a broader scale than merely the first few heavily infested marginal rows, is much more difficult than to destroy them by spraying in the wheat field. On the completion of the wheat harvest, corn usually is of such size that it is difficult to get over the field with the sprayer. If they have been allowed to enter the field, the bugs will be sheltered beneath the leaf sheaths and in the ground about the roots, some being entirely inaccessible. Thus, to insure hitting most of the bugs it is necessary to soak the plants at high pressure. The excessive amount of spray material necessary to reach the interior of the leaf sheaths is very likely severely to injure the plants. While the corn is under 3 feet in height, much good may be done by spraying all of the area where the bugs are numerous, even if that should be the whole field. At that time the bugs are less securely sheltered and much less liquid is required to cover them. Nevertheless, injury to the corn may be expected, although it may not be as severe as would be inflicted by the bugs. The precaution should be taken to spray only in the mornings and evenings or on cool, cloudy days, in order to avoid excessive injury to the plants. Some injury will probably result anyway, but the plants usually will recover inside of a week or two.

SUBSTITUTING NONSUSCEPTIBLE CROPS FOR CORN AND SORGHUM.

Before starting to plant corn or sorghum the farmer should know if any substantial infestation exists in near-by wheat, and if so he should be adequately prepared to defend his crops from the bugs or else substitute nonsusceptible crops for corn and sorghum. A nonsusceptible crop, such as those listed below, even if not as profitable as a crop of corn, may be far more profitable than a chinch-bug-damaged crop of corn.

The chinch bug depends entirely upon grasses and grass-like plants, including corn and small grains, for food. The spring brood must have wheat and other small grains or grasses to live upon from the time of emergence from hibernation until corn or similar row-crops are of a size to meet its needs. If the growing of corn and sorghum could be stopped in the semiarid regions of the West, bugs of the summer generation would be practically starved out and unable to attain serious numbers, and wheat would accordingly cease to be injured appreciably. Likewise, if the growing of wheat could be stopped, bugs of the spring generation would not have sufficient food on which to develop and would consequently do no great damage to corn. Such measures, however, are usually impracticable.

A threatened outbreak may be avoided by substituting for corn a leguminous crop on which the bugs will not feed. As early as 1785 some districts in North Carolina suffered such losses in wheat by chinch bugs that wheat production was abandoned. In 1809 the farmers of Orange County, N. C., cooperatively resorted to the method of planting no wheat for two successive years and were satisfied that they destroyed the chinch bug by so doing.

On the following crops the chinch bug will not feed: Cowpeas, soy beans, velvet beans, clovers, peanuts, stock beets, sunflowers, and rape. The crop or crops chosen for substitution must of course depend on the locality, the prevailing local conditions, and the markets.

OPERATION OF BARRIERS.

As the wheat ripens, beginning about 10 days before harvest, the bugs become restless. Some climb the ripening stems and continue to suck juice from the plant as long as there is any greenness at the upper nodes and in the head. Others wander away, finding succulent vegetation somewhere, most conspicuously in the nearest cornfield. At this time, speed in action against the bugs is vital. Those corn growers who have not destroyed the bugs before this migration should then devote their best attention to the pest until they have destroyed it. To temporize with it is to lose some of the crop and much time.

If the insects have not as yet been controlled by spraying in the margin of the field of young wheat, or by other methods previously recommended, the quickest efficient barrier that can be constructed should be thrown up against them. The groove drag, if made in advance, in anticipation of chinch-bug trouble, will be the quickest barrier maker. Usually the ground is dry when migration begins; if rainy, the wheat continues juicy and migration may be delayed. The trench, double trench, and ridge groove or straddle drags require preliminary soil preparation with a plow or lister before they can be applied. The same is true before a log or barrel can be used. These several barriers are made in the following ways: (1) A deep furrow is plowed along the sides of the field from which the bugs are threatening to invade the corn, the soil being thrown toward the infested field. A second run of the plow may be necessary to obtain sufficient depth to stop the bugs. The sides and bottom are then reduced to a covering of fine dust by dragging repeatedly back and forth in the furrow, a trench drag, a barrel, or a log. (2) The furrow may be made with a lister, the soil being thrown both ways, and the surface pulverized as described above. (3) A strip of ground is disked and rolled or dragged until there are several inches of fine, loose soil and dust, and a furrow is made by means of the trench or double trench drag. (4) A ridge is made by throwing two furrows up together, and is then pulverized and grooved by means of the ridge-groove or straddle drag. In applying barriers against the migrating bugs, it may be necessary or at least expedient to construct a second barrier or even a third. The additional barriers will not be necessary if the first barrier is made at the edge of the field before any bugs have crossed the line and is maintained in an impassable condition until migration has ceased.

The barriers mentioned above are all dust barriers and are effective only when dry. In case of a shower a crust is formed on them over which the bugs can walk without hindrance, until the soil dries enough to allow redragging. As quickly as the shower is over, oil or crude creosote may be poured in the groove of the groove-drag barrier or in the bottom of the trench barriers and in the groove of the ridge barrier. Very good results have been secured by throwing up a ridge, as indicated in method (4) above, and applying crude creosote *in a line three-fourths of the way up the ridge* instead of along its summit. Oil, to be effectual, must be kept soft in a continuous line during every minute that the bugs are trying to cross the line. This requires several treatments during the first 24 hours, until the oil has made a hardened crust for itself, after which two treatments a day may be sufficient to keep the line continuously impassable. An oil line in the floor of a trench barrier is very apt to become defective or passable from the falling of clods from the sides of the trench into the oil.

Where special tools are not available smooth paths may be made along edges of a field by the use of a shovel, perhaps aided in places with a hoe or grubbing hoe, the path patted down with the back of the shovel, and an oil line laid on this path. The cost of labor with this type of barrier is likely to be much greater than with the other types.

DESTROYING THE BUGS ALONG BARRIERS.

As the bugs accumulate along the barriers some will be killed by the combined heat of sun and soil and suffocation by the dust. Large quantities can be killed by gasoline torches without disturbing the efficiency of the barriers, and burning as often as the massing of the bugs warrants is an effective way of destroying them. Another way to collect and destroy them is by digging holes at intervals of from 15 to 30 feet with a post-hole auger on the bug side of the barrier, the edge of the hole touching the edge of the oil line or the foot of the slope in the trench and ridge barriers. As the bugs come to a line which they can not cross they follow it and fall into the holes. If the holes are 12 to 18 inches deep, the bugs massing therein may die without further treatment. It is necessary, however, to watch that they do not climb out on trash blown into the holes. They may be killed by pouring a little coal oil into the holes, by burning, or merely by tamping. One difficulty with the postholes is that along the dust barriers they have to be remade with each renewal of the barrier.

Bugs may be trapped along barrier lines by laying 8-inch sections of green cornstalk close to the line 6 inches to 6 feet apart, depending upon the number of bugs, then quickly tapping the bug-laden pieces over a bucket half full of water overlain with a film of coal oil. The bugs should be collected in this way as frequently as their numbers on the stalks seem to warrant. The pieces of stalk will continue attractive for two or three days.

The barrier work should not be substituted for an aggressive all-year campaign, but should be regarded rather as a play for time on the part of the grower. While many bugs are killed by the proper care of barriers (their numbers being estimated in bushels where catches in post-holes have been most successful), at best the barriers leave large numbers of bugs alive to migrate anywhere except across the barrier, and some will even succeed in crossing unless the greatest care is taken to keep the barrier line free from trash.

PLOWING THE BUGS UNDER IN WHEAT STUBBLE AND CORN.

With the harvesting of the small grains, spraying or deep plowing of the stubble should be rushed before the last of the bugs have left the "pigeon-grass" and other green grasses growing in the stubble field. In case some of the bugs have succeeded in starting an infestation on the first few rows of corn and the latter is small enough to plow under completely, it is best to sacrifice those several rows by plowing them under. Plowing should be at least 7 inches deep and the ground should be immediately dragged and rolled, to compact the soil so that practically no bugs can escape. It is possible in the case of a small field, where the corn is too large to plow down and there is no spraying equipment available, to destroy the bugs in heavily infested first rows by cutting and submerging the corn quickly in a tub of water coated with one-fourth inch of coal oil. The plants must be handled gently in cutting and lifting over the coal oil, as the bugs will drop to the ground on comparatively slight disturbance.

Under favorable conditions. a second brood of bugs usually occurs in the corn, resulting in prematurely deadening the stalks in late August, or in September. As quickly as the crop is harvested, plows should be started on the fall clean-up, overtaking as large a proportion of the winged adults and nearly mature young as possible, before they leave for their winter quarters. This completes the year's round of opportunities for chinch-bug destruction.

COOPERATION.

It may be observed from the foregoing recommendations that the destruction of the bugs at every period of the year, and by every known practice, has been advocated on the basis that the best means adaptable under the circumstances shall be used. It will be observed also that plans for evasion of losses from chinch bugs are presented in crop rotations and nonproduction of continuous-season host crops. *Cooperation is absolutely necessary* in order to obtain the fullest possible value from any method or combination of methods which may be used.

First, there should be team work in surveying the neighborhood for possible pests. Growers should be continuously alert to discover the chinch bug, and other important crop pests as well, before such pests have begun their raids. Exceptional abundance, or even the mere presence of any unusual insect which may prove harmful, should be brought to the attention of their neighbors and the county agent or the nearest entomologist. Where possible this information should include the name of the pest, its host plant, or its place of occurrence, and an estimate of its abundance. If it is plainly injuring a crop this fact should be stated. If its name is not known, specimens should be sent to the county agent or other authority, together with the name and address of the owner of the property where the suspected pest or the infestation occurs.

Second, on discovering a threatened or actual outbreak a conference of the farmers and the county agent in the threatened area, and, if possible, a State or Federal entomologist, should be held to plan the best possible campaign of control and to determine what equipment and chemicals are on hand or what must be purchased, either cooperatively or by individuals. There should be agreement upon the time to strike and the duties of each person concerned. Each man should definitely understand his duties, and agree to work simultaneously with his fellows so that their combined effort will either destroy a known center of infestation or at least place the pest under the most efficient control in that area or neighborhood. It is not enough merely to limit the direction of spread of the pest to a point away from the fields of the cooperating community. As an illustration, consider an extremely infested wheat field close to a county or State line. Cooperation is apt to be unusually difficult in such a neighborhood because two county organizations are involved. It is none the less vital, however, to have cooperation. To guard against the movement of the bugs to properties lying adjacent on one, two, or even three sides in the one county, and allow them to escape to property on the fourth side simply because that property is in another county, merely postpones and multiplies the trouble. Let us suppose the farmers in one county have cooperated with regard to purely defensive measures, causing bugs to migrate to adjacent fields in the adjoining county. The dispersion will furnish material for new infestations which will reinvade the territory originally occupied by the bugs, just as soon as the artificial barriers are removed and attractive crops appear. This may be within a few days, a few weeks, or the following years.

It will cost the farmers much less to help a neighbor in the purchase of the labor and supplies necessary to make an immediate aggressive attack, and thus wipe out an infestation when first discovered on his place, than to allow it to cross property lines, multiplying the needs of equipment and labor, and increasing the losses caused by the bugs.

While it is reasonable that a farmer should stand the loss of his own crop by an infestation of bugs first observed on his land, it is sometimes well worth while for his neighbors to consider the advantages of appraising with him the value of his damaged crop, mutually bearing the loss and the cost of the campaign, and to destroy immediately both crop and bugs. There are times when the destruction of a damaged crop will be cheaper by plowing and dragging than by any other method, and when plowing is thorough, at least 7 inches deep, and is immediately followed by thorough harrowing and dragging, the kill thus secured is nearly 100 per cent.

Third, the community adoption of growing crops which are not susceptible to chinch bug injury, in order to break the continuity of host crops over large areas, may sometimes be advisable.

Fourth, team work is absolutely necessary to secure thoroughgoing benefits from the important work of burning the chinch bug hibernating places. Complete and thorough burning of the bunch grasses in November and December, undoubtedly a very valuable measure, can be accomplished only where there is cooperation. Burning in patches and at different dates, even if ultimately thorough and distinctly beneficial, leaves opportunities for the escape of the unburned bugs. Bugs whose cover is burned on one farm may transfer to nonburned cover, and again move if that is burned; whereas, if all the fields, etc., are burned at one time, at the earliest date practicable after vegetation is killed by frost, the surviving bugs generally will be killed by exposure to the winter weather.

In conclusion, it should be fully recognized that the chinch bug, even though it may not now be abundant on your own farm, is a very potential crop destroyer, and with favorable weather may rapidly become injurious over large areas. The fact that your neighbor is the loser to-day makes it most probable that you will be the chief loser to-morrow. It can not be too strongly urged that you at once ally yourself with your neighbor, determine upon your course of procedure, and *stop the chinch bug right where it is to-day.*

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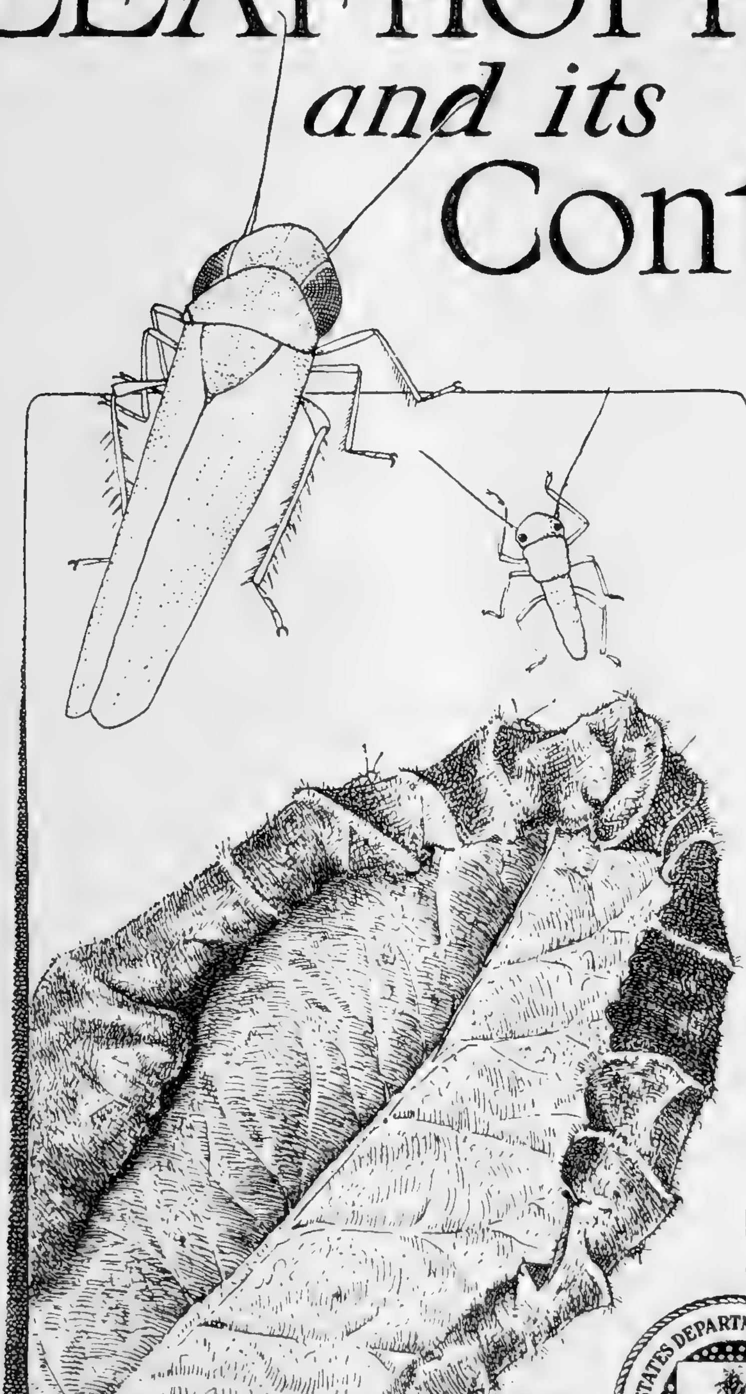
FARMERS' BULLETIN 1225
UNITED STATES DEPARTMENT OF AGRICULTURE

THE POTATO LEAFHOPPER *and its* Control



THE POTATO LEAFHOPPER is a serious and costly enemy of potato, bean, sugar beet, and other crops in the North-Central and Northeastern States. It is a very small green insect which often occurs in vast numbers.

It injures potato by feeding on the foliage and causes a diseased condition called "hopperburn" which may, under conditions favorable to its spread, ruin an entire crop in one or two weeks.

This leafhopper can be controlled and the "hopperburn" held in check by the proper and timely application of Bordeaux mixture. Yields are greatly increased when this spray is used.

This bulletin has been prepared to acquaint farmers with the insect, the nature of its injury to vegetable crops, and the proper measures for its control.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. August, 1921

THE POTATO LEAFHOPPER AND ITS CONTROL.

J. E. DUDLEY, Jr.
Scientific Assistant, Truck-Crop Insect Investigations.

CONTENTS.

The potato leafhopper [1] is one of the most important insect enemies of potato in the United States. Serious outbreaks have occurred periodically in certain sections since the early eighties, and about 1896 this insect became known as a dangerous menace to the potato crop in the Middle and Eastern States. This leafhopper attacks a large number of plants and may at times become injurious on several of them.

FIG. 1.—Adult potato leafhopper. Greatly enlarged.

The feeding injury, although severe, is not nearly as serious as the diseased condition called "hopperburn" which it transmits to the plants on which it feeds.

It is necessary to recognize and to fight this leafhopper to prevent the loss of large acreages of potatoes from "hopperburn."

DESCRIPTION.

The adult or full-grown leafhopper (fig. 1 and fig. 2, G) is a very small, pale green insect, about one-eighth of an inch long, with large, white eyes and a more or less distinct H on its body between the head and base of the wings. There are six roundish, white spots above this H and three white, wedge-shaped spots below it. Adults fly and hop readily when disturbed.

[1] *Empoasca mali* LeB., order Hemiptera, family Cicadellidae.

The eggs (fig. 2, A) are tiny and transparent and are laid in the tissue of the potato leaf. The eggs can not be seen from the outside, but after they hatch the leaf tissue dies and forms small, sunken pits marking the previous location of the eggs.

The nymphs (fig. 2, B–F), or young leafhoppers, pass through several stages of growth and shed their skins several times, developing wings in the adult stage. When newly hatched, the nymphs are very small and nearly white, but slowly turn green as they grow. When the insect is nearly mature, the partially developed wings may be seen on each side of the body, and the "hopper" at this stage is quite active, being able to hop from leaf to leaf.

DISTRIBUTION.

The potato leafhopper occurs in practically every State of the Union and in parts of Canada and Mexico. Its greatest damage to potatoes has occurred in the Northern and Central States, roughly from Montana to New York and south to Ohio, Illinois, and Kansas.

ECONOMIC IMPORTANCE.

The economic loss to the potato grower caused by the attack of the potato leafhopper and the accompanying "hopperburn" is said to be second only to that caused by the Colorado potato beetle. In years when the leafhopper and "hopperburn" are abundant the combined loss may take first place in some regions among all potato insects and diseases. It is, therefore, essential that the grower become familiar with the insect, with the nature of its injury, and with measures for its control when a serious outbreak occurs.

SEASONAL HISTORY.

The potato leafhopper lives over winter in the adult stage, hidden away in brush heaps, matted weeds, and other protected places. Some time during May the leafhoppers emerge from their winter quarters, feed for a week or so on various trees and shrubs, then suddenly migrate to potatoes and beans where mating and egg laying begin. There are two generations of the insect in the Northern States with three, four, or perhaps five generations in the Central and Southern States.

Under Wisconsin conditions the adults which have lived over winter die off during July and their young mature about the last of July, forming the first generation. Thus it takes approximately one month from the time the eggs are laid until the adult leafhoppers appear. A second generation is now produced, although in a slightly shorter time, and the new adults begin to appear about the first of September. These adults live over winter and do not lay eggs until the next spring.

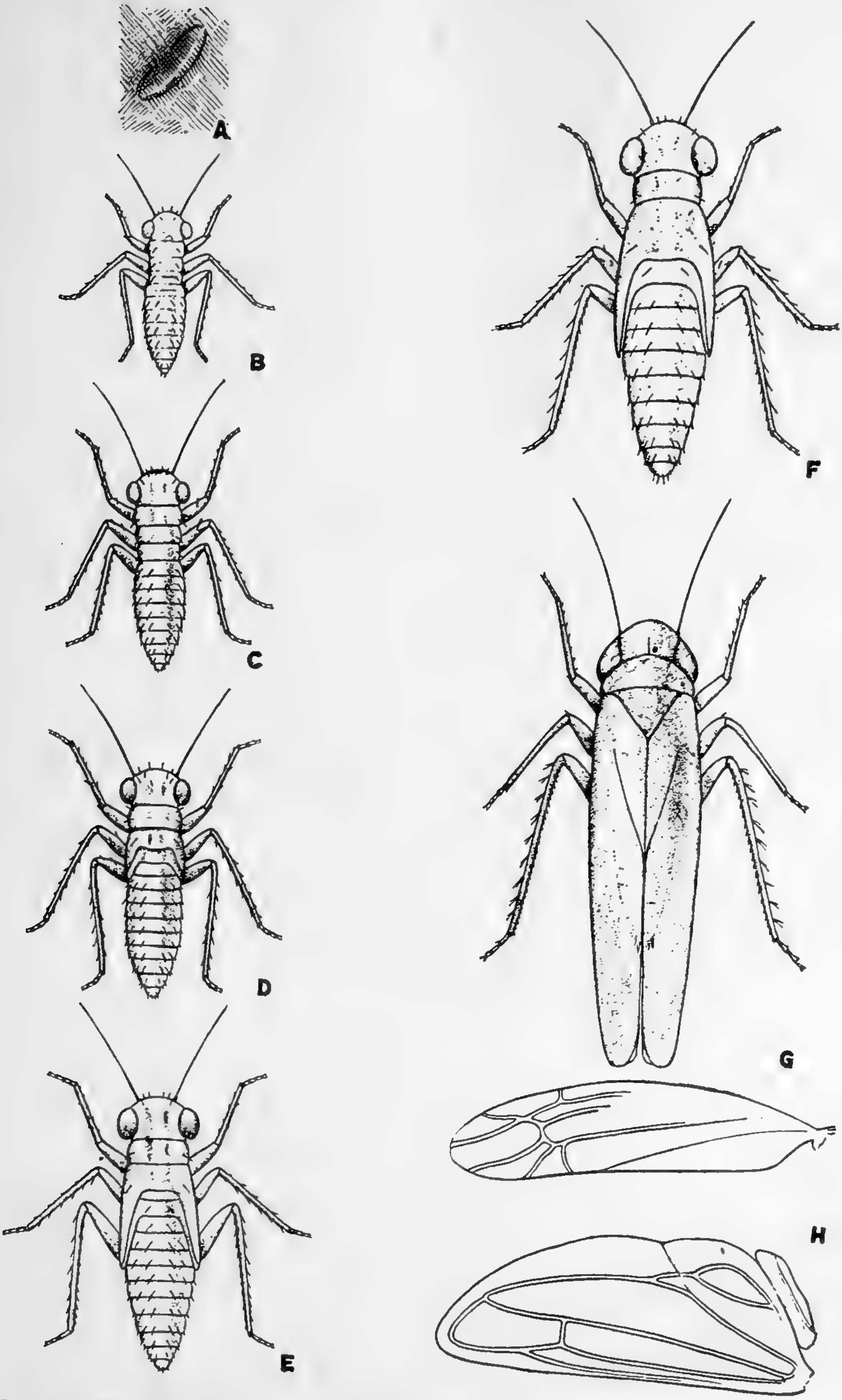


FIG. 2.—Stages in the growth of the potato leafhopper: *A*, Egg in tissue of leaf; *B-F*, stages of young leafhopper or nymph; *G*, adult leafhopper; *H*, fore and hind wings of adult leafhopper.

INJURY CAUSED BY THE POTATO LEAFHOPPER.

FEEDING INJURY.

Adults and nymphs of the potato leafhopper, in common with other sucking insects, extract the juices or sap of plants by means of their delicate beaks which they insert into the epidermis of the leaves. The injury thus caused through loss of plant juices is considerable and alone would cause the leaves to turn yellow. When a large number of leafhoppers are present the plant will sometimes wilt.

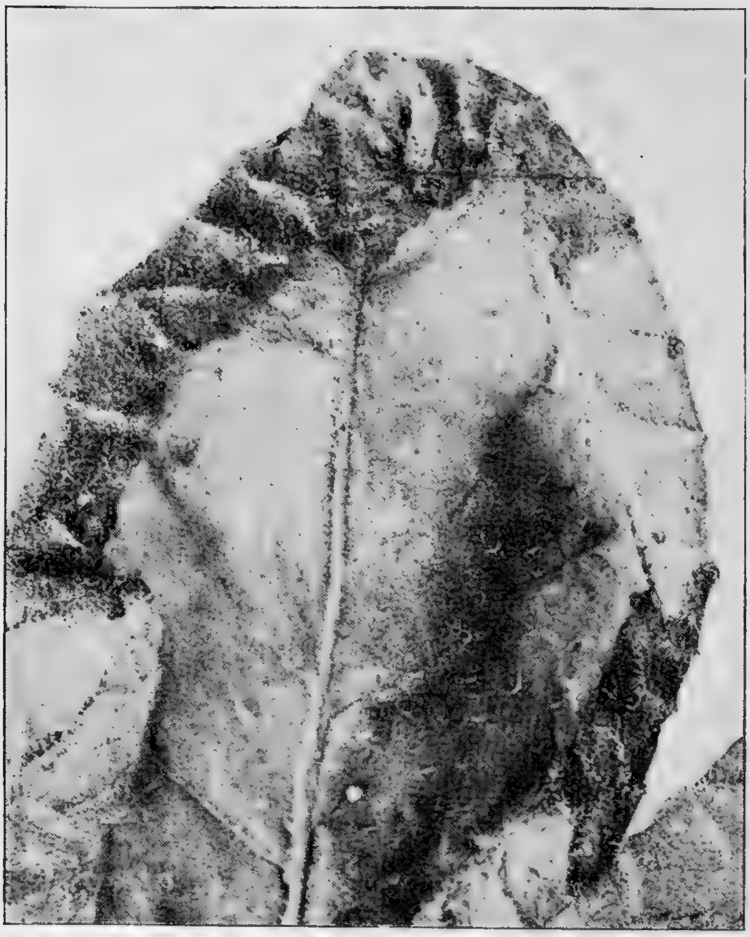


Fig. 3.—Potato leaf affected with "hopperburn." Upper surface of leaf showing typical upcurled brown tip and margin.

"HOPPERBURN."

In addition to the injury caused by loss of plant juices this leafhopper is the cause of a distinct injury called "hopperburn" which follows its feeding on potato and many other plants (fig. 3).

The first symptoms of "hopperburn" are a slight yellowing, usually of the tip of a leaf. As the disease progresses the leaf slowly turns brown, curls upward, and dies. The disease spreads from the tip or margin toward the midrib of the leaf, but spreads more slowly toward the base, and the basal area may remain green until the whole plant is nearly dead.

During periods of hot, dry weather "hopperburn" spreads rapidly and whole fields of early potatoes may be killed in a week's time (fig. 4). On the other hand, during cool, moist weather, or where protective sprays have been applied, the disease is checked and throughout the summer may progress no farther than the primary symptoms (fig. 5).

It has been found that even one or two leafhoppers placed on a healthy potato plant covered with a cage were able to cause sufficient "hopperburn" to kill the entire plant, while other caged plants kept free of leafhoppers remained healthy.

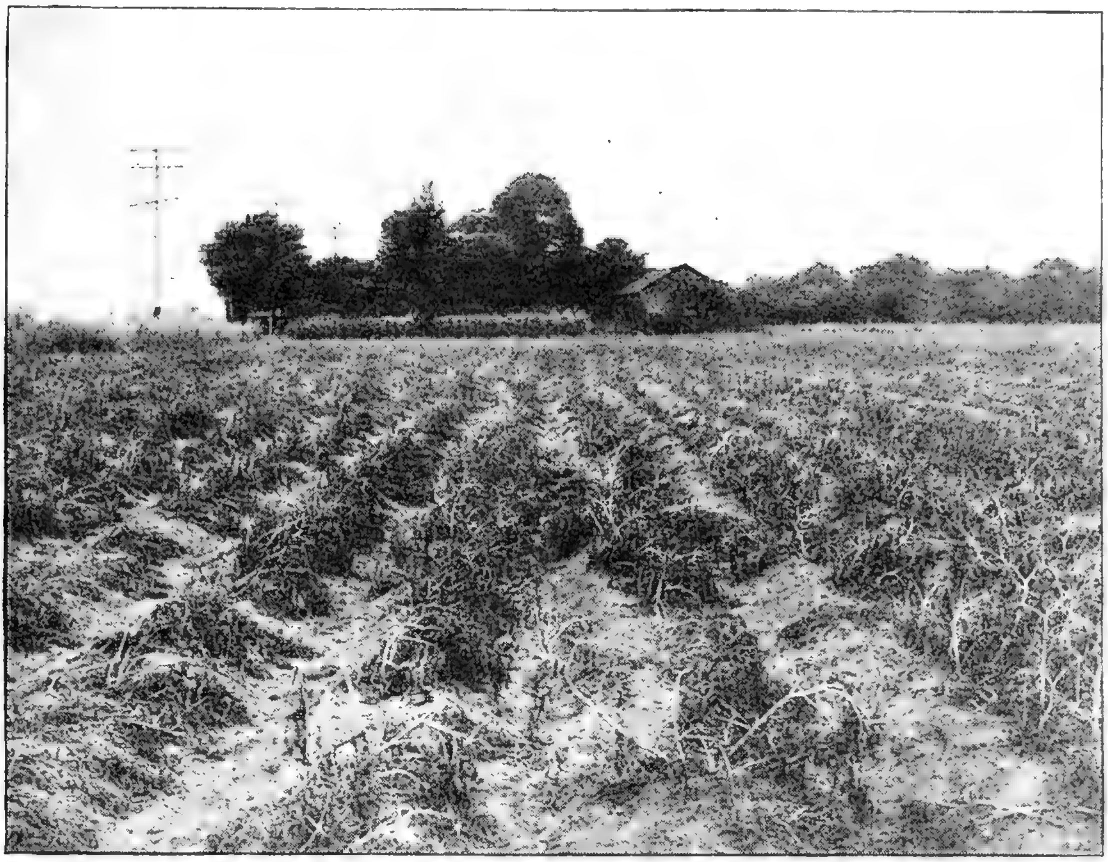


FIG. 4.—Early Ohio potatoes killed by "hopperburn." Great abundance of leafhoppers and a period of hot, dry, July weather caused these potatoes to succumb to "hopperburn" in a short time.

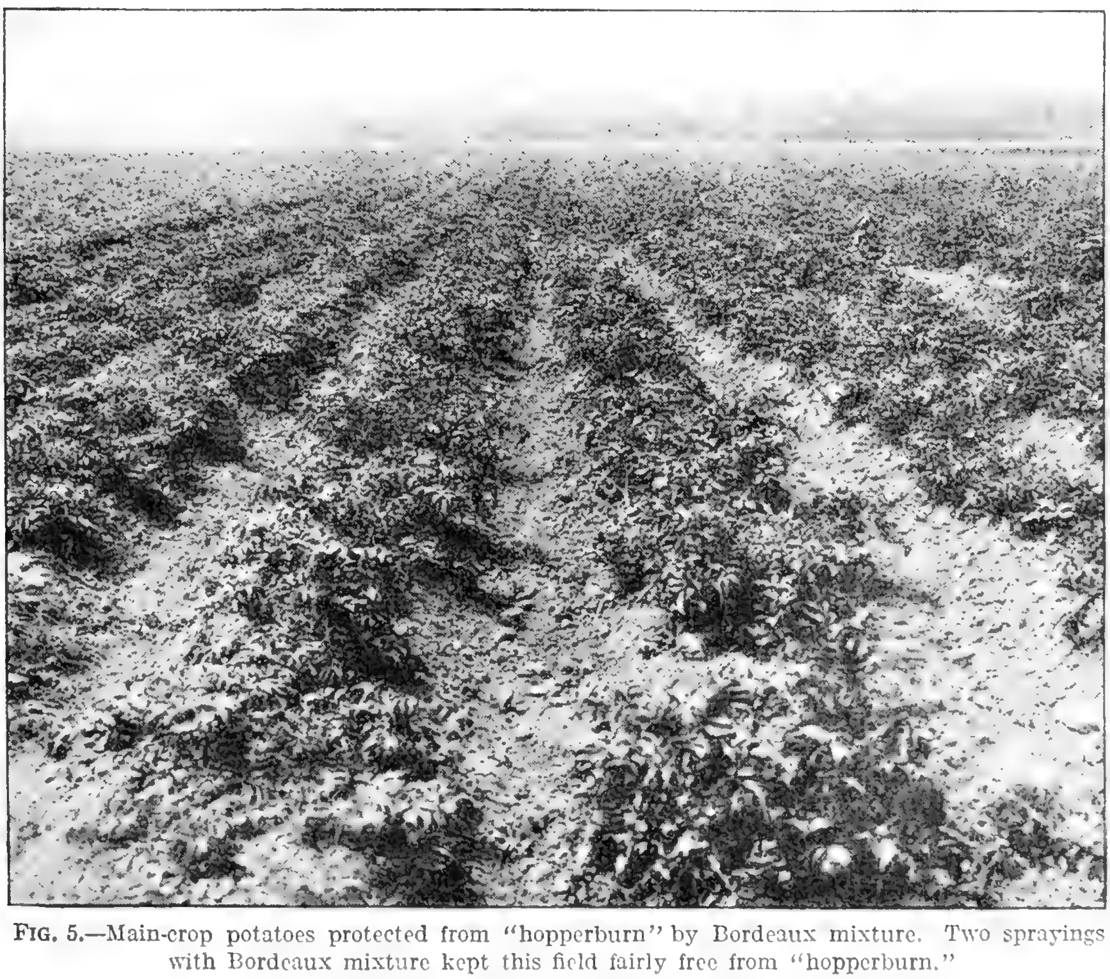


FIG. 5.—Main-crop potatoes protected from "hopperburn" by Bordeaux mixture. Two sprayings with Bordeaux mixture kept this field fairly free from "hopperburn."

Observations made in Wisconsin have shown that whenever leafhoppers were present in potato fields "hopperburn" could be found, and when no leafhoppers were present no "hopperburn" could be found.

FIG. 6.—Presence of many "hoppers" means "hopperburn." Triumph potatoes growing in field, covered with large cage containing leafhoppers for entire season. *A*, Condition of plants on August 14; *B*, condition of same plants when dug on September 2. Compare with figure 7.

HOW "HOPPERBURN" AFFECTS DIFFERENT VARIETIES.

Leafhoppers placed on Early Triumph plants growing in a field and covered with a large cage caused "hopperburn" which killed the plants in 23 days (fig. 6, A and B). "Hoppers" placed on

Early Ohio vines under the same conditions caused "hopperburn" which killed the plants in about 40 days. Similarly "hopperburn" killed Irish Cobbler plants in about 55 days and Rural New Yorker

FIG. 7.—Absence of numbers of leafhoppers means no "hopperburn." Triumph potatoes growing in field, covered with large cage for entire season and kept free of leafhoppers. *A*, Condition of plants on August 14; *B*, condition of same plants when dug on September 2. Compare with figure 6.

plants in about 50 days. Green Mountain plants under like conditions became badly diseased, but were still alive two months after the leafhoppers were placed on them.

Plants of all the foregoing varieties which were caged and kept free of leafhoppers showed no symptoms of "hopperburn" during a period of two months (fig. 7, A and B).

Observations made in several potato-growing sections of Wisconsin have shown that the Triumph variety is invariably more severely affected with "hopperburn" than any other variety grown commercially in that State. Usually the Rural New Yorker has been found to be the most resistant to "hopperburn" of any variety grown commercially in Wisconsin.

FIG. 8.—"Hopperburn" accompanies leafhopper feeding. Apple seedling at left, covered with cage containing leafhoppers, developed "hopperburn" in a few days. Seedling at right, covered with cage free of leafhoppers, remained healthy.

FOOD PLANTS.

The potato leafhopper visits a considerable number of plants for feeding purposes. The more important economic plants on which reproduction takes place and "hopperburn" occurs are the following: Potato, beans (practically all varieties), sugar beet, hemp, apple, and raspberry. It also attacks several ornamental trees and shrubs. Reproduction appears to take place most readily on potato, with beans as a second choice. Hemp, sugar beets, and apple nursery stock are more liable to severe injury when growing near potato or bean fields.

It has been found that two leafhoppers placed on an apple seedling covered by a cage caused "hopperburn" which killed the seedling in a short time (fig. 8). The same is true of bean plants.

String, pole, and navy beans have been severely injured by "hopperburn," and if the plants were not killed the yields were greatly reduced. Lima and soy beans are not so heavily attacked nor is "hopperburn" ever severe on them, in Wisconsin at least.

Sugar beets are liable to attack when grown adjacent to potatoes, especially after the potatoes are nearly dead from "hopper-

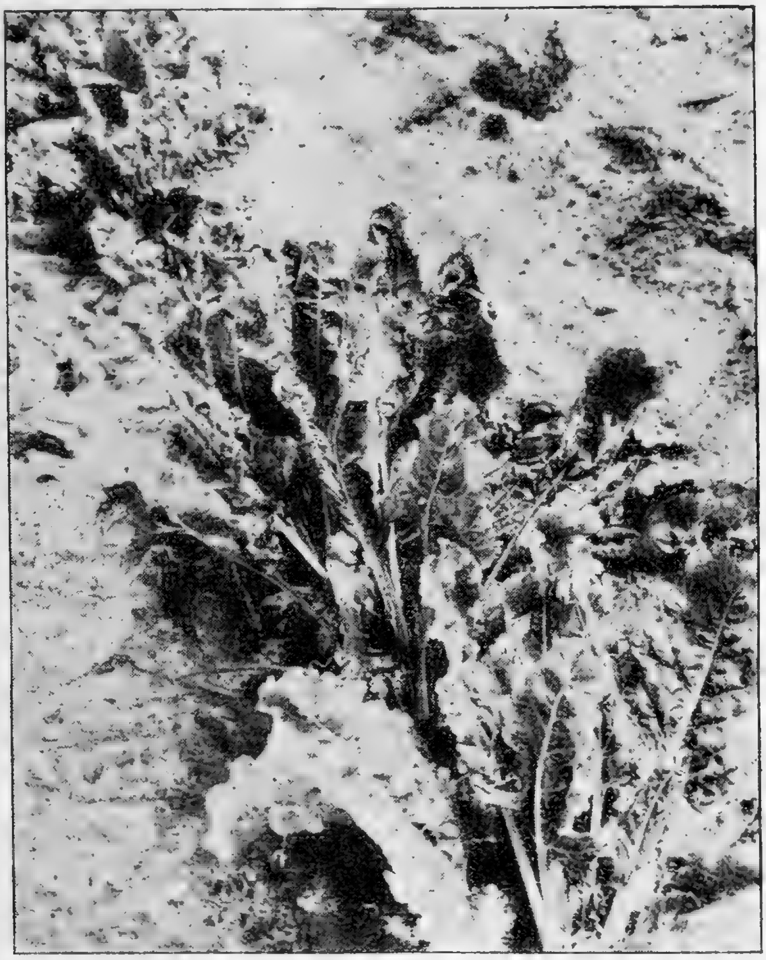


FIG. 9.—Sugar beets develop "hopperburn" when attacked by leafhoppers. Dead potato plants in adjacent row deserted by the leafhoppers.

burn," at which time there is a great migration of "hoppers" from potato to beets. So far, however, "hopperburn" has not become nearly as serious on sugar beets as on potatoes (fig. 9).

NATURAL ENEMIES.

Although there are three natural enemies of the potato leafhopper, none has become important as a control. One, a tiny insect parasite,[2] breeds in the leafhopper eggs, but does not occur in sufficient numbers to reduce noticeably the number of "hoppers."

[2] Probably a dryinid.

A fungus [3] disease attacks both adults and nymphs. Leafhoppers affected with this fungus soon die and turn from green to yellowish in color. In a short time a heavy fungous growth, iridescent in appearance, i. e., having colors of the rainbow, appears on the insect's body (fig. 10). Warm, moist weather is necessary for the growth and spread of this fungus. In 1919 it was common all over Wisconsin and in certain localities practically "wiped out" the leafhoppers. In 1920, however, not a single specimen of the fungus was found.

Spiders often prey on both adults and nymphs.

FIG. 10.—Fungous disease to check leafhoppers. The fungus has a rainbow-like appearance after covering body of the insect.

SELECTION FROM RESISTANT VINES.

Not only are certain varieties of potatoes less severely affected with "hopperburn" than are others, but some vines of any one variety are found to be more resistant to "hopperburn" than are other vines of the same variety.

Selections made at digging time of tubers from healthy and badly diseased vines when planted the following year gave interesting results. Of five varieties used—Early Ohio, Irish Cobbler, Green Mountain, Rural New Yorker, and Late Puritan—"hopperburn"

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[3] *Entomophthora sphaerosperma.*

in every case was worse on plants which had come from tubers of diseased vines of the year before than on plants coming from tubers of healthy vines of the year before.

It is hoped that it may be possible in time to develop a strain of some varieties resistant to "hopperburn."

CONTROL OF THE LEAFHOPPER AND PREVENTION OF "HOPPERBURN."

USE OF BORDEAUX MIXTURE.

Results of two years' work have shown that Bordeaux mixture will repel the leafhopper, control "hopperburn," and is the best

FIG. 11.—Potatoes protected from "hopperburn" by use of Bordeaux mixture: yield high. Five varieties shown here were given four sprayings with Bordeaux. Very little "hopperburn" present on August 23. Compare with figure 12.

remedy. Bordeaux mixture made according to the 4–4–50 formula, containing 4 pounds copper sulphate and 4 pounds unslaked lime to 50 gallons of water, was used.

Bordeaux combined with nicotine sulphate acts a little more quickly in ridding vines of leafhoppers than does Bordeaux alone, but the results obtained do not appear to justify the added time and expense of using the nicotine.

Nicotine sulphate and soap combined were found very effective in killing nymphs and a few adults present when the spray was applied. There was no lasting effect, however, because leafhoppers reappeared in a few days. "Hopperburn" was not controlled.

Kerosene emulsion acted in the same way as nicotine and soap, killing the leafhoppers it hit, but having no lasting effect. Moreover, "hopperburn" appeared to be worse on these plants than on plants sprayed with any other material.

WHAT BORDEAUX WILL DO.

Bordeaux mixture properly applied to plants will drive away leafhoppers and keep the plants quite free of them as long as a good coating of spray is kept on the foliage.

Bordeaux will also very largely prevent the symptoms of "hopperburn" from developing and will check the spread of what has already

FIG. 12.—Potatoes not protected from "hopperburn" give poor yields. Five varieties shown here were never sprayed. "Hopperburn" killed all but late varieties, and even they were badly affected with "hopperburn" on August 23. Compare with figure 11.

appeared. (Fig. 11.) Unsprayed plants growing next to properly sprayed plants or even among them will be heavily attacked by "hoppers" and become badly affected with "hopperburn." (Fig. 12.)

The effect of Bordeaux on "hopperburn" varies with different varieties. Rural New Yorker plants well sprayed have remained almost free of any "hopperburn" until digging time. Triumph plants, on the other hand, while prevented from becoming badly diseased until after tubers had well developed, were affected much more by "hopperburn" than any other variety tested. Unsprayed Triumph plants died from the effects of "hopperburn" before the middle of the season.

HOW AND WHEN TO APPLY BORDEAUX.

To control the potato leafhopper, Bordeaux mixture *must* be applied to the underside of the leaves. The spraying must be done thoroughly, covering practically all of the foliage. Each side of every row of plants must be sprayed.

A high pressure (150 pounds at least) should be maintained in order to cover the leaves with a fine mist, which gives a much better coating than does a coarse spray. (Figs. 13, 14.)

In years when leafhoppers are abundant at least three applications of Bordeaux mixture should be made, the first as soon as the leafhoppers have appeared on the plants. It is often possible at

FIG. 13.—Good type of wheelbarrow sprayer effective for small patches. This sprayer holds 12 gallons, and 150 pounds pressure can be kept up when 2 nozzles are used.

this time to add an arsenical and control the Colorado potato beetle. The second spray should be applied from 10 days to 2 weeks later, depending upon the amount of spray remaining on the plants and the amount of new growth. A third and even a fourth spray might be necessary in very hot, dry summers and in years when leafhoppers occur in vast numbers.

As Bordeaux mixture is used for several purposes on potatoes—to repel fleabeetles and control certain diseases—it is most fortunate that it has been found to be a control for leafhoppers and "hopperburn" and may fit nicely into the regular spraying schedule.

YIELDS.

It has been found that the yield of sprayed fields of early potatoes may be increased over 100 per cent above the yield of unsprayed fields, and the yield of sprayed fields of late potatoes increased over 50 per cent above the yield of unsprayed fields, by the use of Bordeaux mixture against the potato leafhopper and "hopperburn."

SUMMARY OF CONTROL MEASURES.

Spraying appears so far to be the best practical method of control for the potato leafhopper and for preventing the appearance or spread of "hopperburn."

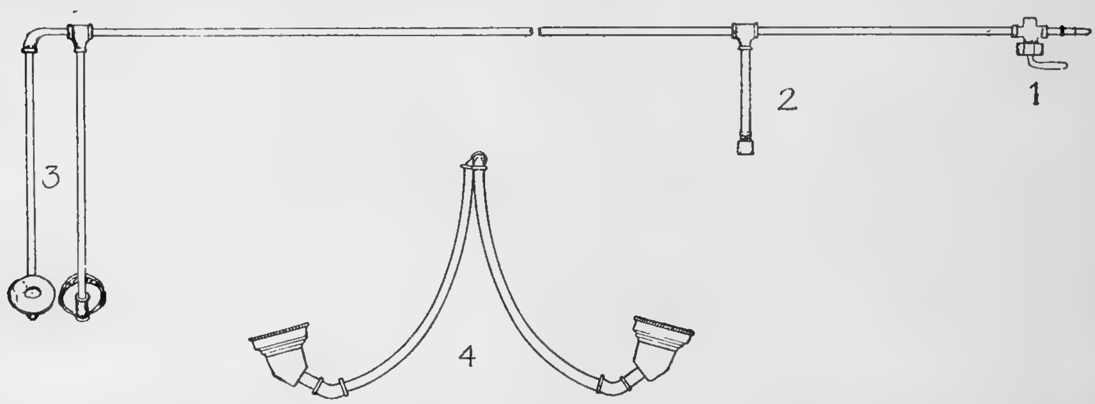

FIG. 14.—Details of sprayer shown in figure 13: *1*, Hose connection; *2*, handle to assist in holding and directing rod; *3*, adjustable booms and nozzles, side view; *4*, same, front view.

Bordeaux mixture 4–4–50 is the best spray to use.

It should be applied to the *underside* of the leaves thoroughly, at least 150 pounds pressure being used so that a fine mist spray will result.

Make at least three applications, and spray a fourth time if necessary to keep down "hopperburn" until the crop has matured.

To make the application thorough, spray both sides of each row.

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THE PEACH BORER

HOW TO PREVENT OR LESSEN ITS RAVAGES

The Para-dichlorobenzene Treatment

A. L. QUAINTANCE
Entomologist in Charge, Fruit Insect Investigations

FARMERS' BULLETIN 1246
UNITED STATES DEPARTMENT OF AGRICULTURE

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1921

THE so-called peach borer, the larva of a beautiful clear-winged moth, has been for upward of 150 years one of the principal drawbacks to the successful cultivation of the peach. It feeds on the soft inner bark at the base of the tree, or on the adjacent roots, seriously injuring and frequently killing the trees attacked.

Few American insects have been more experimented with by entomologists and others than the peach borer, but until recently no very effective or practical method of control had been discovered. As a result of experiments begun by the Bureau of Entomology in 1915, it was found that this pest could be largely destroyed by the application around the base of infested trees of a volatile poison known as para-dichlorobenzene. This bulletin treats briefly of the life and habits of the insect; of the "worming" method of destroying the borers, suitable where only a few trees are to be treated; and of the para-dichlorobenzene method for use on trees 6 years of age and older. The chemical has already come into large commercial use with excellent results when applied according to directions.

Orchardists proposing to use para-dichlorobenzene for the peach borer are urged to employ only the pure chemical, which should be obtained of a fineness of granulated sugar or coarse salt.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief.

Washington, D. C. October, 1921

THE PEACH BORER:[1] HOW TO PREVENT OR LESSEN ITS RAVAGES; THE PARA-DICHLOROBENZENE TREATMENT.

CONTENTS.

A VERITABLE SCOURGE.

Among insect pests attacking the peach few, if any, are more important or more serious than the peach borer. Its injuries each year, including the cost of control measures, amount probably to not less than $6,000,000. Throughout much of its range of distribution east of the Rocky Mountains, from Canada south to Florida, it is a veritable scourge and must be combated relentlessly if the peach is to be grown. Trees of all ages, from those in the nursery to the oldest relic, are subject to attack. In many parts of the country the insect is so abundant that most trees in orchards become infested within a year or so after planting.

The peach borer is a native insect and has been complained of in horticultural and other literature almost from the time of the introduction of the peach in this country by the early settlers. Its original food plants were doubtless the wild cherry and wild plum, and on these it can still be found. It attacks also other stone fruits, such as nectarine, apricot, prune, almond, plum, and a few other plants. It is, however, preeminently injurious to the peach.

CHARACTER OF INJURY.

Injury is done by the larva, or borer, in the course of its feeding. Trees are injured principally at or somewhat below the ground level, and galleries or burrows are eaten in the soft bark or cambium at the crown of the trees or along the larger roots (fig. 1). Young trees may soon be more or less girdled (fig. 2) and older trees so injured that their vitality and crop-bearing capacity are greatly reduced.

[1] *Aegeria exitiosa* Say; order Lepidoptera, family Sesiidae.

Injured trees are, perhaps, more subject to infestation by certain diseases, such as root-rot, crown gall, and peach yellows, and are certainly less able to withstand periods of drought.

Infestation of trees by the borer is usually shown by an exudation, around the crown, of jellylike gum, more or less mixed with dirt and small brown pellets—the excrement, or frass, voided by the borers in the course of their growth (fig. 3). This exudation of gum is especially evident during moist or rainy weather.

FIG 1.—The peach borer in its galleries at the crown of the peach tree.

HOW THE INSECT DEVELOPS AND LIVES.

The peach borer, in the course of its life, goes through four distinct stages—the egg; the larva, or borer; the pupa; and the adult, or parent moth.

THE EGG.

The eggs of the peach borer are small and inconspicuous, reddish brown in color, oblong in shape, and measure about $\frac{1}{50}$ inch in length (fig. 4). They are deposited rather promiscuously over the trunk, limbs, and foliage of the peach tree, and many eggs are laid on weeds and trash or on the ground at or near the base of the trees. The eggs hatch in about 10 days, though this period may vary somewhat. The abundance and destructiveness of the peach borer is due, in considerable part, to the fact that the moths are very prolific. Observations on the number of eggs deposited by a given female show that she may lay as many as 829 eggs, with an average of about 400.

THE LARVA OR BORER.

When the egg has hatched, the little larva coming out of it makes its way as rapidly as possible to the collar of the tree, if not already at or near its base, and at once begins burrowing into the bark, entering often through a crack or wound. Some of the larvæ enter on the trunk, or even on the limbs, but these usually fail to survive long. After the larva has gained entrance to the soft bark of the tree it feeds greedily and grows rapidly, and in the course of a few weeks has become of sufficient size to do material damage.

FIG. 2.—Young peach tree practically girdled by the peach borer.

The number of larvæ which may infest a single tree is often surprising, and it is a matter of wonder that trees so infested are not completely killed within a season. The average number of larvæ to a tree in orchards varies widely according to region, in some sections there being only 2 or 3, whereas in other regions some 8 or 10 borers are usually present. In extreme cases 40, 60, and even 90 borers have been found infesting the roots and crown of individual peach trees 6 or 7 years old.

There is only one generation a year. The larger borers pass the winter in their burrows in the bark, though many of the smaller ones construct a cell, or hibernaculum, outside of the burrow on the bark of the tree. Feeding is active from early spring until late fall and, in the South, also during warm periods in the winter. Larvæ varying from quite small to nearly full grown are to be found in the trees during summer; during late spring, however, they are more nearly of full size. The mature peach borer (fig. 5) is about an inch long, yellowish-white, with dark reddish head. On the body are a few brownish hairs arising from tubercles.

FIG. 3.—Gum and frass exuding from base of peach tree, the usual sign of infestation.

THE PUPA.

The peach borer, when full grown and ready to change its form, incloses itself in a cocoon composed of silk, in which are incorporated particles of bark and excrement, forming a tough, brownish, capsule-like structure. The cocoon (fig. 6) is usually constructed at the head of or somewhat beyond the larval burrow, and, owing to its similarity in color to that of the bark of the tree, it is often overlooked by orchardists. Borers infesting the roots some inches from the base of the tree may work directly upward to the surface of the soil and there construct their cocoons. Sheltered within the cocoon the larva changes to a pupa, or chrysalis. The pupa (fig. 7) is about three-fourths of an inch in length, brown, and provided with stiff spines on the back to assist it in working itself out of the cocoon, thus facilitating the escape of the moth. Within three or four weeks the pupa is fully developed and wriggles out of the cocoon, the emerging moth leaving the empty skin protruding more than halfway from the cocoon (fig. 6).

THE MOTH.

The moths of the peach borer are beautiful clear-winged insects, the male differing strikingly from the female in markings. In the male (fig. 8) the wings are transparent, with steel-blue trimmings along the margin and veins, and the abdomen is marked with narrow yellow bands, quite conspicuous on the steel-blue ground color. The female (fig. 9) is steel-blue, with opaque forewings, and there are one or two orange-colored bands around the abdomen.

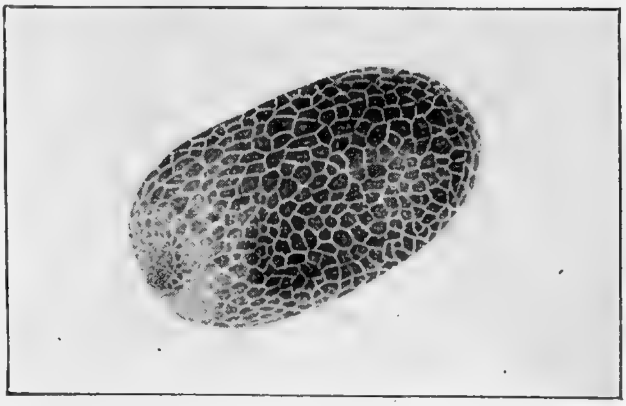

FIG. 4.—Egg of the peach borer moth. Considerably enlarged.

The adults are day fliers and, owing to their general resemblance to wasps when on the wing, are at times mistaken for these. Very soon after emergence mating takes place and oviposition begins. It is doubtful whether the moths feed to any extent during the course of their lives, and within a few days the eggs have been deposited and the moths have died.

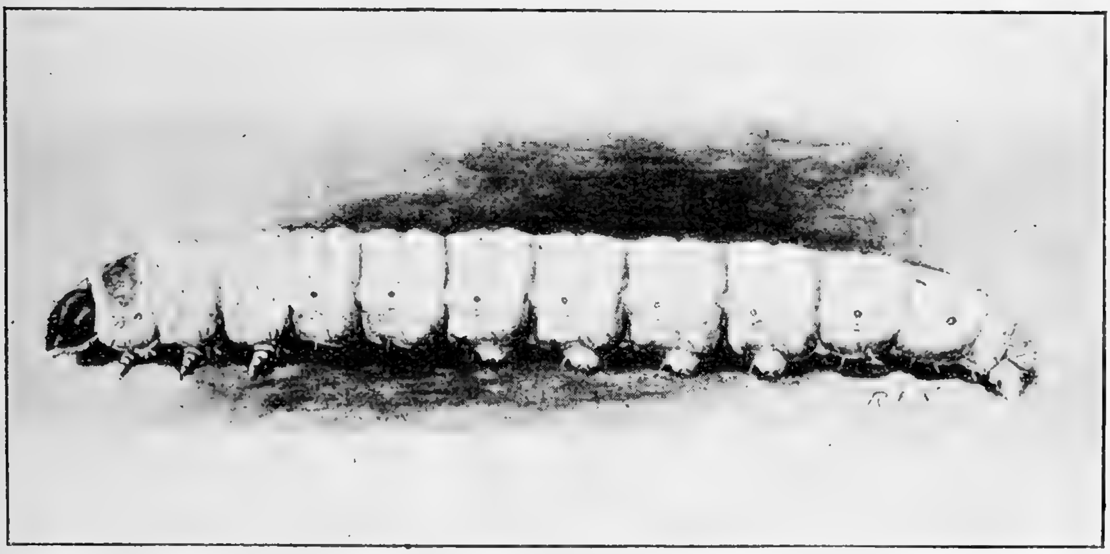

FIG. 5.—The peach borer. Enlarged.

HOW TO CONTROL THE PEST.

Many methods of control of the peach borer have been proposed during the more than 150 years that this pest has been known to injure the peach. Horticultural literature contains numerous accounts of the experience of growers with this or that wash or method of treatment of the borer, and entomologists, during the last 20 or 30 years, have given much time to discover, if possible, ways and means of preventing or reducing its injuries. While some of the washes and procedures recommended undoubtedly have reduced infestation, they have not afforded the trees adequate protection. Commercial peach growers for the most part have depended upon "worming" the trees. A few use a wash on the trunk after worming, or mound the earth around the trees, or do both, but the great majority have followed no other method than worming the trees in the fall or spring, the more careful growers worming during both seasons.

FIG. 6.—The peach borer cocoon and empty pupal skin. Enlarged.

Worming of peach trees has always been a bugbear to the commercial orchardist. It is a disagreeable and arduous task and likely to be slighted by the worker. Unless done conscientiously and thoroughly, with due care to remove all borers and not to injure the trees, worming is of questionable expediency. A decidedly better method of borer control, especially valuable for commercial growers, has been developed by the Bureau of Entomology and is described on pages 10–14. Careful worming of trees, however, may be preferred by some, especially where only a few trees are involved, as in small home orchards.

FIG. 7.—Pupa of the peach borer. Enlarged.

"WORMING."

Previous to worming, the earth should be removed from around the crown of the tree to a depth of 4 or 5 inches, and, if feasible, the trunk brushed or scraped to remove loose bark and dirt. With a little experience the worker can readily locate the borers in their burrows and remove them by means of a knife or other suitable tool. In worming care should be taken not to cut the sound bark more than necessary, and the cutting should be done vertically. Carelessness in the use of worming tools may result in as much damage to trees as that caused by the insects. After trees have been wormed it is desirable, if practicable, to go over them again a few days later, when the location of any larvæ missed during the first examination will usually be indicated by the exuded excrement or frass. When the worming has been completed the earth should be replaced around the trees—in the fall, always before freezing weather sets in.

After spring worming, a wash can be applied, or the earth mounded somewhat around the base of the tree, or the wash and mound may

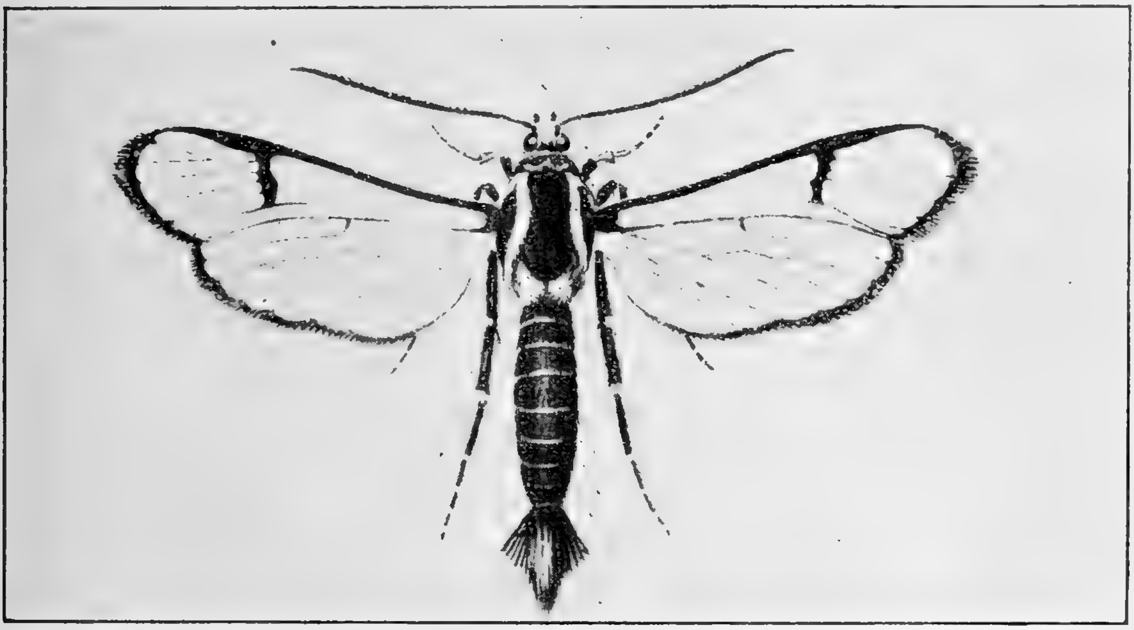

FIG. 8.—Adult male of the peach borer. Enlarged.

both be used (fig. 10). There is little if any advantage in the use of a wash, or in mounding, after the fall worming, since infestation occurs during the summer and early fall. The mounding will cause the borers to enter the bark somewhat higher, facilitating their detection and removal. If washes or wrappings are to be used they should be put on at once after the spring worming and before the earth is replaced around the trees. Perhaps as good a wash as any can be made from lime-sulphur concentrate (33° Baumé), used at the rate of 1 part to 6 or 7 parts of water, to which an amount of lime has been added to give it the consistency of heavy paint. A caustic wash can sometimes be used to advantage in the fall to destroy any little borers more or less exposed on the tree. For this purpose use caustic soda or lye at the rate of 1 pound to 8 or 9 gallons of water, and to this, after careful slaking, add about 10 pounds of stone lime.

THE PARA-DICHLOROBENZENE TREATMENT.

In 1915 the Bureau of Entomology began experiments in the use of various toxic gases as a possible means of control of the peach borer. This work, carried out by Mr. E. B. Blakeslee and continued for several seasons, covered a wide range of soil, climatic, and seasonal conditions, and demonstrated the usefulness for borer control of para-dichlorobenzene and the impracticability of using carbon disulphid, sodium cyanid, and certain other materials. Many experiments with para-dichlorobenzene showed that when properly used it is uniformly effective in killing a high percentage of the borers without injurious results to trees 6 years of age and

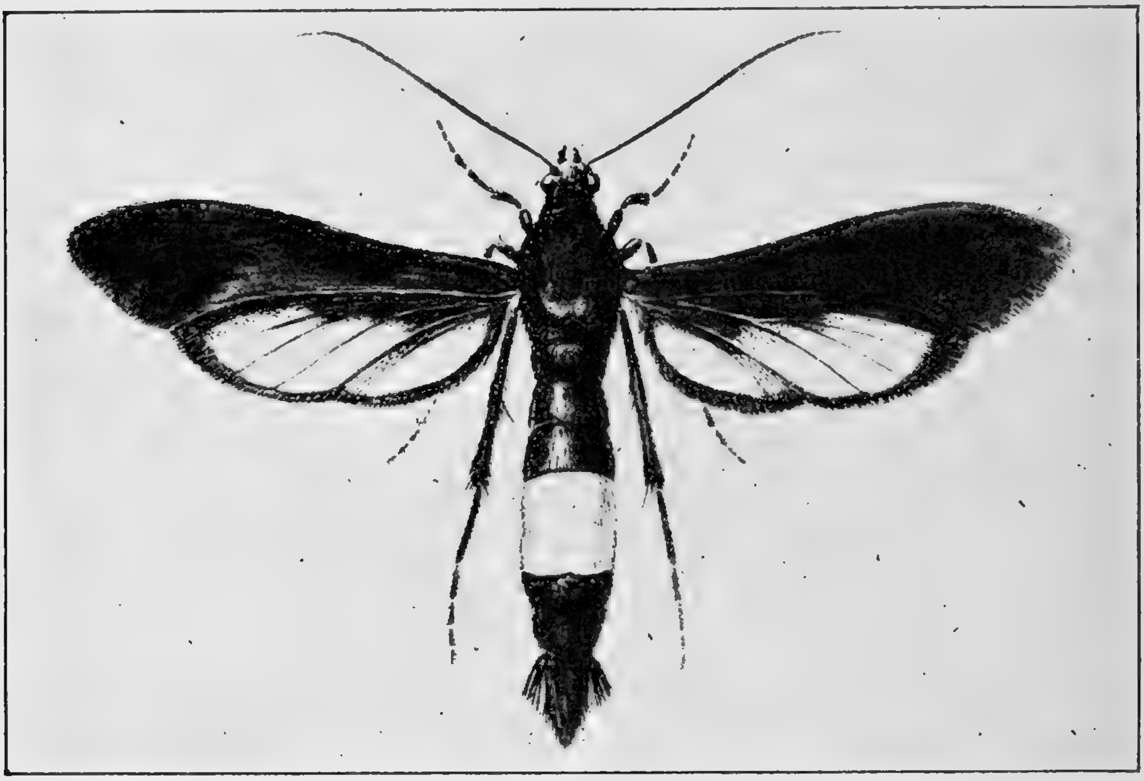

FIG. 9.—Adult female of the peach borer. Enlarged.

over. The results were published in United States Department of Agriculture Bulletin No. 796 (Oct. 21, 1919), and resulted in the prompt adoption of the treatment by many commercial peach growers. There has now been accumulated a sufficient body of experience, based on large-scale commercial use, and further experiments by the bureau and others, principally the New Jersey Agricultural Experiment Station, to show that a practical economic method of control has been found for this heretofore almost invulnerable pest.

PARA-DICHLOROBENZENE DESCRIBED.

Para-dichlorobenzene, for which the abbreviated name "paradichlor" is suggested when referred to as an insecticide, is a white crystalline substance having an etherlike odor, and vaporizing readily under favorable conditions. The vapor, while harmless to persons and domestic animals under ordinary conditions, is poisonous to insects confined in its fumes for a sufficient length of time. Its vapor is heavier than air and readily permeates the soil. The chemical is, for practical purposes, noninflammable, and the fact that it is a finely divided solid adds much to the ease with which it may be applied. As usually sold it is a little too coarse for rapid volatilization, and orchardists in purchasing it should specify that they be furnished with a grade of the fineness of granulated sugar or coarse salt. Only the pure article should be purchased. Should there be some loss by evaporation in the containers the remainder of the chemical is

FIG. 10.—Peach tree to which a wash has been applied and earth mounded around the base.

always 100 per cent pure. If mixed with some inert material, the loss by evaporation of the "paradichlor" will result in a weakened mixture difficult to employ at a known strength.

WHEN TO APPLY IT.

The application of "paradichlor" to peach trees for the control of the peach borer should be made in the fall, after most of the moths have oviposited, to avoid late infestation of the trees. At this time many of the larvæ are still small and more or less exposed, and hence more susceptible to the gas than if deep in their burrows on the crown and roots. Applications must not be delayed, however, until the soil temperature is so low that proper volatilization of the chemical will not result. Many studies have been made as to the soil temperature conditions best for the application of "paradichlor" and the following dates tentatively decided upon as best on the average for the respective regions:

Michigan, Ohio, Connecticut	September 1.
New Jersey, West Virginia, Maryland	September 10.
North Carolina and the Ozarks	September 25.
Georgia and Texas	October 10.

There are, however, limited seasonal variations in time of cessation of egg laying by moths in the fall. If applications of "paradichlor" are made as indicated, any belated young larvæ as they hatch will be killed for the most part during the continuance of the chemical around the trees—a period of several weeks—and beyond this time not much, if any, infestation will occur.

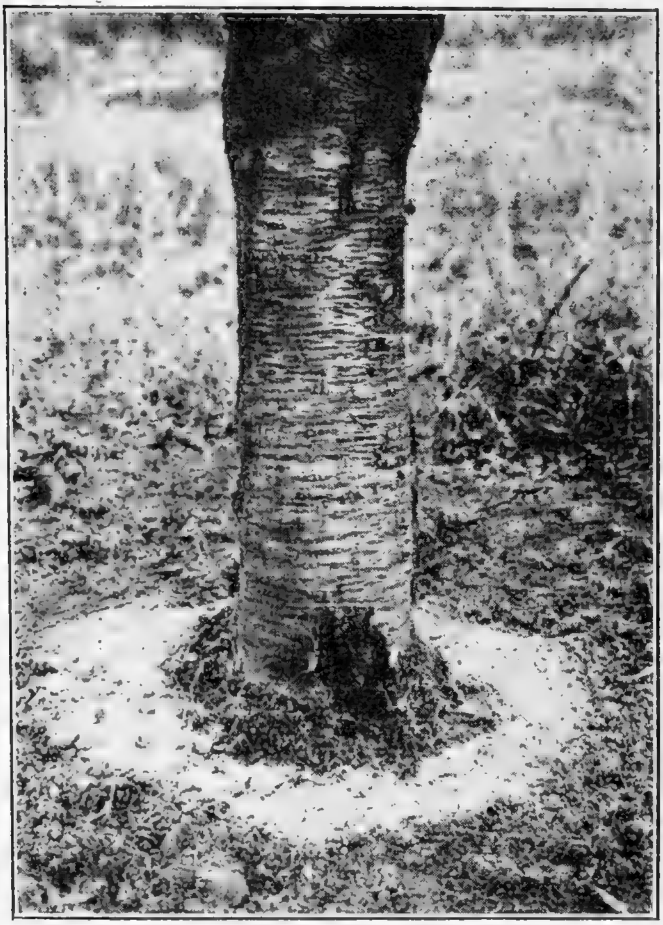

Fig. 11.—Preparation of ground previous to applying paradichlorobenzene and method of application of the chemical.

PREPARING THE TREES.

The earth for 15 or 18 inches around the base of trees should be cleaned of grass and weeds and leveled off, without, however, digging up the soil any more than necessary to break the surface crust (fig. 11). If borers are present in the trunk of the trees somewhat above the ground level, as indicated by the presence of gum or frass, a few shovelfuls of earth should be thrown around the tree and leveled off to form a bed for the application of the "paradichlor" high enough to subject the infested trunk to the fumes of the gas. As a rule the raising of the soil level around the tree will be unnecessary and is undesirable as favoring the washing down of the mounds by rain and interfering with the effectiveness of the treatment. If there is a decided mound of earth around the collar of the tree, this should be scraped down level with the surrounding soil. Excessive gum and frass should be removed and the bark lightly scraped. Exposed roots should be covered with a light layer of soil, since these are less resistant to gas fumes than the bark of the trees.

APPLYING THE "PARADICHLOR."

After the soil around the base of the tree has been prepared the "paradichlor" is applied evenly in a circular band an inch or two wide entirely around the tree, care being taken that the inner part of the band is about 2 inches from the tree trunk (fig. 11). Use 1 ounce per tree, by weight, or somewhat more for very large trees, and for convenience in measuring the chemical a small bottle or wooden or tin box holding just the desired amount may be employed. As soon as the chemical has been applied, cover it carefully with several shovelfuls of dirt, making a cone-shaped mound around the tree trunk by packing the earth with the back of the shovel (fig. 12).

FIG. 12.—Earth mounded around the base of peach tree to cover the para-dichlorobenzene.

IMPORTANT POINTS TO REMEMBER.

Under average fall weather conditions, with soil temperature around 60° F., or higher, most of the "paradichlor" under the soil covering will have evaporated in four to six weeks, killing from 90 to 100 per cent of the borers. Cooler weather than this, and frequent rains which keep the soil more or less wet, will greatly retard evaporation of the "paradichlor." Under these conditions, and in general practice if feasible, mounds should be removed some five to six weeks after application of the chemical, so as to avoid subjecting the tree further to the gas on account of danger of injury. From present knowledge, orchardists are taking undue risks, especially in case of applications later than above indicated, in allowing the mounds to remain around the trees over winter—a practice that has been frequently observed. Labor arrangements should be made to put on the chemical at the right time for its proper evaporation. In large commercial operations the work could well be divided into sections, with the necessary number of men in each section, under a competent foreman, to carry it along expeditiously. One group of men could prepare the trees for the "paradichlor," another group apply the chemical, and the third group follow immediately to cover and mound the trees.

DANGER OF INJURING TREES.

Most materials effective in killing insects will also injure trees when used in large dosages. In the successful use of insecticides it is necessary to ascertain the minimum amount which will kill the insect and which will not injure the plants treated. Para-dichlorobenzene is a good example of such a chemical where the margin of safety is adequate for its practical employment as an insecticide, but where care on the part of users must always be employed. Close adherence to the directions given, as to the time, method of application, and dosage, is urged upon the users of the "paradichlor" method of peach-borer control. In the experiments of the Bureau of Entomology when so used, no injury has been noted to trees 6 years of age and over, and its use on trees younger than this is not recommended.

How To Do It

DO YOU want practical suggestions on how to build a silo, a hog house, a poultry house, a potato-storage house, or how to make a fireless cooker, or other farm home convenience? Are you seeking ideas on how to prepare vegetables for the table, how to care for food in the home, how to bake bread and cake and other appetizing foods in an efficient and economical manner? Is there some practical question about your corn or wheat or cotton or other crops, or about your poultry or live stock, to which you are seeking an answer? The answers to thousands of such questions and practical suggestions for doing thousands of things about the farm and home are contained in over 500 Farmers' Bulletins, which can be obtained upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C.

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FARMERS' BULLETIN 1252

UNITED STATES DEPARTMENT OF AGRICULTURE

SAWFLIES INJURIOUS TO ROSE FOLIAGE

THE foliage of roses is very frequently attacked by sawfly larvæ, which feed upon the leaves and cause the bushes to become unsightly, or at least much less beautiful and ornamental. Three common species eat the leaves of roses, and are well distributed and quite injurious over the United States east of the Rocky Mountains.

These insects are easy to control. Knocking them some distance from the bush with a stream of water is a simple remedy. Since they eat the leaf tissue, thoroughly spraying the leaves with a stomach poison, such as 3 rounded teaspoonfuls of powdered arsenate of lead to 1 gallon of water, whenever the larvæ begin to appear, will kill them and thus prevent the injury.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. Issued February, 1922

SAWFLIES INJURIOUS TO ROSE FOLIAGE.

WILLIAM MIDDLETON, *Scientific Assistant, Forest Insect Investigations.*

CONTENTS.

THREE COMMON ROSE SLUGS AND THEIR OTHER FORMS.

MOST varieties of roses, especially climbers, hybrid perpetuals, and hybrid teas, are subject to the attack of insects which feed upon the leaves, giving the bush an unsightly appearance and lessening its vitality.

The commonest of these pests belong to the group of insects which in the adult form are termed "sawflies," or in the immature stages are often spoken of as "false caterpillars." The adults have received the name "sawflies" because the egg-laying apparatus of the female more or less resembles a saw and is used to cut slits or pockets in the plant tissue in which the eggs are placed. The larvæ are spoken of as "false caterpillars" because, although they resemble caterpillars, they produce adults radically different from moths.

The rose sawflies, in common with all insects of the group, have four phases which differ in appearance and it is during only one of these that the species is injurious. The first phase is the egg; the second is the feeding, growing stage, the larva, which is wormlike or caterpillarlike; the third phase is the resting, nonfeeding stage during which the wormlike creature in a case or chamber changes gradually to a form resembling the adult but lacking free-moving wings and legs; from this helpless pupa the adult emerges and freeing itself from the confining cell is ready to perform its part in the life cycle by laying eggs and perpetuating the species.

The adult stage of the rose sawflies offers no opportunity for control and because it is seldom associated with the damage done by the larva is not discussed in this bulletin. The other stages, however, offer satisfactory means of identifying these insects, and since it is during these immature stages that the damage is done or that control measures may be applied successfully the following descriptions and illustrations point out the differences in the pests.

There are three common or injurious species of rose sawflies in the United States. They are the bristly rose slug,[1] a native species closely resembling a European species with which it has been long confused; the European rose slug,[2] a species present in both Europe and North America; and the coiled roseworm,[3] a species chiefly remarkable for its habit of boring into the ends of pruned shoots to pass its resting stage, and named for the curled or coiled position it assumes when feeding upon the leaves.

THE BRISTLY ROSE SLUG.

The bristly rose slug is by far the most frequently encountered rose defoliator, and a rosebush is seldom seen which does not show some traces of its work. It occurs in the States east of the Mississippi River and north of a line drawn from St. Louis, Mo., to Richmond, Va. Often all but the newest leaves are covered with work of the various stages of this species, the bush presenting a much-abused and sickly appearance.

The eggs are laid in slits cut in the midrib of the leaf from the upper side. These slits are about one-sixteenth of an inch long and usually appear as small yellowish spots against the green midrib. The yellow color is due to the presence of sawdust, or drying plant tissue, torn out by the saw.

The larva, as its common name suggests, is sluglike, greenish white, and clothed with long, rather stout hairs. Upon hatching from the egg the young larva begins its attack upon the leaves, usually from the underside and, eating all but the thin upper skin of the leaflet, furnishes as evidence of its presence skeletonized spots readily recognized by their white translucency. As the slug increases in size, its work changes from skeletonizing to hole-eating and finally to eating the entire leaflet, without regard for any but the largest veins. When full grown, the larva constructs an irregularly shaped cocoon of varying thickness from a brownish to whitish transparent membrane. During the spring and summer this cocoon is placed without regard to other than temporary shelter on leaves, at the angles of twigs, and in such places, but the overwintering insects choose a place that is rather more protected, as in the ground.

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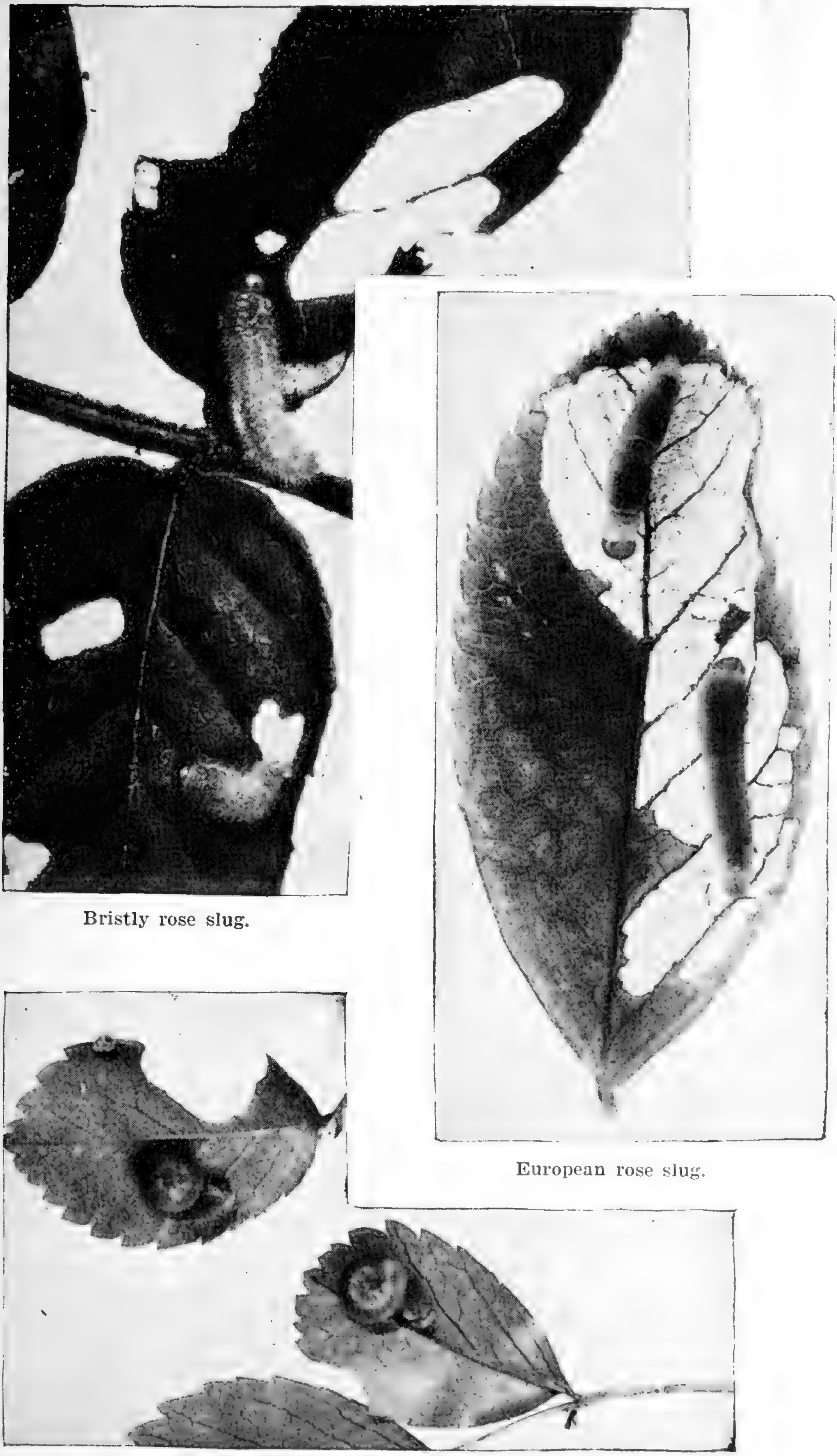
[1] *Cladius isomerus* Norton; order Hymenoptera, suborder Chalastogastra, superfamily Tenthredinoidea, family Tenthredinidae, subfamily Cladiinae.

[2] *Caliroa aethiops* Fab.; order Hymenoptera, suborder Chalastogastra, superfamily Tenthredinoidea, family Tenthredinidae, subfamily Messinae.

[3] *Emphytus cinctipes* Norton; order Hymenoptera, suborder Chalastogastra, superfamily Tenthredinoidea, family Tenthredinidae, subfamily Allantinae.



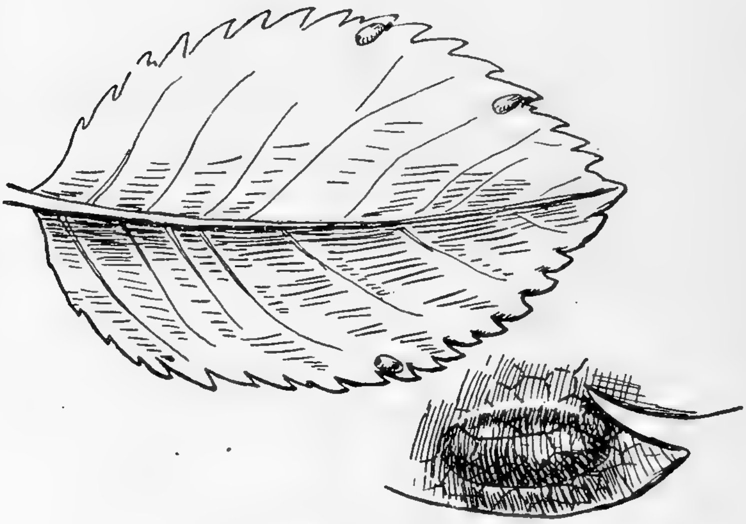
Bristly rose slug.

European rose slug.

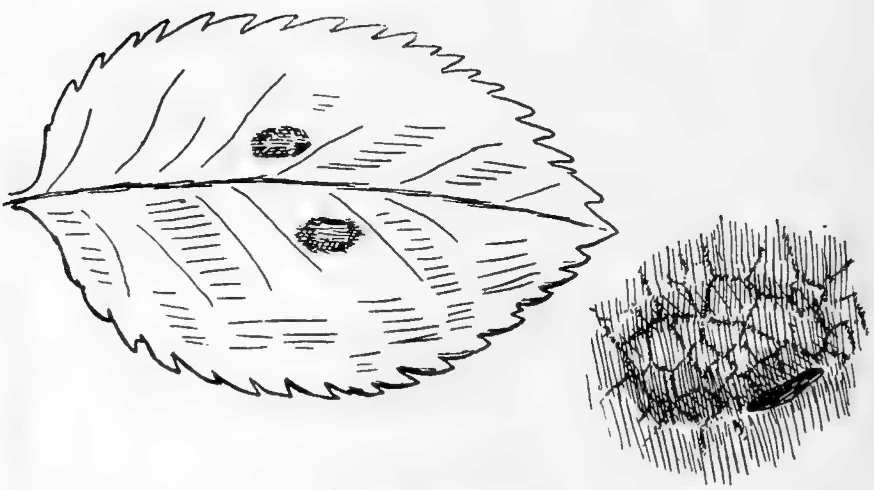
Coiled roseworm.

FIG. 1.—Our three injurious rose slugs. All more or less enlarged.

Bristly rose slug.

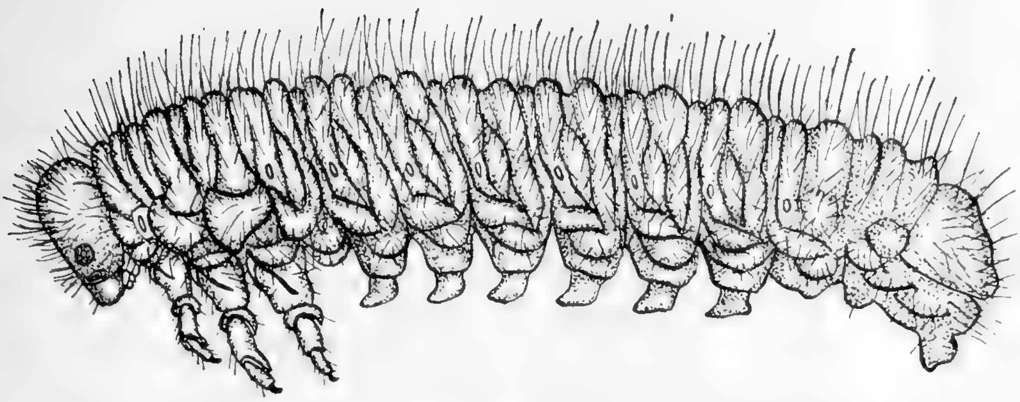


European rose slug.

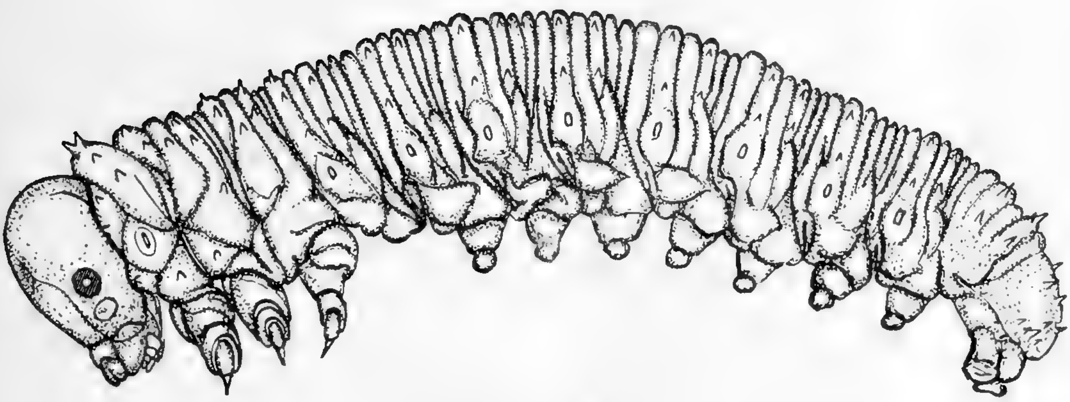


Coiled roseworm.

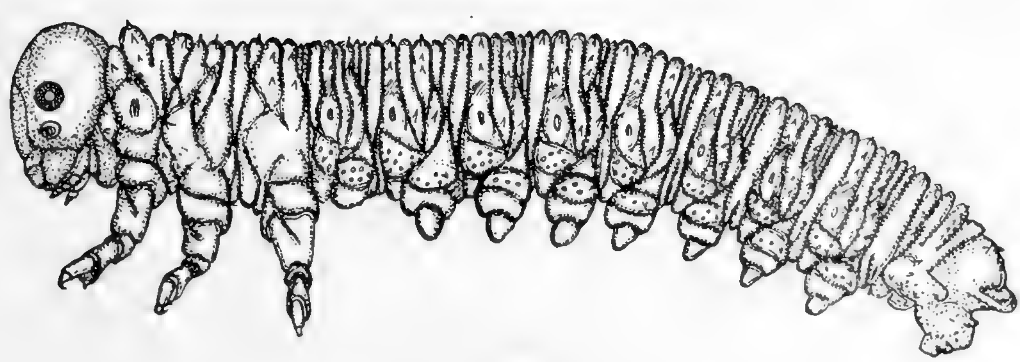
FIG. 2.—Eggs of the three rose slugs and where they are placed.



Bristly rose slug.

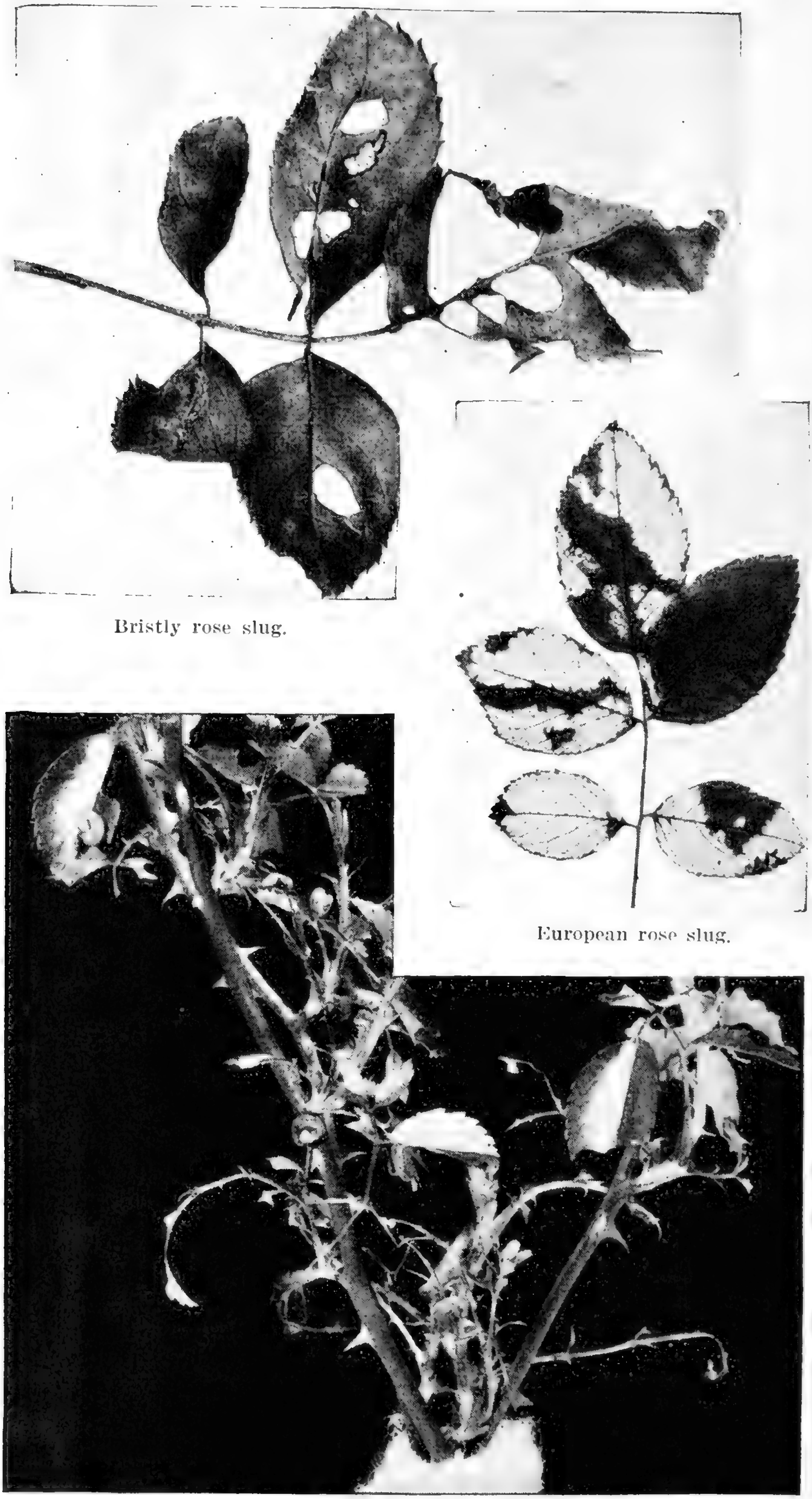


European rose slug.



Coiled roseworm.

FIG. 3.—Our three injurious rose slugs and how they differ. Greatly enlarged.

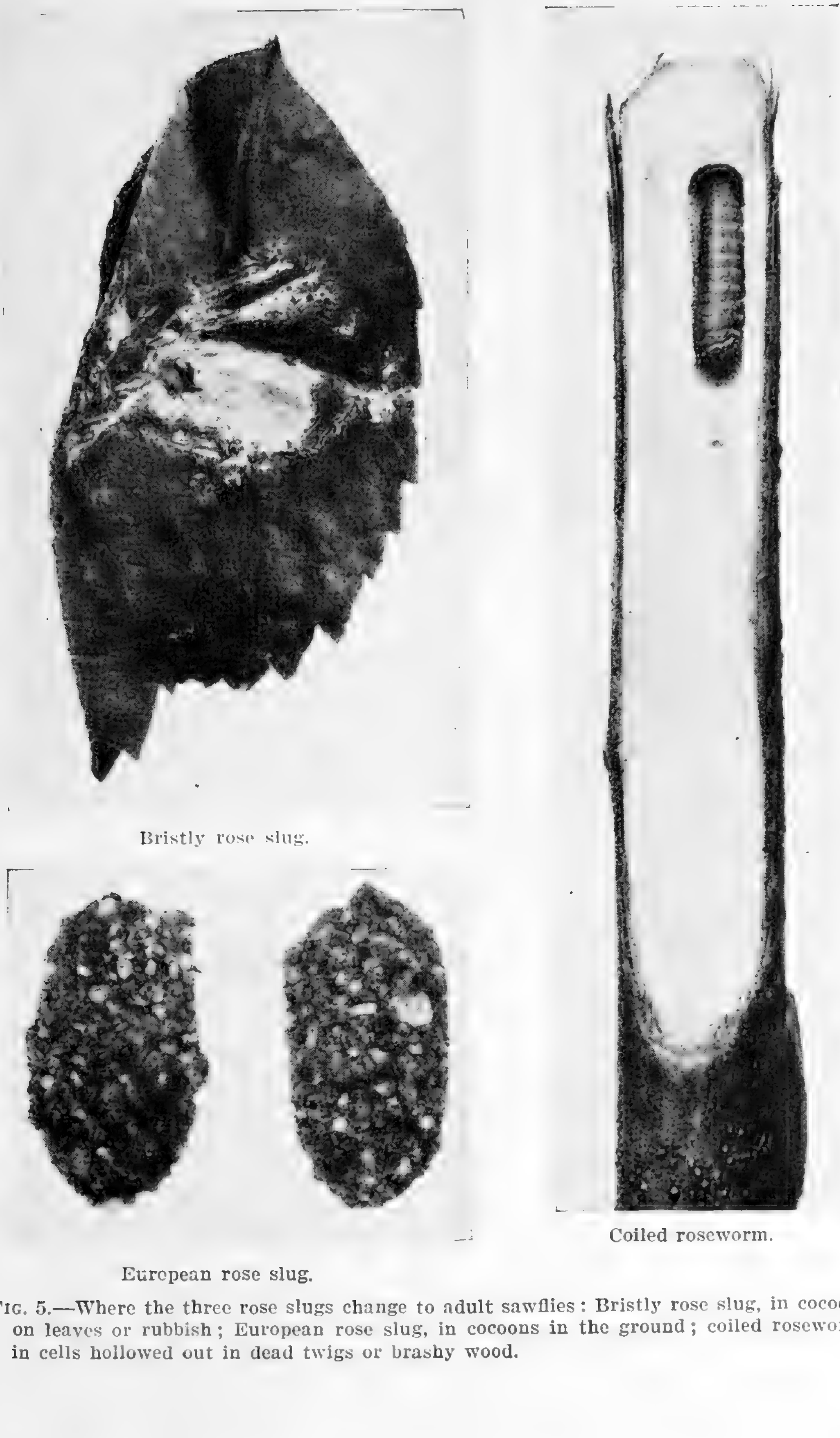


Bristly rose slug.

European rose slug.

Coiled roseworm.

FIG. 4.—Work of the three rose slugs contrasted.

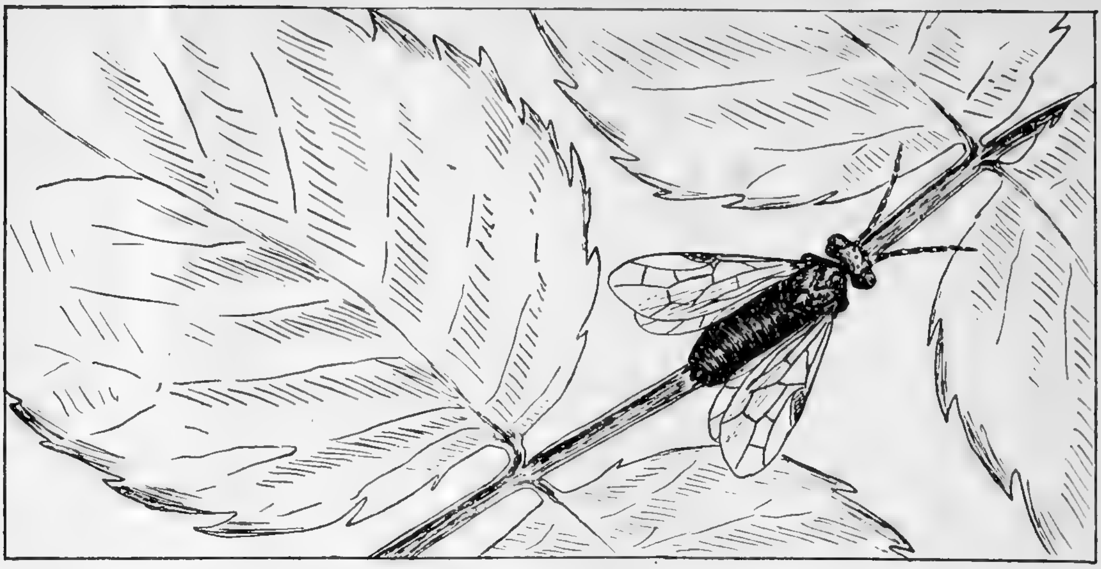


Bristly rose slug.

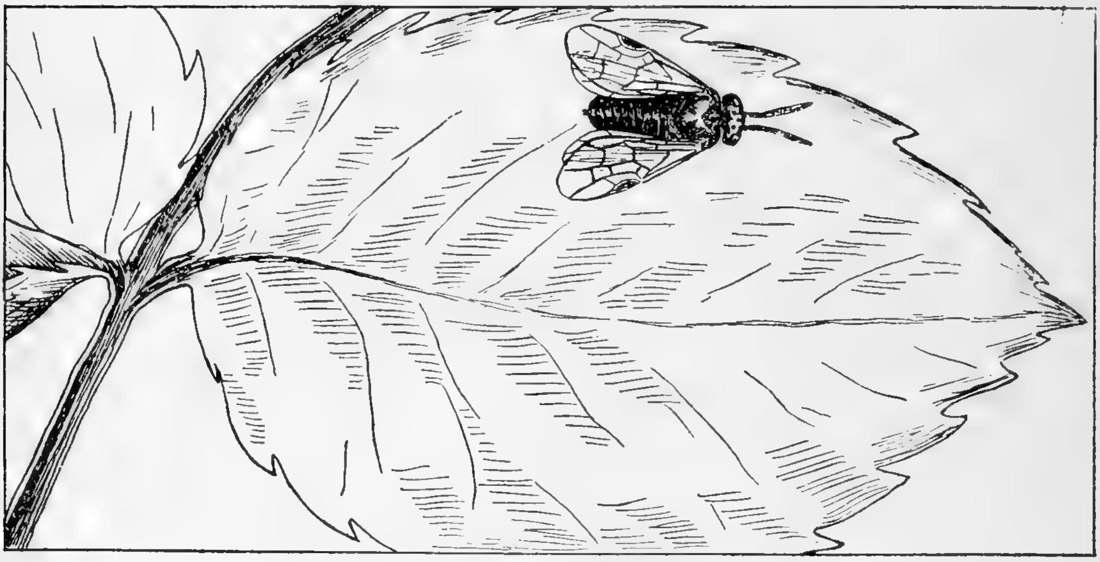
European rose slug.

Coiled roseworm.

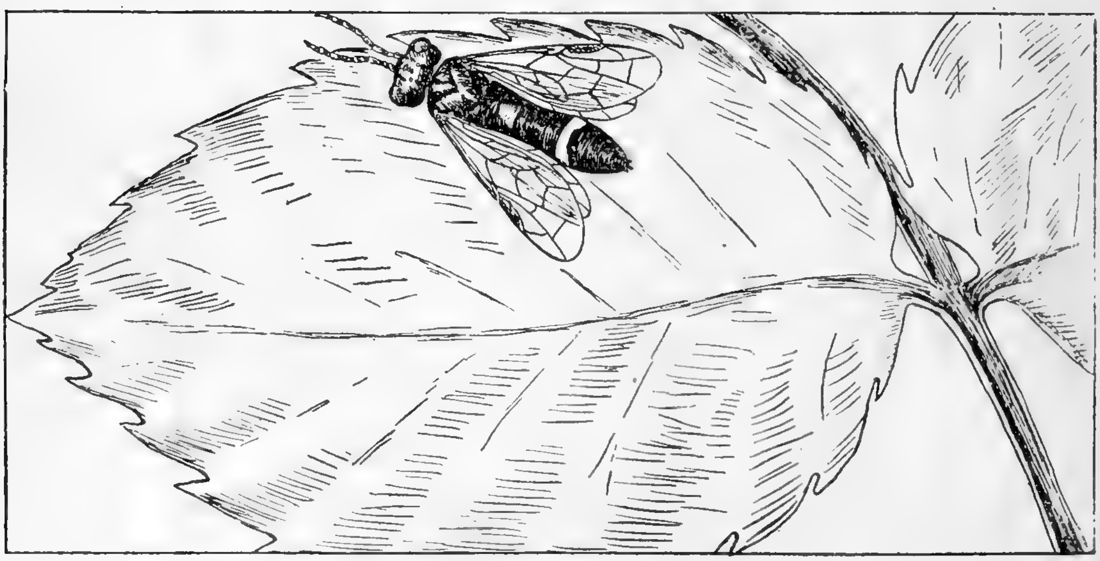
Fig. 5.—Where the three rose slugs change to adult sawflies: Bristly rose slug, in cocoons on leaves or rubbish; European rose slug, in cocoons in the ground; coiled roseworm, in cells hollowed out in dead twigs or brashy wood.



Bristly rose slug.

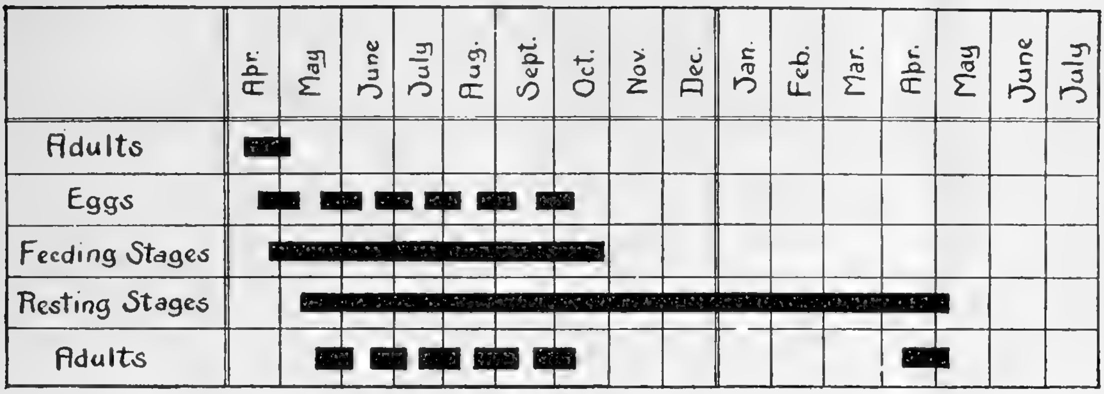


European rose slug.

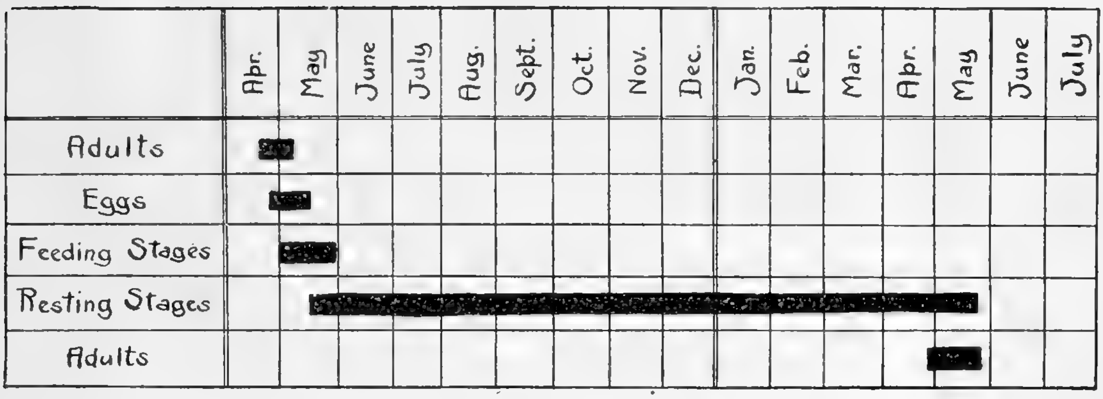


Coiled roseworm.

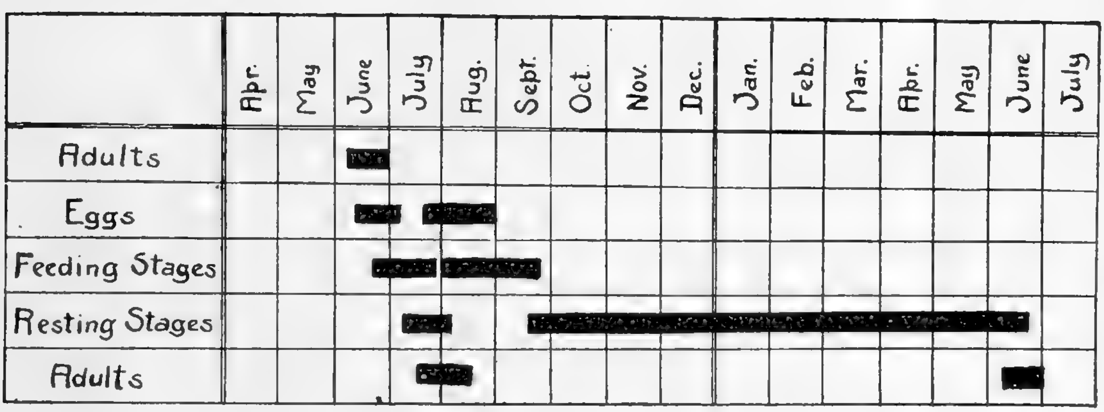
FIG. 6.—The adults, or sawflies, which develop from the three kinds of rose slugs. Much enlarged.



Bristly rose slug.



European rose slug.



Coiled roseworm.

FIG. 7.—Diagrams showing life and seasonal histories of the three rose sawflies.

The entire life cycle from egg to adult occupies approximately 30 days. In the vicinity of Washington, D. C., there are six of these 30-day life cycles or generations each season. There is such a great overlapping of these generations, due to the irregularity of emergence of the overwintering adults and the variation in individual development, that shortly after the first brood all stages may be present at the same time.

THE EUROPEAN ROSE SLUG.

The European rose slug is probably the next most common rose sawfly and is reported as injurious in States as far west as the Rocky Mountains. The eggs of this species are laid in pockets in the leaf tissue quite near the edge of the leaflet, with the slit at the base of one of the leaflet's serrations and with the egg prominent on the underside of the leaflet and protected and held in place there by the thin under membrane of the leaf. The larva is yellowish green in color with food causing the alimentary tract to appear dark olive green. It feeds upon the upper surface of the leaf by a characteristic chafing method, eating only the soft tissue and leaving the veins and under tissues showing yellowish on the green leaflet. When full grown the larva leaves the bush and enters the ground where it constructs a cell, cementing together particles of sand and earth to form a capsule-shaped chamber. It is within this cavity that the quiescent period is spent. This stage occupies most of the year, carrying the species through the summer, fall, and winter until the following spring. Thus the life cycle is approximately a year in length and the species has only one generation a year.

THE COILED ROSEWORM.

The coiled roseworm is not especially abundant in any section of the country, but occasionally occurs in sufficient numbers to attract attention, either because it bores into the pruned ends of shoots or because it feeds on the leaves. It is the former habit that causes it to be most frequently the object of inquiry. This species occurs from Minnesota to Maine and as far south as northern Virginia.

Its eggs are laid in the upper surface of the leaflet and not especially near the edge, as in the preceding species. The larva which hatches begins feeding by skeletonizing patches from the underside of the leaflet, leaving only the thin upper skin which appears whitish transparent. This method of feeding does not last long, as the larva soon begins devouring all of the leaf tissue, first eating holes through and then feeding on the entire leaflet, exclusive of the largest veins. When full grown this larva searches for a piece of soft wood or similar material, and when the pruned ends of rose shoots are available it will bore into the pith of these and construct a gallery and cell for its resting stage.

In the southern range of the species there are two generations, one having a short life cycle of several days more than a month and the other occupying the remainder of the year.

HOW TO CONTROL ROSE SLUGS AND PROTECT THE FOLIAGE.

The control of these pests is easy. So simple a thing as a strong stream of water applied often and from different angles is a remedy in that it knocks the larvæ from the leaves and they perish before they are able to return. In places where a strong stream of water is either unavailable or inconvenient to use, a stomach poison like lead arsenate and water sprayed upon the leaves gives good results. If the spraying is to be extensive and a large quantity of the mixture is to be used, 1 pound of powdered lead arsenate to 50 gallons of water is the proper proportion and a large compressed-air hand sprayer or barrel pump will be found suitable. If the spraying is to be limited to several bushes 3 rounded teaspoonfuls of powdered lead arsenate to a gallon of water is a good mixture and one of the small hand spray pumps will serve the purpose.

Another spray which will be effective against young larvæ and which has the additional advantage of being a good aphid remedy is 40 per cent nicotine sulphate which should be diluted as recommended upon the container, usually 1 part to 800 parts of water in which some fish-oil or laundry soap has been dissolved. For small quantities use approximately 1 teaspoonful of the nicotine sulphate to 1 gallon of water in which 1 ounce of soap has been dissolved.

The life cycles and the number of generations have been discussed in this paper in order that those whose plants are infested may be able to determine for themselves whether it will be necessary to spray once or a number of times during the year.

Since the European rose slug spends most of the year in cells or resting chambers in the ground, thorough working of the soil will help to reduce its numbers, by breaking up the cells and exposing the soft, weak, unprotected pupæ to the weather and various predatory enemies.

The coiled roseworm may also be combated by painting the ends of pruned twigs, removing all pithy stems and brashy wood, and leaving no suitable hibernating place available.

The bristly rose slug can be destroyed in large numbers by burning the old leaves and other litter in which they have spun cocoons. Hence clean cultural methods are to be strongly recommended as a means of insect control in the growing of roses.

It will further simplify the task of a grower if he will endeavor to interest his neighbors who have roses to cooperate with him in destroying pests, for if bushes belonging to them remain infested they will be a constant source of reinfestation for his.

A STUDY of this bulletin should make it possible to identify the particular kind of sawfly attacking roses. This done, information on the number of generations to be expected may be had by consulting the life-cycle diagrams (fig. 7). If only one generation occurs, as in the European rose slug, one or two sprayings should effect control; but if there is more than one generation, as with the coiled roseworm and the bristly rose slug, the gardener will have to keep a closer watch upon his bushes and spray more often.

Farmers' Bulletin 750, which deals with roses and their culture, contains a discussion of the remedies for various insect pests. This bulletin is of value to all rose growers and may be obtained from the Division of Publications, United States Department of Agriculture, Washington, D. C.

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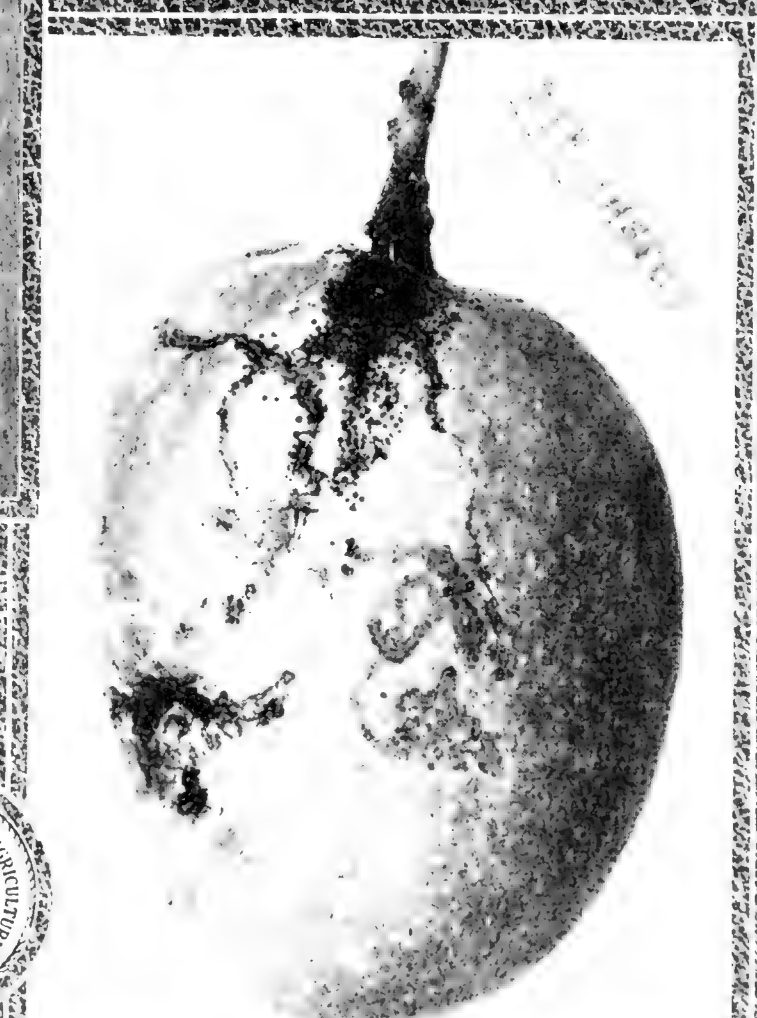
FARMERS' BULLETIN 1257
UNITED STATES DEPARTMENT OF AGRICULTURE

INSECTS INJURIOUS TO THE MANGO IN FLORIDA AND HOW TO COMBAT THEM



WITH THE DEVELOPMENT and increased propagation of the mango in Florida various insect enemies have made their appearance, and, when abundant in a grove, often cause considerable injury. Some of these insects are native and have adapted themselves to the mango, others may have been introduced into the State.

All parts of the mango—fruit, blossom, foliage, trunk, and branches—are attacked. The grower should watch his trees carefully for insect pests and apply control measures promptly. This bulletin contains brief descriptions of the principal pests attacking the mango in Florida and information on their life histories and the means, in each case, found most effective for combating them. The more serious foreign insect enemies of the mango are considered briefly, that the grower may recognize them and their work, should any of them enter the United States despite the rigid quarantines designed to keep them out.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief
Washington, D. C. Issued February, 1922

INSECTS INJURIOUS TO THE MANGO IN FLORIDA AND HOW TO COMBAT THEM.

By G. F. Moznette, *Assistant Entomologist, Fruit-Insect Investigations.*

CONTENTS.

Every part of the mango tree is at some time affected by one or more insect pests which cause concern and loss to the grower. While some of these insects may have been introduced, others probably have always been present on native vegetation and have adapted themselves to the mango.

INJURIOUS INSECTS OF THE MANGO IN FLORIDA.

THE BLOSSOM ANOMALA.

When the mango is in bloom it is sometimes visited in swarms by a beetle[1] which can cause serious damage. Fortunately, however, this beetle is not generally distributed at blossoming time. Groves in certain localities may be visited by large numbers of the beetles, yet other groves escape injury. Groves visited one year may escape the next, and others in turn may be attacked.

The adult beetle (fig. 1) has a black thorax with a yellowish border; the wing covers are yellowish mottled with two crossrows of ill-defined black spots. Variations in color often occur, some individuals being almost black. The beetle varies also in size, averaging from one-fourth to five-sixteenths inch in length.

This pest has been recorded from a number of localities along the lower east coast of Florida, it has been reported from a number of

[1] *Anomala undulata* Mels.

Middle Western and Eastern States, and is present in South America and Central America.

NATURE OF INJURY.

The beetles attack all portions of the blossom spike, and in many instances not only completely strip the spikes of the individual blossoms (fig. 2), but also cut or girdle the spike. Usually, however, the beetles confine their attack to the more tender floral parts, destroying the individual floral clusters about the spikes.

The beetles have been observed feeding upon avocado bloom, when blossoming has coincided with the appearance of the swarms. They have also been noted feeding extensively in bean fields in southern Florida, the plants becoming practically defoliated. In the Middle West this beetle has been recorded as infesting a variety of crops, often to their serious injury; in Ohio, as stripping the leaves from plum and pear trees; in Illinois, as defoliating cherry trees; and in Kansas as injurious to wheat and other grains, feeding on the heads when the grain is "in the dough."

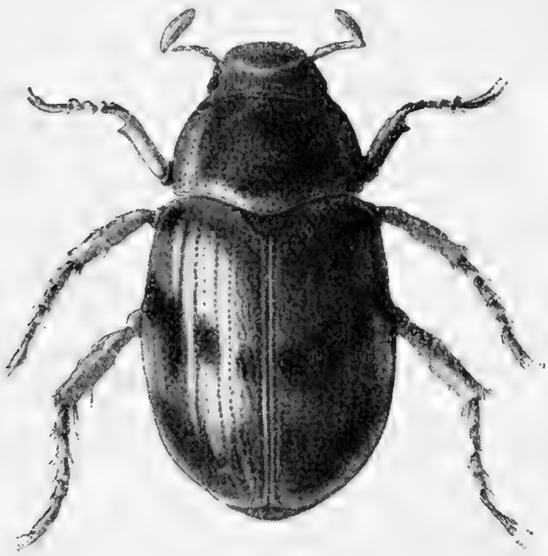


FIG. 1.—The blossom anomala: Adult beetle. Much enlarged.

LIFE HISTORY.

During the day numerous freshly eaten floral spikes were found on mango trees in groves, but the presence of the destructive pest causing the damage could not be detected about the bloom or anywhere on the trees. Below the trees numerous small holes were present in the soil, and upon examination of the soil to a depth of from 1 to 2 inches a considerable number of small beetles were found in a quiescent stage, as if "playing possum." Upon short exposure to the light the beetles became active and immediately started to dig their way into the soil. During the evening great numbers of the same beetles were found busily at work among the trees in a grove, feeding on and flying about the blossom spikes.

After a period of several weeks the beetles usually disappear. Up to the present time the writer has been unable to locate the larva of this species and nothing is known of its habits. Judging, however, from similar species, the larva form, except for its smaller size, is similar to white grubs, or May-beetle larvæ, not only in general appearance but more or less in habits also. The larvæ probably will be found feeding on the roots of some plant or on decomposing vegetable matter in the soil, either on the pine lands or in the stretches of everglades. In the Middle West, where this species also occurs, nothing has been recorded as to its larval habits.

FIG. 2.—The blossom anomala: Injury by the adult beetles to mango blossom spikes.

CONTROL.

The best means of control is spraying the bloom spikes with poison. When the mango is sprayed in the bloom with Bordeaux mixture for the Colletotrichum blight, which attacks both bloom and fruit, arsenate of lead at the rate of $1\frac{1}{2}$ pounds of the powder to 50 gallons of spray should be added, thus making a combination treatment for blight and beetle. The Bordeaux mixture is generally used at a strength of 3–4–50. After the Bordeaux mixture is made and is in the tank the arsenate is added. It is essential, where powdered arsenate of lead is used, that the spraying outfit be fitted with a good agitator, as the arsenical has a tendency to settle rapidly to the bottom of the tank, whereas it should be kept in suspension while spray-

FIG. 3.—The blossom anomala: Spraying mango trees in bloom against the adult beetles.

ing. The spray should be directed to the blossom spikes particularly (fig. 3), as the beetles do not attack the dormant foliage and very little if any new growth is present on the mango at the time of blossoming.

THE RED SPIDER.

The red spider[2] which seriously attacks the avocado in Florida also attacks the mango during the dry winter months. It is similar in shape and appearance to other red spiders which attack various

[2] *Tetranychus yothersi* McG.

other fruits. The greatest damage usually is inflicted between the latter part of November and the 1st of March. The abundance of the pest during this period depends chiefly on the existing climatic conditions. Unlike most other red spiders, the red spider of the mango and avocado confines its attacks to the upper surface of the foliage.

NATURE OF INJURY.

The foliage attacked turns brown and often drops prematurely, and at times there may be a heavy denudation as a result of the depredations of these mites. They multiply so rapidly that the damage caused by them becomes quickly noticeable. The first indication of red spiders on the foliage is the pale spots scattered about over the leaf surface, showing the feeding places. As the feeding becomes more general most of the functional green matter in the leaf is destroyed, and in time such a leaf turns brown as if scorched and is of little use to the tree. Where the red spiders become numerous in a mango grove, considerable damage results from their attack on the hardened winter foliage through absorption of the functional leaf substance. It is the winter foliage which sustains the bloom in the spring and aids in the setting of the fruit.

DESCRIPTION AND SEASONAL HISTORY.

The egg.—The egg of the red spider is globose, smoky amber in color, about $\frac{1}{150}$ inch in length, and bears a stalk which varies in development from a length equaling the height of the egg to a mere rudimentary papilla; guy fibrils are occasionally seen connecting the egg with the leaf. The eggs are laid on the upper surface of the leaf, usually along the midrib and lateral veins. The incubation period varies according to temperature and general climatic conditions. During midwinter, with mean daily temperatures between 60° and 70° F., incubation requires from 7 to 11 days. During April and May incubation requires an average of only 4 to 5 days, with mean temperatures between 70° and 80° F.

The larva.—The newly hatched larva is round and a very light yellow or almost colorless. It bears six legs and in size does not exceed that of the egg from which it emerged. The average period required for development of the larva is about $2\frac{1}{2}$ days.

The nymphal stages.—Before reaching the adult stage the mite goes through two molts. In the nymph stage which follows the larva stage, the mite attains an extra pair of legs, making four pairs. The first nymphal stage is about one one-hundredth inch in length and the second nymphal stage about one seventy-fifth inch. For the most part the habits of the first and second nymphal stages are similar to those of the larva. The average length of the nymphal stages is about 3 days.

The adult mite.—The adult is eight-legged and the color is rusty-red, because of the internal structures occurring on each side of the body. The eyes are crimson. The body and legs are covered with minute hairs. The male is about one one-hundredth inch in length and the female about one-eightieth inch. In this stage the mites are very active, mating and extensively feeding on the foliage. The number of generations of the red spider varies with the seasonal climatic conditions. In years of little rain during the spring and early fall the red spiders become in evidence more quickly than when rains occur in early spring and early fall. Rain is the factor which influences their reduction more than any other. Intermittent rain frequently recurring during the red-spider season also interferes greatly with the regularity of the generations. Activity of the red spider usually commences during the latter part of August and ceases the first part of April, giving an active season of about 240 days. The duration of the life cycle based on averages is 14.2 days. This would give 17 generations for Florida, if no interruptions due to climatic conditions occurred, or if no other factors interfered with the normal activities of the mites in the field. The length of the generations, however, varies greatly with the climatic conditions. During dry, hot weather the females deposit eggs in great numbers and the growth and molting of the spiders take place rapidly. During colder weather apparently days are passed without any eggs being laid and growth of the immature individuals is much retarded. Although the life cycle is longer during January and February, the climatic conditions do not interfere and the mites reproduce freely. During May, June, and July, and sometimes in August, depending on the weather, the mites are very scarce, but are present on the trees, though barely maintaining their existence.

CONTROL.

When the mites are present on the trees in considerable numbers and the foliage is still green the grower should start immediately to apply control measures. He should not wait until the attacked foliage becomes noticeably brown and begins to drop. By applying either dust sulphur with a dusting machine, or lime-sulphur solution at the rate of 1 gallon of the concentrate to 60 gallons of water, the grower will secure satisfactory results. With lime-sulphur solution a strength of 1 gallon of the concentrate to 75 gallons of water is advisable during winters if the temperature is above the normal, and if the trees do not attain a thoroughly dormant condition.

THE RED-BANDED THRIPS.

The red-banded thrips,[3] an important enemy of the cacao in the West Indies islands of Grenada, St. Vincent, St. Lucia, Dominica, Guadeloupe, Trinidad, Tobago, and the Virgin Islands, in the island of Mauritius, and in Uganda, East Africa, has found its way into the United States, is present in Florida, and has been found infesting mango trees on both the lower east and west coasts of that State.

FIG. 4.—The red-banded thrips: *a*, Uninjured leaf; *b*, leaf badly injured by the feeding of the thrips. (Russell.)

CHARACTER OF INJURY.

Injury by the red-banded thrips is very similar to that of the greenhouse thrips and of a number of other thrips. The adults and the young may be found feeding together on the lower surface of the foliage, causing injury by first piercing the surface of the leaf with the sharp mouth parts, then rasping or scraping out the leaf tissue within and leaving a minute spot where the chlorophyll or green contents of the leaf has been removed. This spot eventually becomes brown. These spots become very abundant and after a while run together, forming large brown patches near the

[3] *Heliothrips rubrocinctus* Giard.

midrib and lateral veins, the leaves later turning brown and shriveling. In severe cases the entire lower surface of the leaf is infested, and the larvæ seek the upper surface of the foliage, where they commence to feed. Thus the function of the leaf is entirely destroyed and often the leaves dry up and fall (fig. 4). In feeding, this thrips excretes over the surface of the infested leaves small spots of a

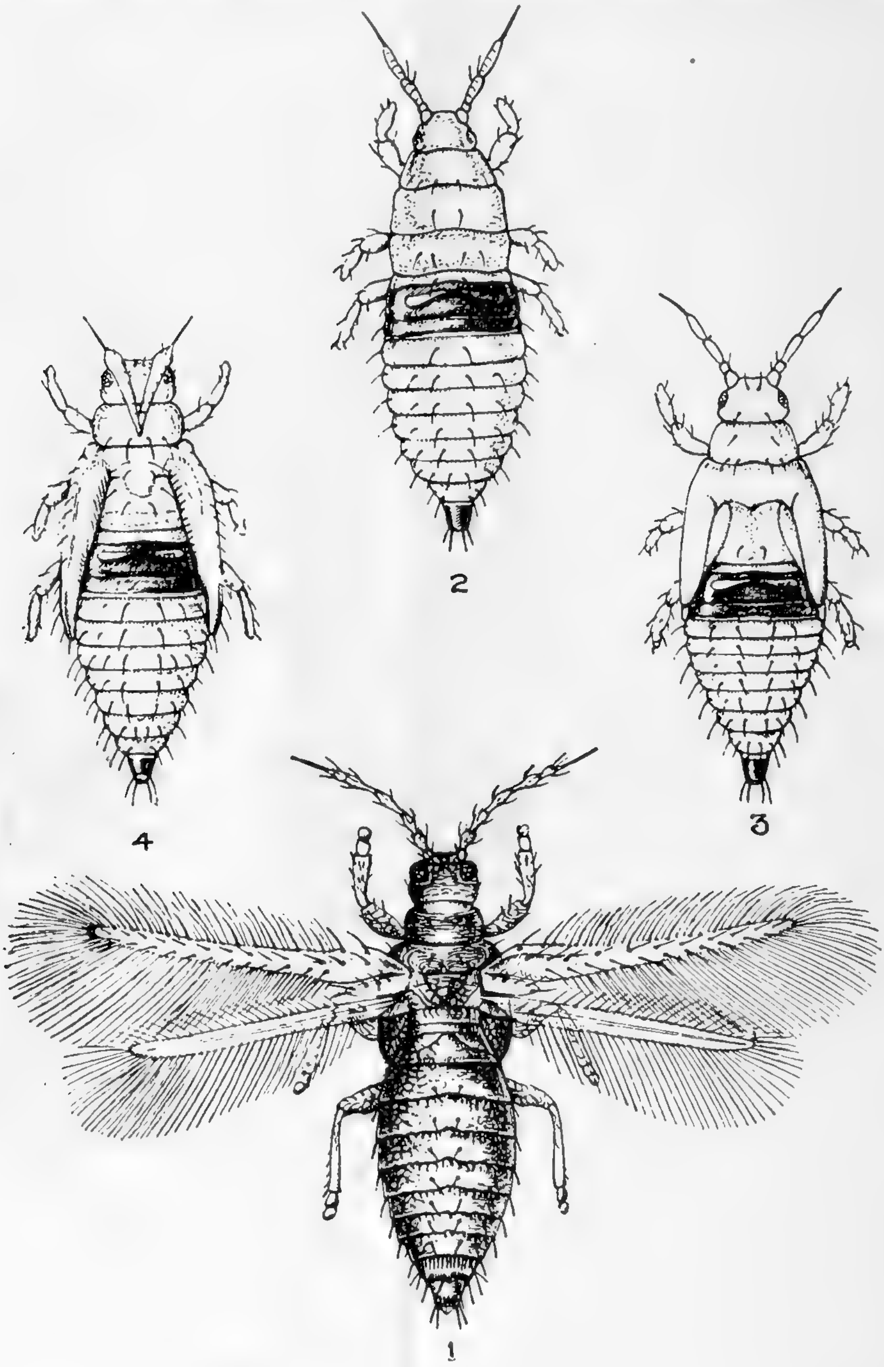


FIG. 5.—The red-banded thrips: *1*, Adult female; *2*, full-grown larva; *3*, prepupa; *4*, pupa. (Russell.)

reddish fluid, which harden and turn black. The species has not been observed to attack the fruit.

DESCRIPTION AND SEASONAL HISTORY.

The egg.—The egg is oval in shape, transparent, and averages approximately one-ninetieth inch in length. The eggs are inserted into the tissues of the lower surface of the mango leaf. The writer has found that the incubation period requires an average of from 10 to 15 days.

The larva.—The larva (fig. 5, *2*), or young, is about one ninety-sixth inch in length upon emergence. It is spindle-shaped, tapering gradually toward the tail end. The head is rather square, rounded in front, with red eyes. The general color is yellow, except several segments of the body which are crossed by a bright red band and the anal segment, which is red. From hatching until growth is completed, about 9 to 18 days as a maximum are required, depending upon temperature and humidity. The larvæ feed on the leaves in company with the adults and generally prefer the underside, but also may be found on the upper side of the foliage. They feed in colonies in folds of the leaf, or along the midrib. As they feed the leaf becomes full of minute brown spots where the chlorophyll has been extracted, and in severe cases these run together and the entire leaf becomes brown and shriveled. At all times the larva holds the tip of the abdomen elevated, and on it a drop of reddish liquid, held more or less in place by the stout anal hairs, collects. The drop increases in size and falls to the leaf, the surface of which finally becomes covered with the excrement, an occurrence also common in the case of other thrips.

The prepupa and pupa.—Like all thrips, the species passes through two intermediate stages called the prepupa and the pupa (fig. 5, *3*, *4*) before the adult thrips is reached. These two stages do not differ materially in structure or appearance. The prepupa measures on an average one twenty-fifth inch in length, and the pupa approximately the same. The prepupæ remain clustered so closely that they almost touch and are nearly motionless. If disturbed, however, they move rapidly about on the leaf. The prepupæ change to pupæ in the colony of prepupæ and larvæ. When the prepupa is ready to molt, the skin is ruptured over the head, gradually worked off at the posterior end by contractions of the body, and left behind on the leaf. The average period of the prepupa stage was from two to five days, depending upon the temperature and humidity.

The pupæ, though possessing the power of motion, are sluggish and will not move around unless disturbed. They carry the antennæ folded back over the head. As the pupæ approach maturity their bodies begin to turn darker, and just before emergence of the adults become almost black. The adults emerge from the pupæ in the same manner that the younger stages molt; they then move a little way off and remain more or less motionless until the chitin hardens. Within a day the full colors have developed and the adults begin feeding. The pupa stage was found to require on an average from three to seven days for development.

The adult.—The adult (fig. 5, *1*) can be separated from others associated with it by the body characters, black with dark wings, by the reddish band which is evident in the first three segments of the abdomen, and by the red color of the anal segment. The adult female is about one twenty-fourth of an inch long and quite stout. The adults feed gregariously with the pupæ and larvæ, all in close proximity to one another, and in many cases rest alongside the midrib or lateral veins of the leaf. The adults select the tender foliage to feed upon, and there the female deposits eggs in the leaf. In Florida the life cycle is influenced greatly by the temperature conditions. During the late summer and fall the life cycle requires approximately 25 days as a minimum, and during the months of January and February 35 days are required. In Florida this insect may pass through from 10 to 12 generations during the year. Rain is one of the controlling factors in the abundance of the thrips at any time.

CONTROL.

Spraying with 40 per cent nicotine sulphate at the rate of 1 part to 900 parts of water has been found the most efficient means of controlling the red-banded thrips. The addition of 2 or 3 pounds of fish-oil soap to the diluted mixture will cause the spray to spread more evenly over the smooth mango foliage and not drop off in small globules. Where the red spider is present on the foliage at the same time as the thrips the nicotine sulphate may be added to lime-sulphur spray, the nicotine being used at the strength indicated above. In this case no soap should be added. The spray should be directed particularly against the lower surface of the leaves, as the thrips will usually be working there. The spray should be applied before the foliage commences to turn brown, when indication of the presence of the thrips is first detected on the green foliage.

THE MANGO SHIELD SCALE.

A number of scale insects attack the mango in Florida, and the one noted to be most injurious up to the present time is the mango shield scale[4] (fig. 6). This scale is quite widely distributed and is found wherever the mango is growing. It has been taken at Fort Myers, Punta Gorda, Palm Beach, Miami, Miami Beach, Biscayne Key, Larkins, and Homestead. The species has been reported from British Guiana and from the following islands of the West Indies: Grenada, Barbados, Dominica, Antigua, Trinidad, and Jamaica.

[4] *Coccus acuminatus* Sign.

CHARACTER OF INJURY.

The mango shield scale infests the lower surface of the mango leaves, where it is to be found usually clustered in rows along both sides of the midrib and the lateral veins. Like all other scales, this species does damage principally through the extraction of the sap contents of the plant. An indirect injury also results, in that, like many other scales, this species produces an abundance of honeydew. This honeydew collects on the bodies of the scales, and when the drop is sufficiently large it falls either to the upper surface of lower leaves or to fruit below. The sooty-mold fungus develops in this honeydew, the accumulation of which gives in time a decidedly blackened appearance to the foliage and fruit (fig. 7). The writer has observed several groves where the sooty mold was so abundant that even the branches and trunks of the trees were blackened by it.

Fig. 6.—The mango shield scale: Showing scales along the midrib of the lower surface of a mango leaf.

SEASONAL HISTORY AND DESCRIPTION.

The adult scale.—The adult scale is yellowish green, bluntly pointed in front, and broadly rounded posteriorly. It is very thin and flat and irregularly marked with black. There seems to be no dormant period in the life of this scale, as young are to be

FIG. 7.—The mango shield scale: Showing sooty-mold fungus accumulation on upper surface of mango leaves.

found at almost any time of the year. The activities of the scales, however, are much retarded during the winter when the foliage of the mango is dormant. During winter more adult scales are present in proportion to the young. This no doubt is due to the lack of young foliage and the lower temperature. The adults reproduce almost continuously on the mango in Florida, and the generations overlap considerably, so that at any time the scales may be found in all stages of development.

The young, or "crawlers."—During the latter part of February or the first part of March, as the new growth commences on the mango, the "crawlers" appear in great numbers. These are born beneath the adult scales on the older leaves, and as their natural instinct is to seek the newer growth of foliage, great numbers of these small crawlers may be seen traveling toward the newer foliage along the twigs. In due time in the spring, the mango, like the avocado, sheds its older leaves and with them many scales, but a sufficient number has gained foothold on the newer growth to perpetuate the species on the tree and to continue the infestation. As with other scales of a like nature, the young are tiny, oval in shape, provided with antennæ, six legs, and threadlike mouth parts. After wandering about for a short while, the young scale settles down, thrusts its threadlike mouth parts into the tissues of the leaf, and begins the extraction of the sap, upon which it feeds. With the first molt the crawlers lose their antennæ and legs. As the scale grows, the cast skins are thrust aside for a new and larger covering. Crawlers which were placed on leaves February 2, 1918, became adult scales May 20, 1918, showing that at this time of year approximately 3½ months are required to go through a generation. From the writer's observations approximately three generations are produced on the mango in southern Florida. During the latter part of June and early July great numbers of the crawlers are in evidence. The generations overlap greatly, however, and there is no distinct demarkation showing when one generation ends and another begins.

In Florida, the writer has taken this species on the rose apple, custard apple, sapodilla, mango, and Allamanda. In the West Indies it has been recorded on mango, breadfruit, Jasminum, Ixora, sapodilla, Allamanda, star plum, star apple, nutmeg, and custard apple.

CONTROL.

The best time to control this scale on the mango is when the trees are dormant, as from the middle of December until the first of February. Oil emulsions have been found satisfactory. There are a number of oil emulsions on the market, some of which when applied to the waters used in spraying in southern Florida work very satisfactorily. Generally these waters come from deep wells in the limestone formation and are termed "hard," but some, which come from surface wells, are as a rule brackish. Certain oil emulsions when combined with these "hard" waters may prove at times unsatisfactory, in that the calcium and magnesium salts present in the water tend to break up the emulsion, causing the oil to be set free during spraying. This free oil is detrimental to mango foliage and causes severe burning. Where a grower has knowledge of such separation, spraying operations should be discontinued and the trouble remedied.

Where separation of oil occurs in using an oil emulsion with the water a grower has available, the water should first be softened by means of caustic potash fish-oil soap. This soap has been found to be satisfactory when 3 or 4 pounds are used to a 125-gallon tank of ordinary hard water. After the water has been softened, the oil emulsion should be added to the tank. There are a number of oil emulsions which contain the proper stabilizers, so that when the emulsion is combined with hard water no separation occurs, thus doing away with the additional expense and labor of softening. As a preliminary precaution it is advisable to test the spray before starting operations in the field. Barring a few difficulties which a grower may experience in the use of oil emulsions with hard water, the emulsions will prove to be most efficient sprays for the control of scales attacking the mango in Florida.

Oil emulsions during the dormant season on the mango at a strength of 1 part to 70 parts of water have proved very satisfactory. Two applications during the winter, with an interval of three weeks between, are recommended. These applications should be so timed, however, as not to interfere with spraying for the red spider or thrips. It has been found that the use of 40 per cent nicotine sulphate solution, at the rate of 1 part to 900 parts of spray, with the diluted oil-emulsion sprays, gives satisfactory results against the scale insects and thrips and temporary relief from the red spider.

THE TESSELLATED SCALE.

Another soft-bodied scale, often found infesting the mango in Florida, is the tessellated scale [5] (fig. 8). It is oval in shape but broadly rounded posteriorly. It is of a dark-brown color, with a decidedly mosaic appearance on the upper surface. It is not so generally distributed in Florida as the mango shield scale, being found only in a few localities on the east and west coasts of Florida. The writer has taken it at Little River, Oneco, Palm Beach, and Miami.

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[5] *Eucalymnatus tessellatus* Sign.

CHARACTER OF INJURY.

Injury resulting from the feeding of this scale is of the same nature as that from the mango shield scale. The seasonal history of this species does not differ materially from that of the mango shield scale, approximately three generations in the year being produced. The plants which this scale infests have been found to be the coconut palm, fishtail palm, and mango.

CONTROL.

The oil-emulsion sprays, as recommended against the mango shield scale, are advised in the control of this pest.

THE FLORIDA RED SCALE.

A scale found to infest the mango at times is the Florida red scale[6] (fig. 9). Occasionally it may be found infesting both the leaves and fruit of the mango. The scale is dark reddish-brown in color, with a conspicuous light-brown center, almost circular in outline, and is about one-twelfth of an inch in diameter when full grown. Besides the mango, this scale infests citrus, the royal coconut, and many other palms, camphor, magnolia, oleander, roses, myrtle, and many other plants.

CHARACTER OF INJURY.

This species does not produce honeydew, and hence the sooty-mold fungus is not found where it is present on the trees. Like the other scales, its principal injury is caused through the extraction of the sap from the foliage and fruit.

FIG. 8.—The tessellated scale: Showing scales on the lower surface of a mango leaf.

[6] *Chrysomphalus aonidum* L.

The eggs produced by this species are yellow. From the eggs come crawlers, bright yellow in color and oval in outline. They begin to form their scales when less than a day old. By the second day they cease to crawl and by the third day the scale has become nearly circular. The first molt occurs at the age of about 3 weeks. The male of this species is a very delicate two-winged insect which appears at a certain period of development of the female scale; its life is very brief and after mating it soon dies. Egg laying begins when the females are about 10 weeks old and continues for two weeks.

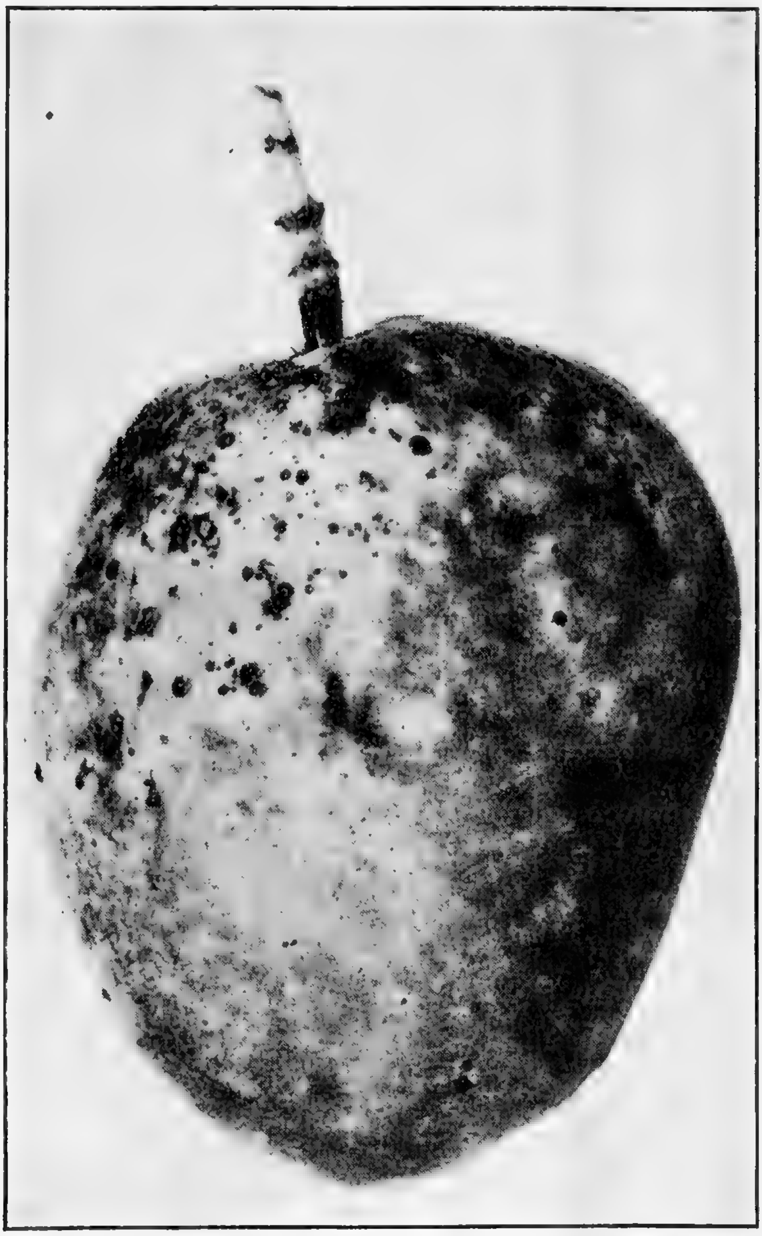

FIG. 9.—The Florida red scale: Adult scales on mango fruit.

CONTROL.

The same oil emulsions which are used against the soft scale insects of the mango may be used against this scale also. On account of the thick and heavy scale, however, which fits the leaf or fruit very closely, the mature females and the eggs under the scales are not easily killed. To control effectively a heavy infestation of this scale, therefore, two or three sprayings may be necessary. The second should be applied from 3 to 4 weeks after the first. This will give the females that were not killed by the first spraying time to mature and die and their last eggs to hatch, but will not allow sufficient time for a new generation to mature.

THE MANGO SCALE.

A scale insect which is to be found on the limbs and trunk of the trees is the mango scale[7] (fig. 10). It masses in cracks or under loose bark, and resembles minute seeds or eggs. When numerous it also appears somewhat like the chaff scale on the branches and trunk of the tree. It is not very destructive. The female scale is from one-fiftieth to one twenty-fifth inch in length. It is narrow and flattened at the tip. The scale is convex and has a loosely adhering, saclike, waxy white covering. It does not infest plants other than the mango,

FIG. 10.—The mango scale: Adult scales on mango bark. (Photograph by Sasscer.)

and has been found at Homestead, Larkin, Palm Beach, Little River, and Miami. It is a pest of the mango in India, and was apparently introduced into Florida from that country.

CONTROL.

The oil emulsions, as used against the soft scales during the winter, have been found most satisfactory for this species, the spray being directed toward the branches and trunk of the tree with sufficient pressure for penetration, preferably 250 pounds.

[7] *Leucaspis indica* Marlatt.

THE FLORIDA WAX SCALE.

The Florida wax scale[8] (fig. 11), when not obscured by sooty mold or other foreign matter, is pure white, often with a pinkish shade imparted to it by the red color of the insect beneath. When seen against the deep green of the mango leaf or stem, it is a beautiful object. The full-grown female is an eighth of an inch or less in length, oval in general outline, but presenting an angular appearance, due to the dome-shaped masses of wax on the back. Of these there is one large, rounded, central dome, surrounded by six or eight

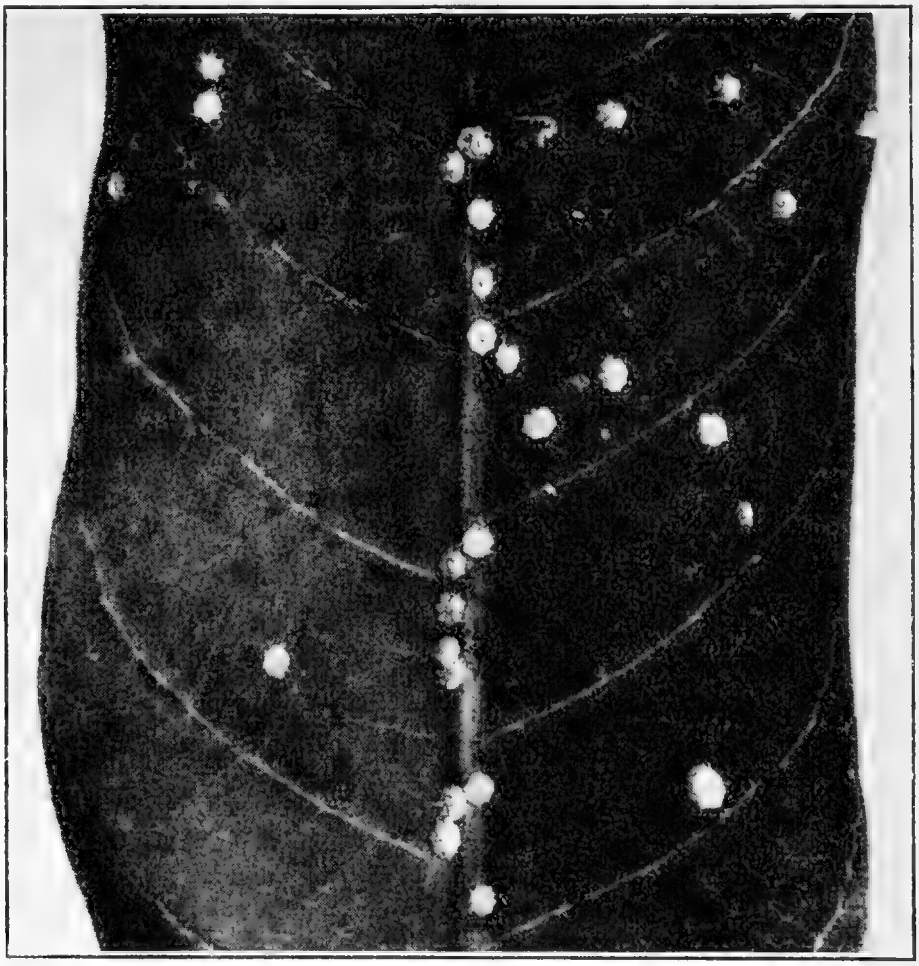

FIG. 11.—The Florida wax scale: Adult and young scales on mango leaf.

lesser ones, placed in a circle about the margin of the scale and separated from the central dome by a depression.

The eggs are dark red and many are clustered beneath an adult female. The pale-brown crawlers show a preference for the leaves, where they collect, especially along the midrib on the undersurface. The young larvæ are star-shaped and even more beautiful than the adults. Three or four months are required for growth, and there are three principal broods of crawlers, which appear during April and May, July and August, and October and November.

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[8] *Ceroplastes floridensis* Comst.

Besides the mango, this scale infests citrus and gallberry, guava, cherry laurel, sea grape, Ficus, loquat, and many other plants.

CONTROL.

Should it become necessary to spray for this scale, the oil emulsions will be found satisfactory. As the scale possesses a hard covering, three sprayings will perhaps be necessary to control it completely.

FOREIGN INSECT ENEMIES OF THE MANGO WHICH SHOULD BE KEPT OUT OF THE UNITED STATES.

In its native lands the mango has a number of very destructive insect enemies, which, were they to follow it and gain entrance to the United States, would probably prove highly destructive. The United States Department of Agriculture, fully aware of the possibilities of the introduction of dangerous foreign mango pests, has established rigid quarantines, and with the cooperation of the States where mangoes are grown is doing everything possible to protect the mango industry.

The most serious pests of the mango in foreign lands are the fruit flies, of which four species are conspicuous, namely, the Queensland fruit fly, the mango fruit fly, the Mexican fruit fly, and the West Indian fruit fly. The adult flies lay their eggs on or in the fruits, into which the young, or larvæ, burrow, rendering the fruits unfit for food.

The Queensland fruit fly [9] is found in India, Ceylon, Java, Amboina, and Australia. The adult measures about one-fourth inch in length, with a wing expanse of about one-half inch. The wings are transparent, and the body is constricted at the base and broadly rounded at the tip. The thorax possesses a broad, creamy, often pale, dorsal band. Besides the mango, this species infests the banana, peach, nectarine, orange, apple, cheesewood, loquat, and a number of other fruits.

The mango fruit fly [10] is found in India, Java, Ceylon, Amboina, and the Philippine Islands. It is particularly injurious to overripe fruit and is the commonest species in India and Ceylon. Besides the mango, it infests a number of citrus fruits. The adult measures about one-fifth inch in length. The color is rusty red, with the upper surface of the thorax varying from black to rusty red, and sometimes the abdomen is marked with almost black bands.

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[9] *Bactrocera tryoni* Froggatt.

[10] *Dacus ferrugineus* Fabricius.

The Mexican fruit fly,[11] known also as the Mexican orange maggot and Morelos fruit worm, is found in Mexico, where it is considered a serious pest of the mango, orange, sweet lime, guava, and a number of other plants. The adult measures nearly one-third of an inch in length and is of a dull ocherous yellow color, with the wings transparent, mottled, and striped with brownish-yellow bands. The eggs of this species are deposited under the skin of ripening fruit.

The West Indian fruit fly,[12] might be introduced into Florida and the other Gulf States, as it is at present in Mexico, Central America, South America, and the West Indies, where it infests the guava, coffee, pear, peach, mango, Para plum, Japanese plum, Japanese persimmon, and a number of other fruits. In these countries it is considered a very serious pest. The adult fly is about one-half inch in length, with a wing expanse slightly over 1 inch. The color of the body is rust yellow or brownish yellow. The wings are clear, tinted in part with a characteristic pattern of yellow brown.

The mango hopper[13] is a mango pest which in certain parts of India is reported to reduce the mango crop to one-third its normal value. The adults are small, dark, wedge-shaped insects which jump when disturbed. They appear at the time the mango is in flower, the time at which the principal injury is done. The eggs are laid and hatch in the flower panicles, and the young as well as the adults blight the bloom by sucking the juices that should assist in the formation of the fruit.

The mango seed weevil[14] is a serious enemy of the mango, especially in Hawaii, where it is reported to have infested from 60 to 90 per cent of the crop. There is danger of its introduction inside the seed. It is also present in the East Indies, the Philippines, the Straits Settlements, Madagascar, and South Africa. The adult weevil is from one-fourth to one-third inch in length. When it is nearly developed it is pale pinkish in color, later changing to a dark brown with yellow markings. The egg is deposited in the fleshy part of the fruit. When hatched the larva enters the seed, undergoes its entire development there, and emerges as an adult.

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[11] *Anastrepha ludens* Loew.
[12] *Anastrepha fraterculus* Weid.
[13] *Idiocerus atkinsonii* Leth.
[14] *Sternochetus mangiferae* Fab.

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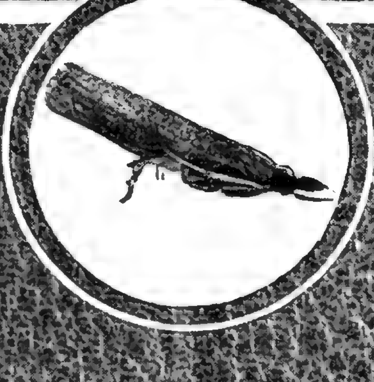
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1258

WEBWORMS INJURIOUS *to* CEREAL AND FORAGE CROPS *and* THEIR CONTROL



DEFORMED corn plants are often found to be infested by webworms, which gnaw the stem below the surface and by their ravages prevent the production of marketable grain. Grasslands of all kinds—meadows, pastures, lawns—furnish the normal food of sod webworms, and, although the injury is often difficult to estimate, under conditions favorable to the insect it may become very serious.

All of the feeding, whether upon corn or grass, is done by the insect in the larva or worm stage. Outbreaks of the various species of webworms in corn can be prevented only by cultural methods, such as early fall plowing, disking in the spring, the application of fertilizer, and the sowing of sound seed. Neither trapping nor poisoning has met with any success. Control of injury to grasslands is very difficult, and little can be done short of plowing up the sod and planting it to some immune crop.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief

Washington, D. C. May, 1922

WEBWORMS INJURIOUS TO CEREAL AND FORAGE CROPS AND THEIR CONTROL.

By GEO. G. AINSLIE, *Entomological Assistant, Cereal and Forage-Crop Insect Investigations.*

CONTENTS.

INJURY CAUSED BY WEBWORMS.

THROUGHOUT a large area in the middle eastern United States much damage is done annually by the corn and sod webworms. The insects which cause this damage are often overlooked and the injury attributed to other causes, but their method of work is so characteristic that once seen it is easily recognized thereafter.

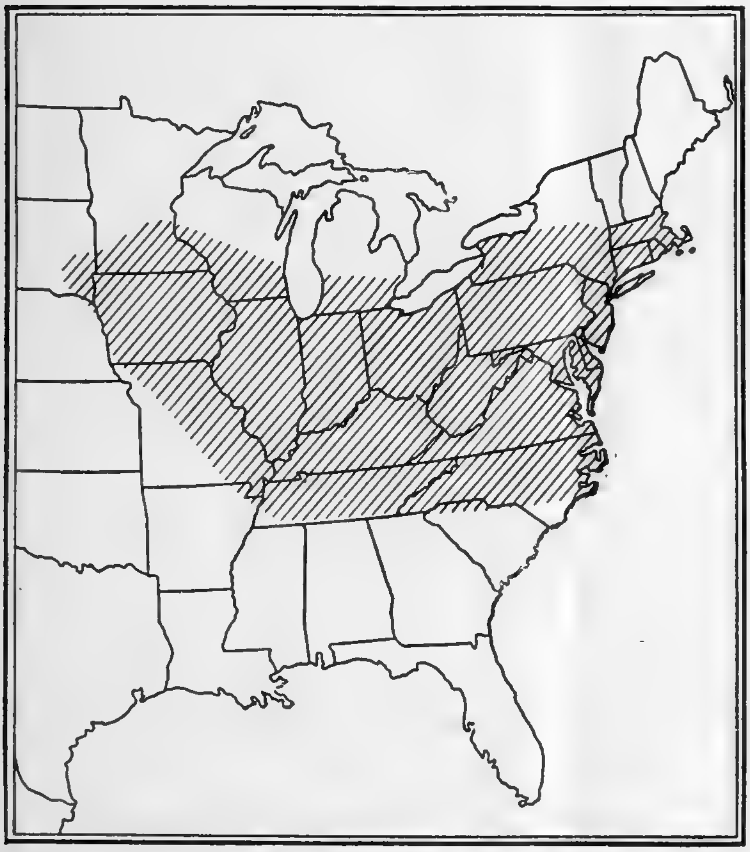


FIG. 1.—Approximate injurious distribution of webworms in the United States.

The section of the country where these pests occur and do their destructive work extends from New York and Massachusetts south to North Carolina and Tennessee and west to Iowa. These limits are roughly indicated on the map (fig. 1). Unlike most of our more destructive insect pests, the webworms are all natives of America and have not been introduced from foreign lands.

The injury caused by these worms is of two kinds: First, that done to cultivated crops, principally corn and tobacco, following sod or weed land; and, second, that occurring in meadows, pastures, lawns, and grasslands of all kinds.

The injury done by webworms to corn makes its appearance soon after the plants are up. With a little experience, the affected plants can be recognized at a glance. The leaves stand out from the stem more nearly horizontal than in healthy plants and usually are more or less eaten, ragged, and distorted. Sometimes the whole plant is curled and twisted into a shapeless tangle. Often the middle leaf or "growing point" is cut off at its base and dies. Occasionally the leaves above ground are eaten but usually the feeding occurs within or upon the stem below the surface (fig. 2), thus causing the deformed condition mentioned above. If an infested plant be pulled, it will be found that, from the ground level down to where the roots branch, the stem is scarred and eaten along one side, often with at least one hole reaching to its center, thus cutting off the middle leaf and killing the "bud." Where such plants are allowed to grow they send out suckers profusely and finally develop into deformed clumps of leaves and stems, seldom reaching a height of more than a foot or two and never producing marketable grain.

FIG. 2.—Corn plant showing injuries inflicted by a webworm.

If a small plant which is thus affected be carefully dug there will be found, close beside the stem, a more or less complete tube or shield of grayish silk mingled with particles of earth (fig. 3). This tube may be from one to several inches long and may or may not open to the surface of the soil. At its lower end it usually angles away from the plant and the worm which did the damage will probably be found hiding in the enlarged end or terminal pocket.

There are several other insects whose work on corn may be mistaken for that of webworm larvæ, but, as their common name indicates, the most characteristic feature about the webworms is the presence of the silken tube or web with which they invariably surround themselves. The work of billbugs, cutworms, southern corn rootworms, wireworms, and stalk-borers bears some resemblance to that of webworms, but a careful observer soon learns to distinguish the characteristics of each.

FIG. 3.—Seedling corn plant showing silken nest of webworm attached to stem at right just below surface of soil.

The presence of scars, pits, and gnawed places on the underground stem of the plant and the presence of a protecting silken web or tube are the characters which, almost with certainty, identify the cause of the injury as a webworm. The other type of injury by sod webworms is that done to meadows, pastures, lawns, and grasslands of all kinds. Under normal conditions sod webworms are grass feeders and will be found only in sod or grass clumps. In fact, the injury to corn described above is not normal to the habits of these insects and occurs only when sod or grasslands are plowed and planted to corn while the worms are still present in the soil. The injury to meadows and pastures is ordinarily inconspicuous and the degree of such injury is practically impossible to estimate in definite terms. That it is severe and a real factor in reducing the productivity of such lands may, however, be readily understood when it is realized that there are often many thousands of these worms to the acre, each cutting off and consuming several blades of grass every 24 hours. And they continue their destructive work not only in the spring when conditions are favorable for grass growth, but throughout the whole summer and even during the fall. Different species or additional generations of the same species follow one another so that at any time throughout the growing season these pests may be found actively at work. Especially in times of drought and when plant food is insufficient to permit rapid, thrifty growth, the sod webworms may consume practically all the growth as fast as it appears, thus leaving nothing for the owner of the land. In fact, there are on record several well-authenticated instances where the worms have stripped whole pastures and hay fields absolutely bare; in one instance, occurring in New York State, farmers of several counties found it necessary to dispose of their cattle because of the shortage of feed which resulted from the work of these insects. That such serious injury does not occur more often is due only to a combination of natural influences which prevents these worms reaching devastating numbers, and if at any time one or more of such forces fail to act, destruction and loss are likely to result.

WEBWORMS AND PARENT MOTHS.

Webworms are the caterpillars or young of certain small whitish moths or millers which are readily to be observed in meadows or pastures, particularly toward dusk. They are quite conspicuous when flying; but because of their peculiar habit of folding their wings closely about their bodies when at rest, they are often very difficult to see after they have alighted on a grass stem or leaf. There are many sorts of webworms, some 60 or 80 kinds being found in the entire United States, all of which are very much alike in both larva and moth stages. Practically all of these insects feed on grasses, but less than a dozen of them are of agricultural interest, as the others either attack unimportant wild grasses or are so rare that they are of no economic importance. All of them have the same stages in their life history but vary considerably in their seasonal history, and a knowledge of these differences is sometimes essential in planning control measures.

GENERAL LIFE HISTORY.

The eggs (fig. 4) are very small and are dropped indiscriminately by the female moths as they fly about over the grass at dusk and during the early hours of the night. Being dry, these eggs fall down among the grass stems and are therefore difficult to find. They hatch in a week or 10 days, and the young worms at once begin to feed on the grass leaves about them, cutting small pits in their surfaces. They immediately start the formation of the protective silken net within which they remain during their whole larval life. As they grow larger they are soon able to eat the entire leaf, and when they become too large to be concealed within the fold of a leaf, descend and construct in the earth a burrow lined with silk, with an opening at the surface and sometimes continued upward along the grass stem in the form of a tube made of silk and bits of grass. From this time on the worms cut off the blades of grass entirely and drag them down into the burrow, where they feed in safety and at leisure. Often one finds a blade of grass projecting from the entrance of such a burrow while its motion and gradual disappearance indicate that down below the busy harvester is turning grass into worm as fast as possible.

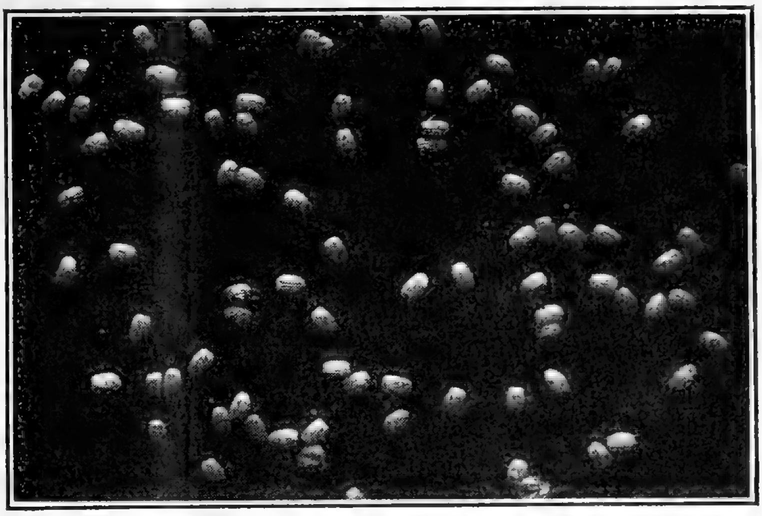


FIG. 4.—Eggs of a webworm moth. Much enlarged.

In order to allow for its rapidly increasing size the larva molts or sheds its skin several times until it reaches a length of half an inch or more, depending on the species (fig. 5). When its appetite is finally satisfied the webworm deserts the old burrow and in the earth near by constructs its cocoon (fig. 6), a neat little chamber with stiff walls of silk and earth, the whole about the size and shape of a peanut meat, although this often has a short neck or tube at one end opening at the surface of the ground. In this cocoon the worm awaits the change that shall transform it to the pupa or chrysalis (fig. 7). This period of waiting may vary in length from a few days to several months, depending on the particular species. The chrysalis is reddish-brown, helpless, and immovable except for the pointed abdomen, which can be rapidly rotated when it is disturbed.

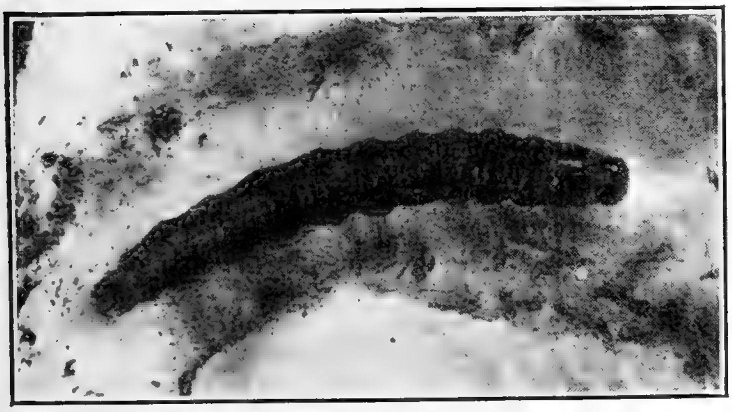


FIG. 5.—Caterpillar of the black-headed sod webworm. About three and a half times natural size.

After a period of from 10 days to 2 weeks in the chrysalis stage, the moth (fig. 8) emerges from the chrysalis and forces her way out through the silken tube to the open air above, where, after a few minutes' pause to spread and dry her wings, she is ready to mate and lay eggs with which to start the cycle anew. All the growing and feeding is done in the larva or worm stage, and it is in this stage only that these insects are harmful. The moths feed only on dew and live but a few days, or long enough to lay the eggs with which they are already filled when they leave the cocoon.

As there are several different species of these webworms, which vary somewhat in their habits, in their method of work, and in the means for their control, it will be best to discuss them separately.

FIG. 6.—Cocoons and pupæ of the striped webworm. Slightly enlarged. (The rule shown is a centimeter rule; an inch is 2½ centimeters.)

CORNROOT WEBWORM.[1]

The cornroot webworm, often known locally as the " budworm" or " wireworm," is by far the most injurious of the sod webworms attacking corn. Often some of the other species are associated with it, but in nearly every case where young corn is seriously injured by webworms the cornroot webworm may be charged with part of the trouble. It occurs from Pennsylvania to Iowa and southward to North Carolina and Tennessee and causes loss in some part of its range every year. In many sections where it occurs the farmers have grown to regard it as a necessary evil and anticipate having to replant at least part of the crop.

The small worms pass the winter in the earth, often around the roots of some of the more common weeds, such as "stickweed" (*Aster*

[1] *Crambus caliginosellus* Clem.

dumosus), plantain (*Plantago lanceolata*), and "fleabane" (*Erigeron* spp.). Very early in the spring, as soon as growth starts, the worms become active and continue to feed until they are fully grown. This is about the 1st of June in Tennessee and correspondingly later in more northern States. They construct their cocoons in the earth near their food plant and change to the pupa or chrysalis. Not all the worms make this change at the same time, but some of them after making their cocoons lie quietly for periods ranging from a few days to several weeks. Usually about 10 days is spent in the pupa stage.

FIG. 7.—Pupa of the bluegrass webworm. About three and a half times natural size.

The first moths make their appearance toward the last of June and from that time through July and most of August some individuals are always present. It has been supposed that there might be a second or intermediate midsummer generation, but such does not seem to be the case. The moths are small and dark, sometimes almost black; they are quick fliers, and, because of their small size and dark color, are difficult to follow with the eye. They seem to prefer weedy and brushy areas, neglected fence rows, etc., and unless very abundant are not commonly found in open places. In Tennessee, at least, corn following fallow or weeds such as spring up after a wheat crop is more likely to be attacked by this species than after clean grass sod. Because of this fact many farmers think that the worms winter in the weed stems, but this is not the case, although many worms and larvæ very similar in appearance to the webworms can be found in such places. The eggs of the cornroot web-

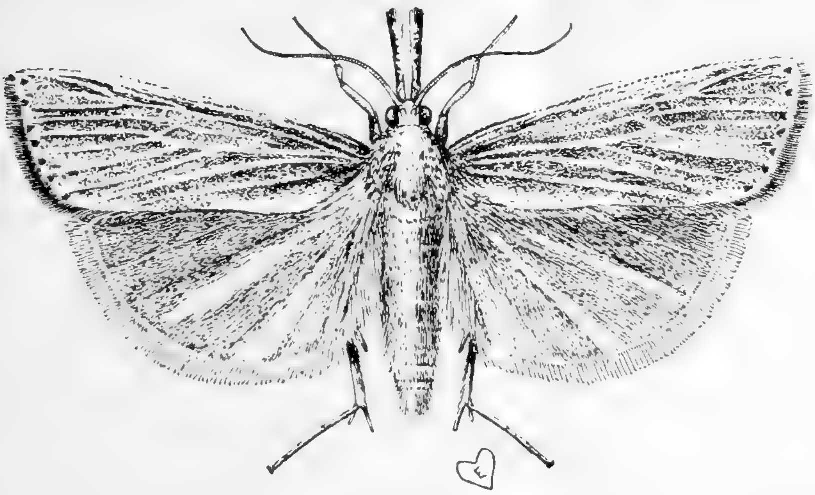


FIG. 8.—Adult of the black-headed sod webworm. About three times natural size.

worm are laid by the moths in July and August and soon hatch. The worms feed but little at this time and soon seek their winter quarters.

HABITS.

When found around corn plants in the spring these worms have a distinct yellowish appearance, sometimes almost golden yellow. Their heads are yellowish-brown; when nearing full growth they become lighter colored. After feeding has been completed they form cocoons in the earth, usually an inch or two away from the food plant. These cocoons are difficult to find and are often not recognized except by chance, because they look like pellets of earth. The time at which the worms cease feeding is determined by their stage of growth and not by external conditions, such as warm or cool weather, rain or dryness, and cultivation or the lack of it. Some of these factors may help or hinder the corn plants in recovering from the injury , but they have no perceptible effect on the worms.

The cornroot webworm is peculiar in that it seldom constructs a complete tube of webbing, but merely one side of it, the stem of the plant upon which it is feeding supplying the other side. This half tube or shield protects it from direct contact with the earth. The burrows do not open to the surface and all the feeding is done underground. The stem is attacked between the earth surface and the point where the roots branch. Irregular holes or pits are gnawed into the succulent tissue, usually along one side of the stem. Often these pits reach the center of the stem and cut off the middle leaf or leaves. This habit renders this comparatively small species much more destructive than some of the larger species of webworms because a plant once attacked usually is deformed beyond the possibility of recovery. The grower may be deceived by the fair appearance of the plants above ground and thus be led to believe that most of them will recover, but if on examination he finds any considerable proportion of the plants infested, he had better plan at once to replant, using the method outlined in the discussion of control measures (p. 15.)

STRIPED WEBWORM.[2]

The striped webworm (fig. 9), is one of the most common and widespread of the economic species. It occurs throughout the entire eastern half of the United States and as far west as Texas, Colorado, and South Dakota. It is one of the larger species, the worms when full grown being nearly an inch long. It is easily recognized by the four narrow, more or less distinct, whitish stripes along the back.

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[2] *Crambus mutabilis* Clem.

The head is dull yellow with distinct black blotches. This species repeatedly has been found injuring corn but practically always in association with one or more other species and only where corn has followed freshly turned grass sod. While this is a larger species and a more vigorous feeder, its injury to young corn is not nearly so severe as that caused by the cornroot webworm because the striped webworm feeds almost entirely above ground and seldom injures the stem. This worm constructs a distinct, tubular burrow which opens at the surface of the soil and from which it emerges and either climbs the plants to feed on the leaves or cuts the leaves off at their bases and drags them to the entrance of the burrow, where it may feed without interference. Very seldom does any deformity result from its work and the plants attacked quickly recover from the loss of a portion of their leaf surface.

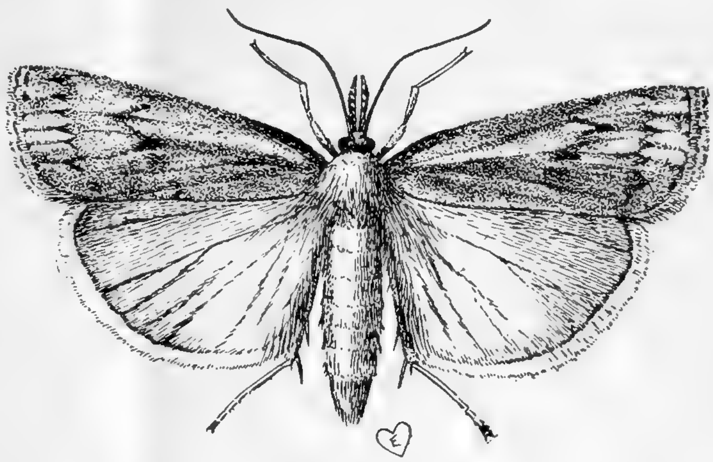

FIG. 9.—Adult of striped webworm. About three times natural size.

In grasslands, especially bluegrass meadows, large lawns, and parks, this worm is a frequent cause of premature browning and failure, especially in times of deficient rainfall. When laying their eggs the moths seek the lower and richer portions of the field where the grass is luxuriant, and the worms are usually more abundant in such places.

There are two generations and sometimes a partial third generation each year, the moths appearing in Tennessee during May, again in July, and again in lesser numbers in late August. The worms do their most conspicuous work on corn in April and by the first of May practically all the overwintering larvæ are mature. The summer generation, coming at a time when seasonal conditions are not so favorable, causes the injury to grass. The worms pass the winter in little cylindrical tubes of silk and grass fragments which they construct close to the earth among the grass stems (fig. 10).

Early fall plowing of grass sod on land intended for corn will greatly lessen their numbers the following spring. In meadows the application of a quick-acting fertilizer might serve to stimulate the growth of grass and aid it to overcome the work of the insects.

BLUEGRASS WEBWORM.[3]

Occurring throughout the eastern half of the United States and as far west as Colorado, the bluegrass webworm (fig. 11) is one of the most abundant species, at least in the southern part of its range. From May to the end of September the moths are present and often very abundant in almost every grassy area and weed patch. The moth is of medium size and may be identified by the white scales on the top of the head. The wings are yellowish gray.

FIG. 10.—Winter nests of caterpillars of striped webworm.

This species is strictly a grass feeder and has never been recorded as injurious to cultivated crops. As its name indicates, its favorite food is bluegrass,[4] although in captivity it can be reared on other grasses, including corn. It is included here because doubtless it is responsible for many prematurely brown pastures and lawns in midsummer.

The worm is dingy yellow and the head is without dark markings. The worms are hard to find in the field, for their burrows are carelessly made and without definite shape. They simply web together some grass stems and fragments at the base of the plant and emerge from this retreat to cut off and drag down one blade at a time until the whole tuft is bare of all green growth. The thousands and scores of thousands of these worms that at times are present in each acre of pasture severely curtail the amount of feed available for stock and reduce the vitality of the plants themselves. There are several generations of this insect each year, but they so overlap that for all practical purposes the worms and moths are continuously present.

BLACK-HEADED SOD WEBWORM.[5]

The black-headed sod webworm (fig. 8) is another grass-feeding species which, except in a few minor instances, has never been accused of injuring cultivated crops. It has shown itself capable, however, in several cases, of severe and costly damage to pasture lands and lawns. The most conspicuous recorded outbreak of this species occurred in northern New York State in the spring of 1881. In this

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[3] *Crambus teterrellus* Zincken. [4] *Poa pratensis.* [5] *Crambus vulgivagellus* Clem.

instance practically all the pastures in several counties were completely stripped of every green blade of grass, appearing in late May as bare and brown as is usually the case in December. Most of such fields produced very little growth during the rest of the season and in many of them much of the grass died outright. While no such severe devastation has been observed since that time, it illustrates the severe injury of which any of these common grass-feeding webworms are capable of when all the conditions favor them.

The black-headed sod webworm has only one generation each year. The eggs are laid in August and September and soon hatch. The tiny worms feed for a few days until cold weather overtakes them and then remain quietly within their little silken galleries throughout the winter. With the opening of spring they become active and feed vigorously until they are fully grown, which usually is about the first of June. They then construct cocoons in the earth just beneath the surface and lie in them quietly until August, when they change to pupæ and emerge a week or ten days later as moths.

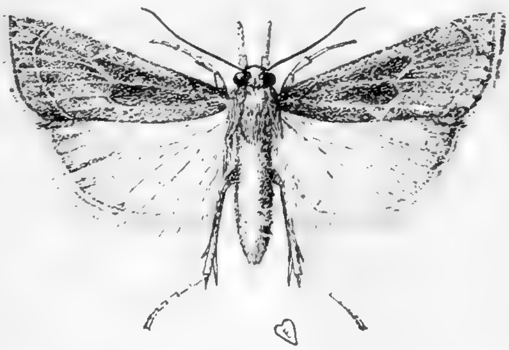

Fig. 11.—Adult of blue-grass webworm. About three times natural size.

The moth (fig. 8) is rather large, clay-yellow, flecked with numerous chocolate-brown scales and with gold fringes on the wings. It is conspicuous when flying and often very abundant. This is probably the most widely distributed of all the sod webworms, as it occurs from Texas to and throughout southern Canada and from Maine to California.

LEATHER-COLORED SOD WEBWORM.[c]

The leather-colored sod webworm is one of the largest of the sod webworms, the mature worm reaching a length of about an inch and the moth spreading about an inch and a quarter. The moth is yellowish gray and the larva or worm dark leather-brown or dingy yellow clouded with brown. This species occurs entirely across the continent in southern Canada, south to Tennessee east of the Mississippi, and almost to the Mexican border in New Mexico. It is abundant and destructive over an area extending from Ohio to Iowa.

There are two or three generations each year. Only small larvæ live throughout the winter. In the fall, usually in October, each tiny larva spins a thin but tough, white, silken case closely about itself and remains tightly coiled in this case until April, when it again begins to feed. These overwintering larvæ complete their

[c] *Crambus trisectus* Walk.

growth about the 1st of June, and it is at this time that they cause the injury to young corn. They have also been reported destroying fields of small grain in early spring. The moths emerge during June and lay eggs for the second or summer generation.

The worms of this summer generation reach maturity during July, and are responsible for damage to meadows, pastures, and lawns. In the southern portions of the insect's range, and in favorable seasons farther north, moths of this second generation appearing in late July give rise to still another generation which appears in late September and October, but this third generation when present is usually smaller and of no economic importance except that it provides the small larvæ which pass the winter.

The worms of this species are vigorous and active and feed freely. They construct definite tubular burrows opening at the surface and feed by cutting off the leaves and dragging them down into their retreats. Each worm during its life eats from 7 to 13 linear feet of blue-grass leaf or its equivalent, and as there are often thousands of them to the acre, it is evident that they may very materially reduce the amount of pasturage for stock or grass for hay.

SILVER-STRIPED WEBWORM.[7]

The silver-striped webworm should be mentioned because of a single small outbreak which occurred in the spring of 1919 in Connecticut. A small field of corn following spring-plowed grass sod became practically a total loss because of these worms. They worked very much as does the cornroot webworm, cutting into the stalk below ground and either killing the plant outright or causing it to become hopelessly deformed. Previous to this outbreak occasional specimens had been taken on various plants, including timothy, wheat, and corn, but not in sufficient numbers to warrant calling it a pest.

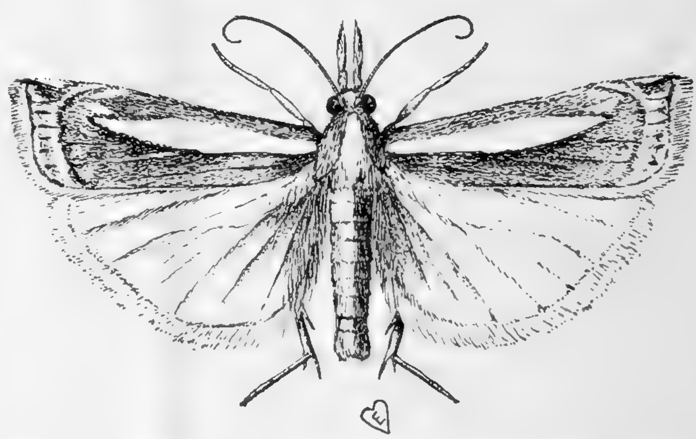

FIG. 12.—Adult of silver-striped webworm. About three times natural size.

The worm is dirty white or gray, with a pale yellow head, quite conspicuously blotched with brown. The moth (fig. 12) is bronze yellow with a single silver stripe running lengthwise in the middle of the forewing. The species is of wide distribution over the eastern

[7] *Crambus praefectellus* Zincken.

half of the United States, but is seldom abundant at any one point. There are several generations each year, the exact number depending on the latitude. The moths seem rather hardy and usually are the first of the webworm moths to be seen in the spring and the last in the fall. The larvæ feed on several kinds of grasses and very likely on other plants as well. It is only one of several species of webworms which may easily become pests if natural conditions favor their multiplication.

GENERAL CONTROL MEASURES.

As there are two main types of injury inflicted by the sod webworms, there are also two main types of control.

For the first type of injury, that to young corn, prevention is better than remedy. In fact, after the corn is once planted and the field is found to be infested there is no practicable method of getting rid of the worms and the only thing that can be done is to produce conditions that will permit the corn to grow in spite of them.

Land that has been in sod, either pasture or meadow, and land that has lain fallow and has grown up to weeds and grass, should be plowed the fall before it is intended to plant it to corn. The earlier it is plowed the better; it should be done in July or August if possible. Plowing in late October and November seems to show very little more beneficial effect in reducing the worms than plowing early the following spring before the corn is planted. It seems probable that the worms are practically all in their winter webs by the middle of October, and even earlier than this farther north, and when they have once sealed themselves up for the winter they are so securely protected that plowing does not injure many of them. Thus it may be seen that fall plowing to be effective must be done early enough to disturb the worms before they have finished feeding and, by the destruction of their food, either starve them before winter or force them to go into winter so poorly protected that many of them die before spring. Such fall-plowed land should be disked or otherwise cultivated in the spring until time for corn planting so that grasses and weeds may be kept down and any worms that may have survived the winter may be starved out.

If, after the corn is up, it becomes evident that it is going to be seriously injured, another course is necessary. If the season is still early and the corn small, delay a few days, if possible, until all the worms in the soil shall have found the corn and begun work upon it. Then without disturbing the corn already growing, replant the field so that the newly planted rows lie midway between the old infested rows. Allow both plantings to stand. The field can be harrowed and, with care, cultivated the first time without seriously disturbing the first planted corn. By the time for the second cultivation most of the worms will have finished feeding and at this time the old corn can be cultivated out, leaving the second planting to occupy the field. It usually is a waste of time and seed to replant the crop in the same rows or hills with the infested plants unless it is very late in the season, because the worms merely turn their attention to the younger plants and soon the condition of these is no better than that of the first planting. Instances have come to notice where four successive plantings were made in the same rows and all but the last of these totally destroyed. The time at which the worms cease feeding varies with the location of the infestation. Seldom is any damage done in Tennessee after June 1. Farther north this date is later, perhaps as much as a month later in northern Ohio and Iowa.

It should also be stated that deep plowing, thorough preparation of the seed bed, the application of fertilizer, sound healthy seed, and any other factors which favor the corn plant will materially lessen injury. It has often been noted that corn growing in some particularly fertile spot in the field, perhaps where a stack has stood or where manure has been spread liberally, will escape almost without injury when the rest of the field is nearly destroyed. Corn plants can stand some mutilation of the outer leaves without apparent injury, if only the growing center or "bud" is not injured. The fast growing, vigorous plants are in much better condition to resist injury and to recover when injured than those already handicapped by other unfavorable conditions.

Rotation is not always a factor in the control of these insects, in fact not a single instance has been recorded where corn after corn was injured.

The possibilities of control for the other type of injury, namely, that occurring to grasslands, are much less. Little can be done that is likely to have much effect on the number or activities of the worms short of plowing up the sod and planting it to immune crops. Application of lime when needed, or of manure as a top-dressing, or any other treatment which will increase the vigor and thriftiness of the grass will lessen the proportion of loss. None of the attempts to poison the worms or to poison or trap the moths have proved successful, and in the main the tried and proved cultural practices which underlie good farming must be depended upon for control.

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United States Department of Agriculture

A SAWFLY INJURIOUS to YOUNG PINES

YOUNG PINES, both nursery stock and natural reproduction, are often defoliated by larvæ of Leconte's sawfly. Defoliation of young pines is usually severe in its effects, killing, misshaping, or weakening the trees to such an extent that attacks of secondary enemies will kill them.

This insect is common on the scrub pines throughout the eastern United States and is a constant menace to the better species in nurseries or reforesting areas. It can be controlled in nurseries and parks, when the infestation is heavy, by spraying with lead arsenate at the rate of 2 pounds of the powder to 50 gallons of water; or, if scatteringly present, by hand methods such as knocking the larvæ from the trees and crushing them.

In larger and less accessible areas, where it would be impractical to attempt control by spraying, rangers and lumbermen should make a practice of destroying the colonies of these larvæ whenever they are found.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. January, 1922

A SAWFLY INJURIOUS TO YOUNG PINES.

WILLIAM MIDDLETON,

Scientific Assistant, Forest Insect Investigations.

The larva, or false-caterpillar, of an insect known as Leconte's sawfly[1] is a serious enemy of pine in nurseries, parks, and reforesting areas in the eastern United States. This insect shows a decided

FIG. 1.—Young silver pine in nursery, completely defoliated by larvæ of Leconte's sawfly.

preference for young trees and has demonstrated its ability to leave its local host and attack other species of pines. The effects of defoliation on young pines (figs. 1, 2), especially before late summer,

[1] *Neodiprion lecontei* Fitch; order Hymenoptera, suborder Chalastogastra, family Tenthredinidae, subfamily Diprioninae.

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are usually severe, the part denuded often being killed. Trees not killed are frequently infested by secondary enemies which com-

FIG. 2.—Young scrub pine on edge of woods, completely defoliated by larvæ of Leconte's sawfly.

plete the work; and, if by chance the trees recover, they are stunted or misshapen and of little or no commercial or ornamental value.

APPEARANCE, LIFE, AND HABITS OF THE INSECT.

The needles are eaten by small larvæ one-eighth of an inch long when young to three-fourths or seven-eighths of an inch in length when full grown, which feed in colonies or groups. The young larvæ (fig. 3) are pale, whitish to leaden white, and unspotted, with the head brownish; but they change in appearance through a series of molts (five for the male and six for the female), becoming yellowish-white with a number of rows of black spots on the body (fig. 4) and with the head dark brown to orange. These larvæ have three pairs of legs on the thorax and eight pairs of smaller legs on the abdomen, and the head has only a single pair of eyes, situated one at each side in a rather large, circular, blackish spot.

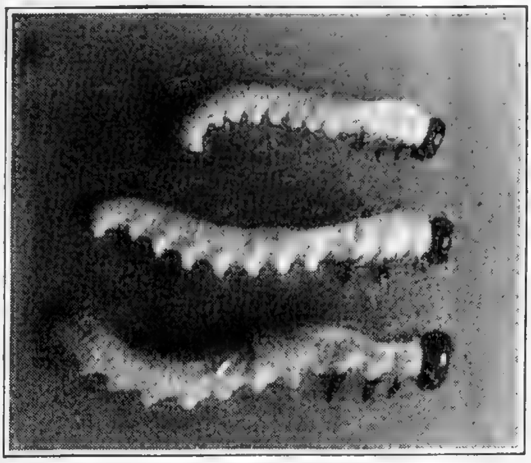

FIG. 3.—Young larvæ of Leconte's sawfly, second and third stages. Four times natural size.

The larvæ are found clustered in colonies feeding on the pine needles and occasionally on the tender bark (fig. 5) of the young twigs.

FIG. 4.—Larvæ of Leconte's sawfly, fourth and fifth stages. Four times natural size.

When full grown the larvæ spin cocoons from which they emerge later as adults. Adult emergence is divided into two periods, a first issuance, brood A, and a second issuance, brood B. When the eggs are laid and hatch in the late spring or early summer, adults of brood A issue from the cocoons in the late summer and early fall of the same year; but adults of brood B from this batch of eggs do not issue from their cocoons until the late summer and early fall of the following year, a complete colony developmental period of 14 months. If the eggs are laid and hatch in the late summer, adults of brood A of these eggs issue from their cocoons in the spring and early

FIG. 5.—Terminal of young scrub pine showing defoliation and feeding work of larvæ of Leconte's sawfly on bark. Three-fourths natural size.

summer of the following year, and adults of brood B of the same batch of eggs emerge from their cocoons in the late summer and early fall of the same year as brood A, making a complete colony developmental period of 12 months. (See diagram, fig. 6.)

The cocoons (fig. 7) have been found several inches underground and only in this location; but it is quite possible that some larvæ, es-

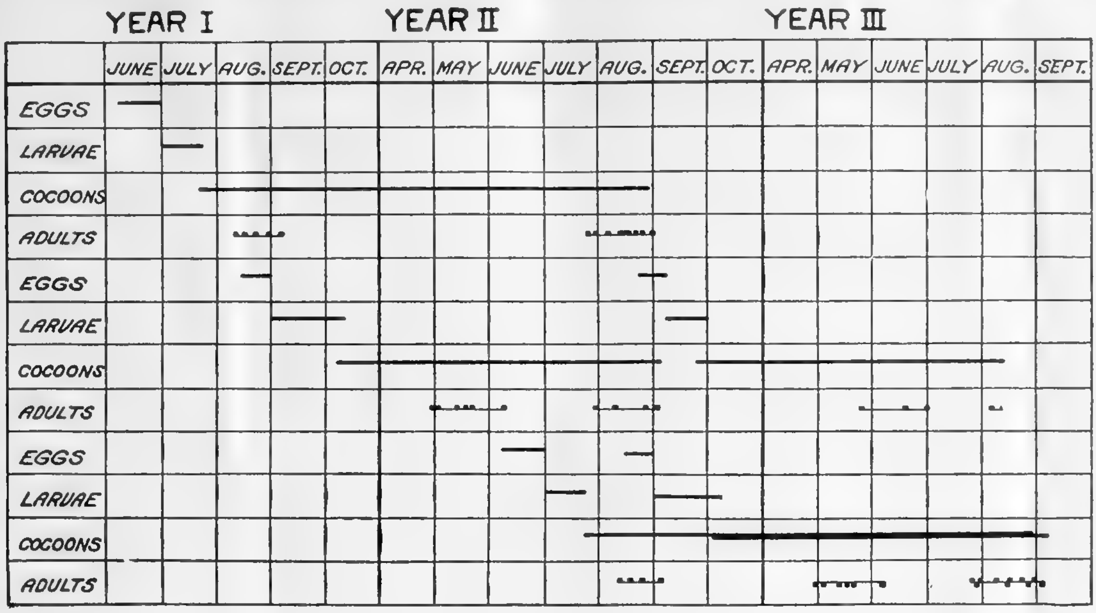

Fig. 6.—Chart showing life and seasonal history of Leconte's sawfly through the active period of three years (November to March omitted, the insect being in the cocoon during this period).

pecially those the adults of which will issue before winter, may spin their cocoons in more exposed places, even on the pine twigs. The

Fig. 7.—Cocoons of Leconte's sawfly: At left, unopened ones containing the insects; at right, those from which adults have issued (emergence holes shown). The females issue from the larger cocoons and the males from the smaller ones. Approximately natural size.

cocoons are tough, papery, red-brown, capsule-shaped cases, five-sixteenths to seven-sixteenths of an inch long.

The adults (fig. 8) are rather robust, four-winged insects. The male is black with reddish yellow legs and has beautiful feathery feelers, or antennæ. The female has the head and first two thoracic segments reddish brown and the third thoracic segment and abdomen black. Her feelers are rather slender and not feathery.

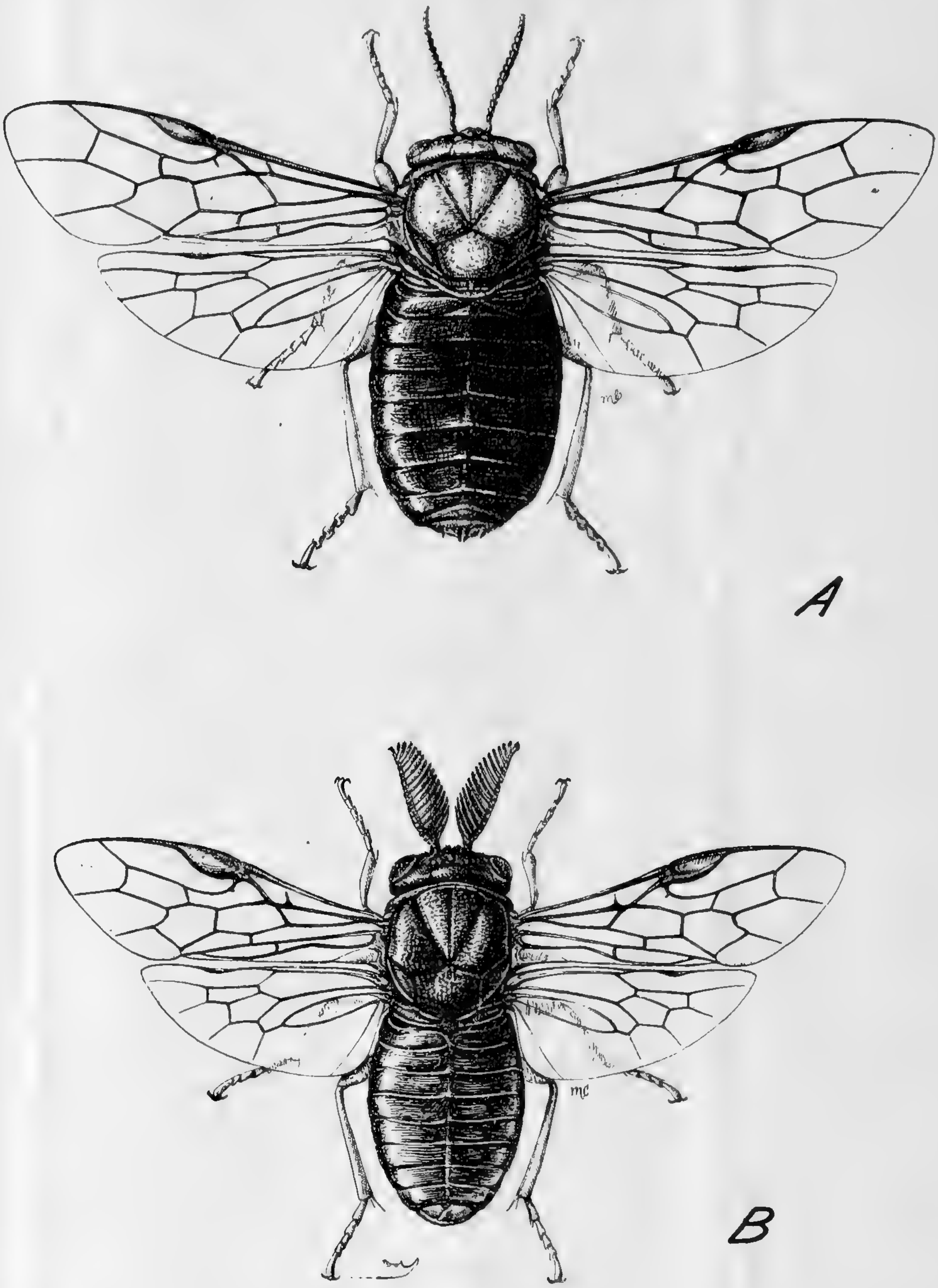

FIG. 8.—Leconte's sawfly: *A*, Adult female; *B*, adult male. About eight times natural size.

The sawflies get their name from the complicated egg-laying organ of the female. It is well named "the saw," having blades and teeth and being used exactly as a saw when tearing into the leaves in cutting a pocket for the eggs.

The eggs are laid in shoe-shaped pockets, or slits, in the needles. Usually, attacked needles occur in a cluster, each needle bearing a

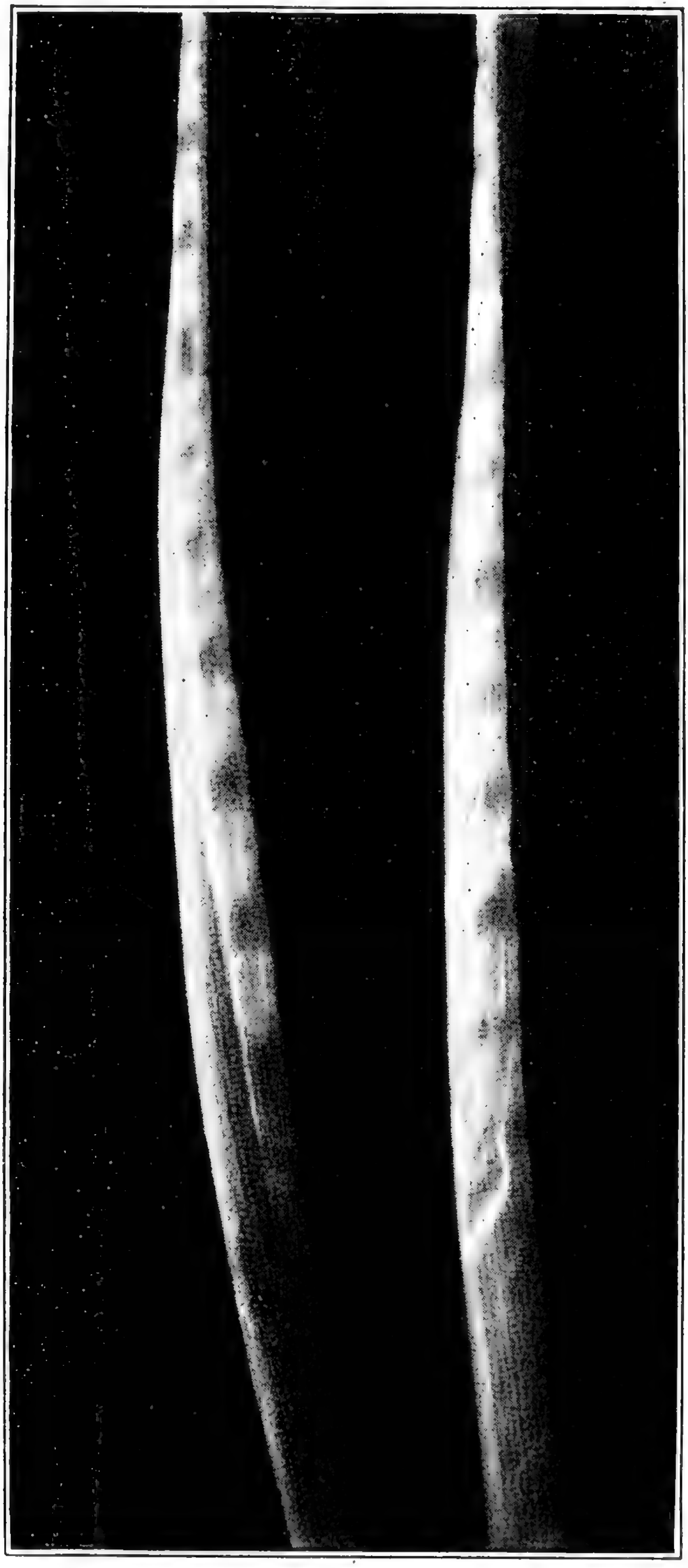

Fig. 9.—Needles of scrub pine showing eggs of Leconte's sawfly embedded in them. Much enlarged.

number of eggs. The egg scars, or pockets, are rather easily seen, being yellowish on the dark green needles. (Fig. 9.)

DISTRIBUTION.

Leconte's sawfly occurs throughout the eastern United States, the accompanying map (fig. 10) indicating localities from which the species has been recorded or specimens received.

TREES ATTACKED.

This species seems to have a preference for jack pine,[2] red pine,[3] and scrub pine,[4] each of which furnishes a local host in some part of the eastern United States throughout which the insect occurs. Its attack is not limited to these species, however, for it is also found on or recorded from white pine,[5] scotch pine,[6] loblolly pine,[7] shore pine,[8] silver pine,[9] mugho pine,[10] western yellow pine,[11] longleaf pine,[12] Austrian pine,[13] and American larch.[14]

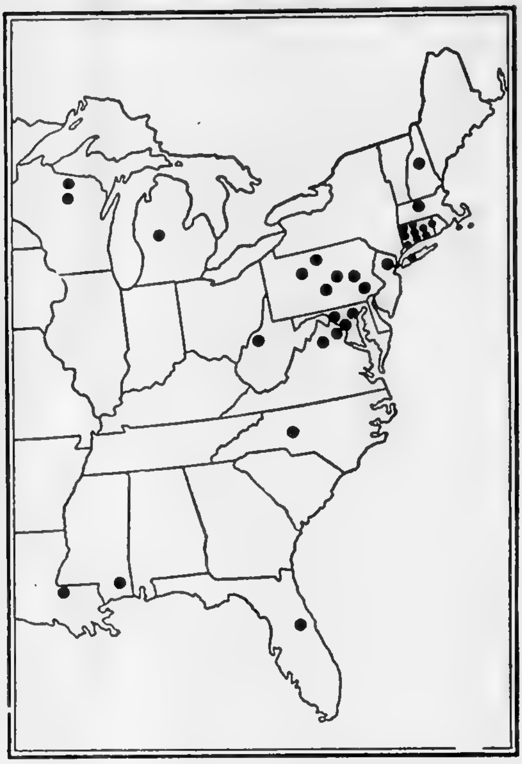

Fig. 10.—Map showing localities where Leconte's sawfly is known to occur.

PERIODICAL OUTBREAKS.

Leconte's pine sawfly, like most insect enemies of forest trees, appears and disappears periodically. For several years this species will be very abundant, then for a few years it will be rare. The cause for this periodic disappearance has not been determined, but the low records of parasitism indicate that some factor other than parasitism plays an important rôle.

NATURAL ENEMIES.

Eight species of insect parasites and an infectious disease have been found killing this sawfly. None of these enemies, however, has been found widely enough distributed or abundant enough to account for the periodic disappearance of the species, and it is certain that neither any nor all of these natural checks are sufficiently numerous or effective to justify disregard of the artificial control measures suggested.

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[2] *Pinus banksiana.*
[3] *P. resinosa.*
[4] *P. virginiana.*
[5] *P. strobus.*
[6] *P. sylvestris.*
[7] *P. taeda.*
[8] *P. contorta.*
[9] *P. monticola.*
[10] *P. mughus.*
[11] *P. ponderosa.*
[12] *P. palustris.*
[13] *P. austriaca.*
[14] *Larix americana.*

CONTROL.

The control of Leconte's sawfly depends largely upon the extent and location of the infestation. In nurseries and parks, when the infestation is heavy, a thorough spraying with lead arsenate, 2 pounds of powdered lead arsenate to 50 gallons of water (or 6 teaspoonfuls to the gallon), will give good results. Spraying should begin when the larvæ are first discovered. In a scattered infestation, hand picking or knocking the larvæ from the trees and crushing them will be found more economical and at least as effective.

In large areas of either natural or artificial reproduction control can not be generally practiced because of its expense; but rangers and lumbermen should make it a habit to destroy the colonies of these larvæ whenever found.

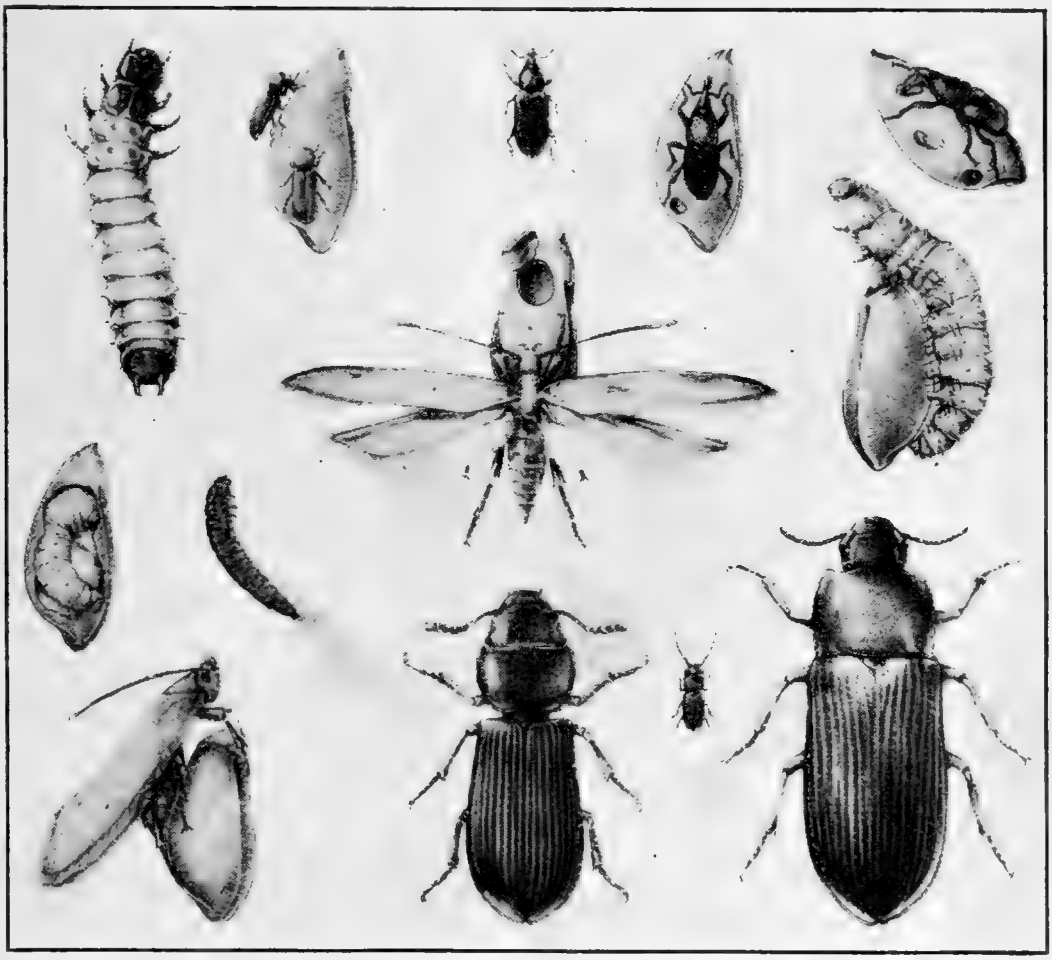
Whenever these insects are observed in any locality and control measures are practiced against them, it is important that the territory be carefully surveyed for the following 14 months, since it is possible that some larvæ may have escaped the treatment and have spun cocoons. This possibility makes watchfulness necessary over the entire colony period of the species in order that an emergence of adults from these cocoons may not reestablish the infestation.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1922

FARMERS' BULLETIN 1260

STORED-GRAIN PESTS

E. A. BACK
Entomologist in Charge
and
R. T. COTTON
Assistant Entomologist, Stored-Product Insect Investigations



UNITED STATES
DEPARTMENT OF AGRICULTURE

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1922

MOST of the damage done by insects to grain in storage and shipments is due to four species. These are the granary weevil, the rice or black weevil, the lesser grain borer or Australian weevil, and the Angoumois grain moth. Others of the 40 species or groups of species described in this bulletin can cause great damage to grain if storage conditions are unusually favorable for their increase. Yet if grain in the unbroken kernel remains unaffected by the four insects mentioned, it is not likely, in commercial storage or shipments, to be sufficiently affected by other insects to cause appreciable loss. These four pests live throughout their larval life entirely within the kernel, where they feed unseen, usually unsuspected, and where they can not be reached by the ordinary methods employed by grain men in their grain-cleaning operations known to the trade as moving, fanning, and screening.

The other pests discussed, with few exceptions, are "surface feeders." Their larvæ may eat into kernels of grain and lie hidden there, yet the greater proportion of them are found feeding upon broken surfaces of kernels exposed either by mechanical injuries to the grain in handling or by the feeding of the four major grain pests with which they are usually associated.

The larvæ, or grubs, of the four major pests mentioned are not ordinarily capable of a free existence outside the kernel but the larvæ of the other grain pests are, in the main, capable of free locomotion, crawling where they will throughout grain in bulk, and are therefore susceptible to removal by fanning and screening. Methods of preventing infestation of grain and of treating infested grain are discussed briefly.

STORED-GRAIN PESTS.

CONTENTS.

POPULAR CLASSIFICATION OF GRAIN PESTS.

Since the establishment of the Federal standards for grain under the provisions of the Grain Standards act, Federal grain supervisors and federally licensed grain inspectors are required to identify the various species of "live weevils and other insects injurious to stored grain" which may be present in the grain, and uniform names for grain insects should be used. Such uniform terminology will indicate definitely to all interested persons, including shipper, purchaser, and elevator operator, the exact nature of the insect found. Of the four major pests, the granary weevil, the rice or black weevil, and the lesser grain borer may be well called "grain weevils." The fourth of the major pests, the Angoumois grain moth, so destructive to wheat and corn, may be called "grain moth." Other insects likely to be found in any lot of grain may be called simply "beetles," "moths," and "mealworms," for their presence usually does not indicate a condition likely to affect the trade, provided that after the grain has reached the elevator it is screened and fanned to remove these insects.

The writers have divided the insects discussed in this bulletin into grain weevils, grain borers, grain moths, flour moths, mealworms, grain and flour beetles, psocids, and mites. In some respects this is not a satisfactory grouping, especially for the insects listed as "grain and flour beetles," but it has the advantage of definitely placing the most serious insects troublesome in bulk grain.

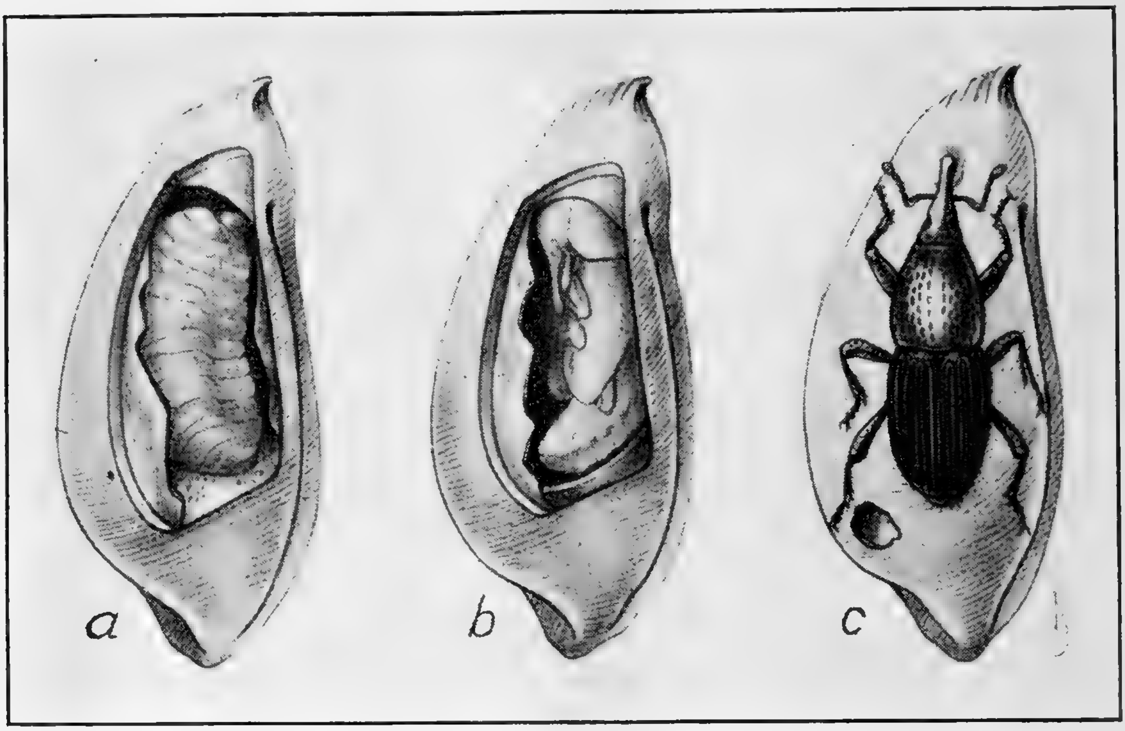


FIG. 1.—Life stages of the granary weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult. Note hole in kernel made by the adult in order to leave the seed, and hole that it is eating into the kernel for the purpose of laying eggs. This weevil closely resembles the rice weevil but has no papery wings beneath its wing covers, and the dot-like punctures on the back behind its head are elongate rather than round.

GRAIN WEEVILS.

Of the four true weevils that attack grain in the United States only two are of primary importance at present, the granary weevil and the rice or black weevil. The broad-nosed grain weevil and the coffee-bean weevil are of minor importance except locally. These four weevils have an elongated beak or snout, as shown in the illustrations, though the beak of the coffee-bean weevil is greatly reduced.

GRANARY WEEVIL.[1]

The granary weevil (fig. 1) is a small, moderately polished, chestnut brown or blackish beetle with head prolonged into a long slender snout at the end of which are a pair of stout mandibles or jaws. It is

[1] *Sitophilus granarius* L.

not more than three-sixteenths of an inch long, and often smaller. It has no wings under its wing covers and the thorax is well marked with longitudinal punctures, two characteristics that distinguish it from the closely related rice weevil, with which it is often found associated. The well-grown footless whitish grub or larva and the pupa are shown at *a* and *b*, respectively, in figure 1. The granary weevil is one of the oldest known insect pests, is a universal feeder upon grains, and is cosmopolitan, having been carried by commerce to all parts of the world. It prefers a temperate climate and is more frequently found in the Northern States than in the South.

Both adult and larva feed voraciously on a great variety of grains. The adult weevils may live for 10 or more months, and during this period each female may lay from 200 to 300 eggs. Before laying her eggs the female bores a small hole in the grain berry with her snout. When this is made she turns about and lays in it an egg, which she then covers with a gelatinous fluid which seals the hole. The small white fleshy and legless grubs that hatch from the eggs burrow about inside the kernel. When full grown, the grub transforms to the pupa stage and then into the adult weevil. In warm summer weather the granary weevil requires about four weeks to pass through the egg, larva, and pupa stages and emerge as an adult of the succeeding generation. The period of development may be prolonged greatly by cold weather.

RICE OR BLACK WEEVIL.[2]

The rice or black weevil is a small snout-beetle which varies considerably in size but rarely measures more than one-eighth of an inch in length (figs. 2 and 3). It varies in color from reddish brown to nearly black and is usually marked on the back with four light reddish or yellowish spots. It closely resembles the granary weevil in form, but it has well-developed wings beneath its wing covers, differs in color and markings, and has the thorax densely pitted with round, instead of longitudinal punctures. Figure 2 gives a good impression of the appearance of the rice weevil and its earlier stages.

This weevil has been known from early times. It is found in all parts of the world where grain is used and is one of the very worst pests in stored grain. It is particularly abundant in warm countries, where it breeds continuously and rapidly destroys all unprotected grain. Throughout the South it causes tremendous losses to corn (figs. 4, 5, 6, and 7) and is the commonest of the serious pests of commercial grain shipments.

The adult weevil lives, on an average, four or five months, each female laying between 300 and 400 eggs during this period. The

[2] *Sitophilus oryza* L.

early stages are almost identical in habit and appearance with those of the granary weevil and need not be further described. The rice

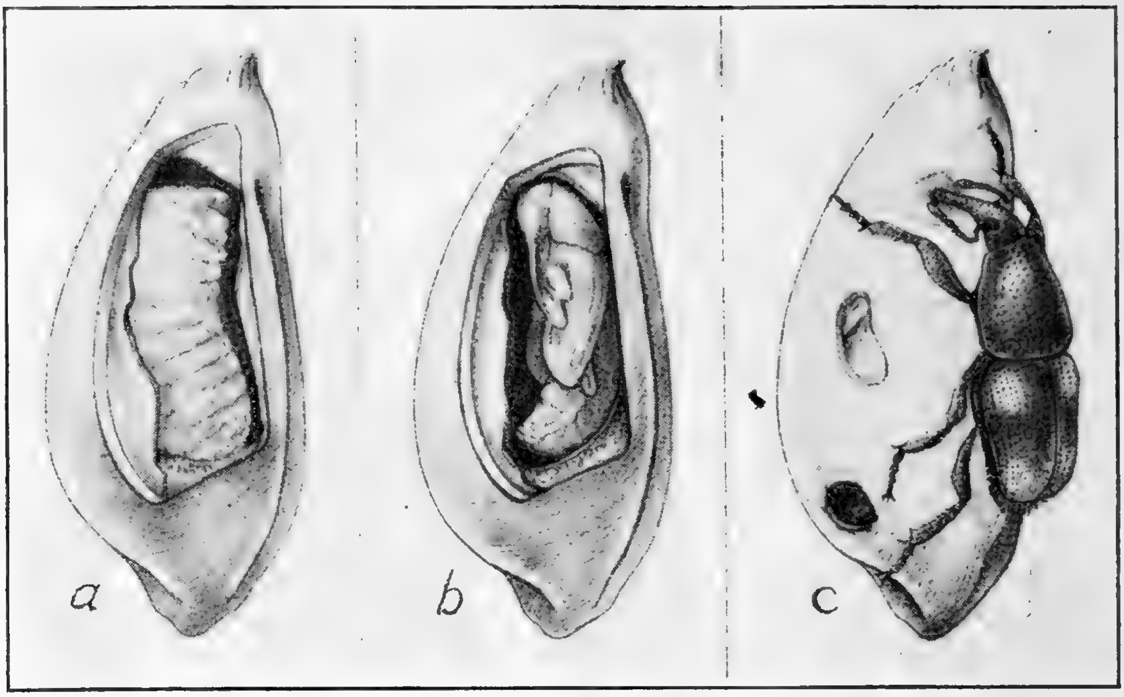


FIG. 2.—Life stages of the rice or black weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult feeding upon kernel. Note in *c* the hole in lower portion of kernel made by the adult on leaving the seed, and at two points higher up shallow holes made by the adult in feeding upon the seed after emergence. The adult weevil is at once distinguished from the granary weevil, shown in figure 1, by the four light reddish brown or yellow spots on its wing covers, by the possession of wings beneath the wing covers, and by the many rounded punctures on the back behind its head.

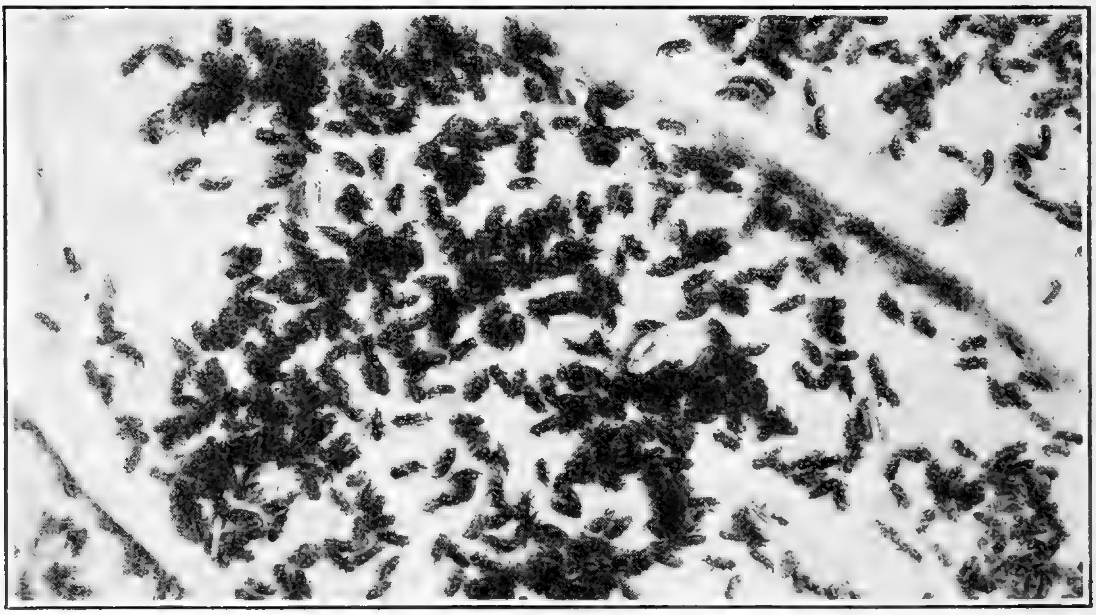


FIG. 3.—The rice or black weevil: Many adult weevils caught in the mesh of a cloth sack containing pearled barley. Compare their size with that of the barley kernels. Adult weevils when disturbed usually "play possum," but if spread upon a cloth in the sun the live ones will soon show signs of life.

weevil is a strong flier. The adults fly from granaries to the fields of grain and there start the infestation that often proves so disastrous after the grain has been harvested. During summer weather

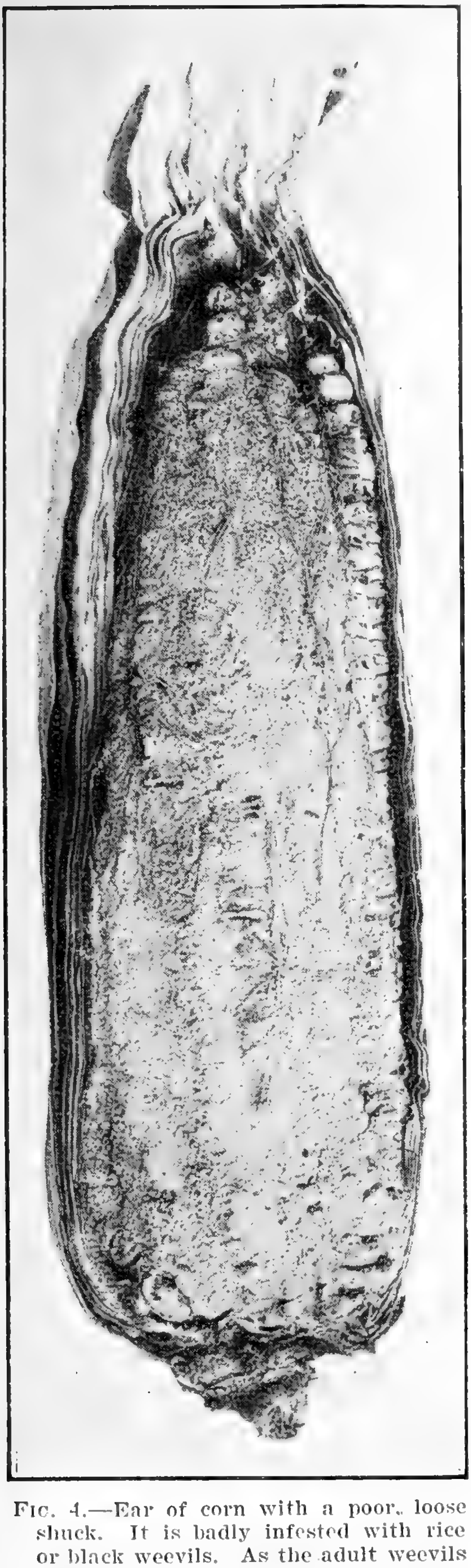


FIG. 4.—Ear of corn with a poor, loose shuck. It is badly infested with rice or black weevils. As the adult weevils feed, they push from the kernels the chewed-up portions, frass, etc., and this material, resembling white dust, collects in larger quantities between the kernels and the shuck, or, if the ears are shucked, it falls like powder onto any object below the ear. (Back.)

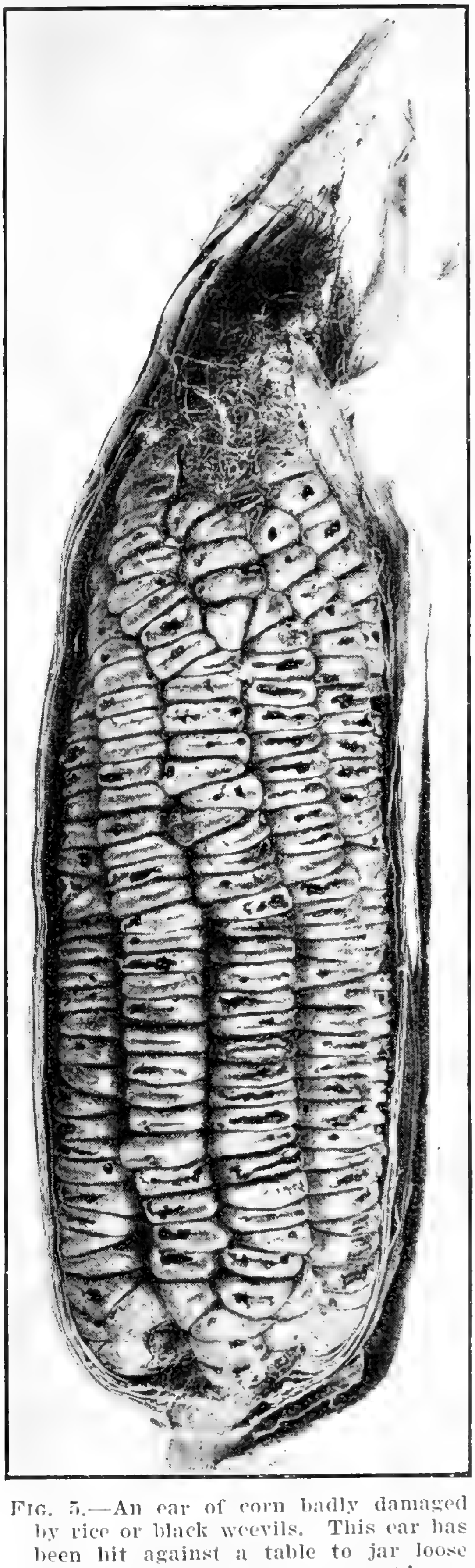


FIG. 5.—An ear of corn badly damaged by rice or black weevils. This ear has been hit against a table to jar loose the powdery substance, sometimes called the farinaceous material, and so reveals the great damage done by the weevils. The kernels of the ear have been reduced to powder and shell. (Back.)

the egg, larva, and pupa stages may be passed in as few as 26 days. This period, of course, is greatly prolonged during cool or cold weather. For a further discussion of this pest see Farmers' Bulletin 1029, United States Department of Agriculture.

Fig. 6.—Kernels of corn taken from badly infested ear corn, showing how the rice or black weevils can thoroughly destroy all parts of the kernels. (Back.)

BROAD-NOSED GRAIN WEEVIL.[3]

The broad-nosed grain weevil is a small dark-brown snout-beetle slightly less than one-eighth of an inch long. In form and color it resembles the granary weevil somewhat but differs from it and other grain-infesting weevils by having a short, broad snout (see figure 8.)

This weevil is occasionally found in Georgia and South Carolina and is wide-spread in Florida, where it is a serious pest of stored grains. It is unable to breed in dry, hard, uninjured grain, but attacks soft or damaged grain, or grain that has been attacked by other grain insects. It is a strong flier, and, like the rice weevil, flies to the cornfields and infests the grain before it becomes fully hardened.

The adult weevils normally live for about five months, and during this time the females lay between 200 and 300 eggs. The small white eggs are usually laid in broken portions of the grain. They hatch in a few days, and the small, white, legless grubs feed on the softer portions of the grain until they become fully grown. They then change to a white pupal form which in a few days transforms to the

[3] *Caulophilus latinasus* Say.

adult beetle and cuts its way out of the grain. The period from egg to adult in summer is about one month.

COFFEE-BEAN WEEVIL.[4]

The coffee-bean weevil is a very active, robust beetle from two-sixteenths to three-sixteenths of an inch long; dark brown in color, clothed with a mottled light and dark-brown pubescence. It may be easily recognized from the accompanying illustration (fig. 9).

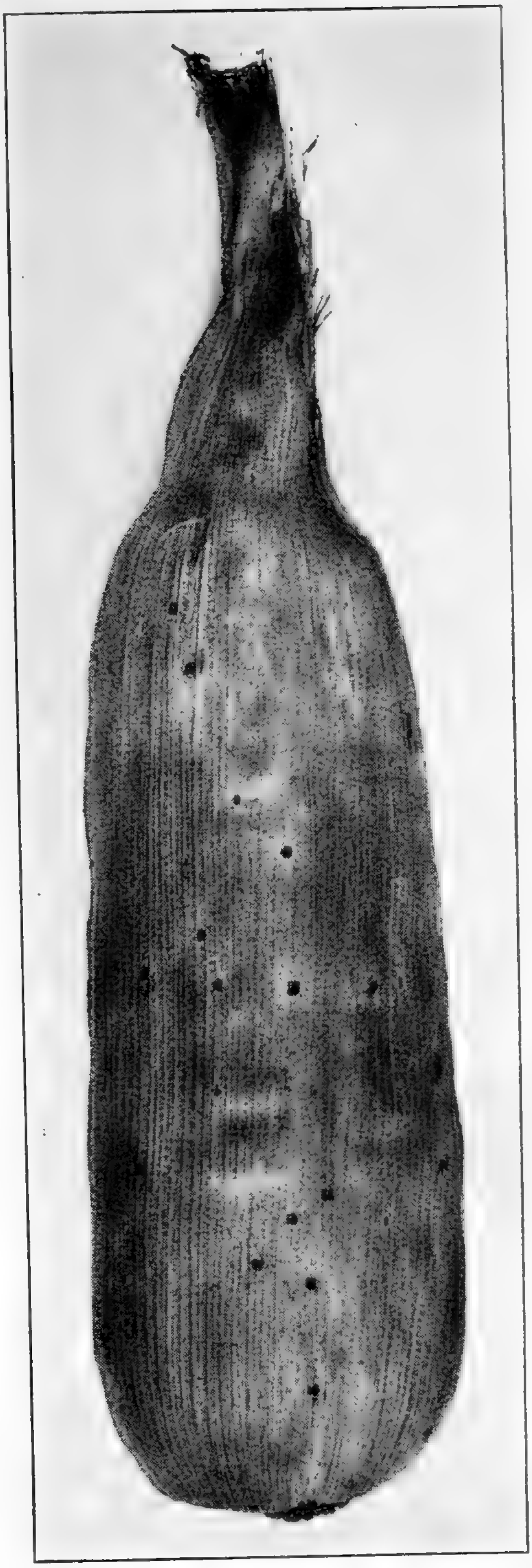


FIG. 7.—Slip-shuck corn showing holes eaten through the shuck by the rice or black weevil. These holes make passages through which all kinds of grain pests move back and forth to bring about a more speedy destruction of the kernels. (Back.)

This weevil is found in many countries and is extremely abundant in the Southern States, where it breeds in dried fruit, coffee berries, cornstalks, corn, and the seed and seed pods of an almost endless variety of plants. It is a strong flier and is frequently to be seen in the cornfields of the South on the exposed and damaged ears. It lays its eggs in the soft kernels of corn and breeding continues after the corn has been harvested and placed in storage. It does not cause much damage to corn in storage, as the corn becomes too hard to be attractive. It may, however, be very abundant locally in corn in Florida during the first three months of storage, and has been reported as com-seeds in Honolulu. Taking the country at large, the coffee-bean weevil is a very minor grain pest. Figure 10, *a* and *b*, shows the rather characteristic holes cut in the kernels of corn and in corn shucks by the larvæ and emerging adults.

[4] *Araecerus fasciculatus* DeG.

GRAIN BORERS.

Two species of grain borers are now established in the southern States. The *lesser grain borer* bids fair to become a very serious

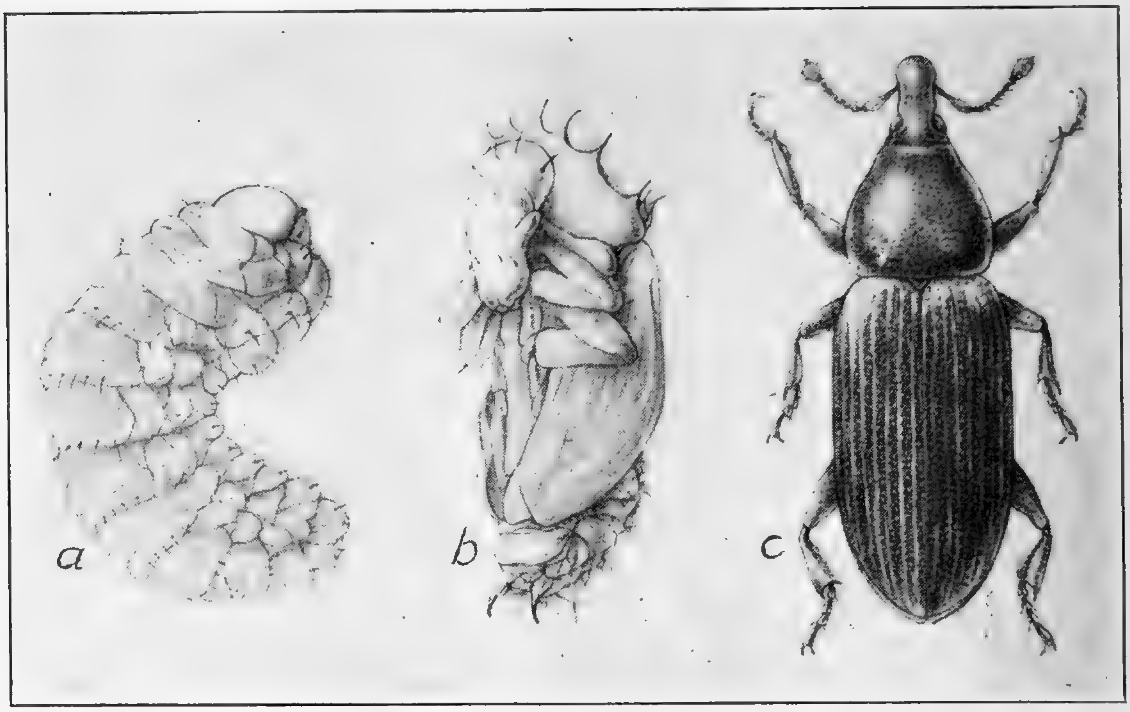


FIG. 8.—The broad-nosed grain weevil: *a*, Full-grown larva; *b*, pupa; *c*, adult weevil. This weevil is not found in northern-grown grains. It is now present in the southeastern Gulf States. The adult weevil is slightly less than one-eighth of an inch long. It is distinguished from the rice and granary weevils by its much shorter beak.

pest of grain throughout the South. The *larger grain borer* has not yet become a factor in commercial shipments of grain.

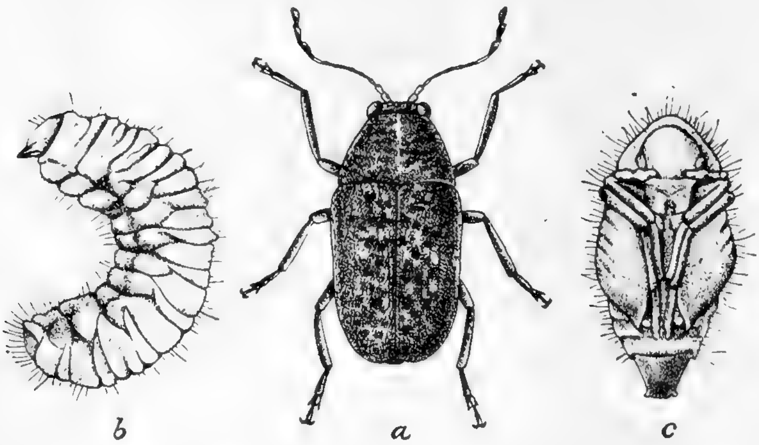


FIG. 9.—The coffee-bean weevil: *a*, Adult; *b*, well-grown larva; *c*, pupa. The adult is about three-sixteenths of an inch long, of a dark brown color covered with a light and dark brown hairiness. (Chittenden.)

LESSER GRAIN BORER.[5]

The lesser grain borer, known to many grain dealers more popularly as the "Australian wheat weevil," because of the large supplies of wheat infested by it that reached this country from Australia during the war, is one of the smallest beetles injurious to grain in this country. It appears to be steadily spreading throughout the South, and infested grain

[5] *Rhizopertha dominica* Fab.

has been found in Texas, Kansas, Oklahoma, Louisiana, Florida, and California, besides at many points of entry. It is readily distinguished from other grain pests by its slender cylindrical form and small size. It is a polished dark brown or black in color, with a

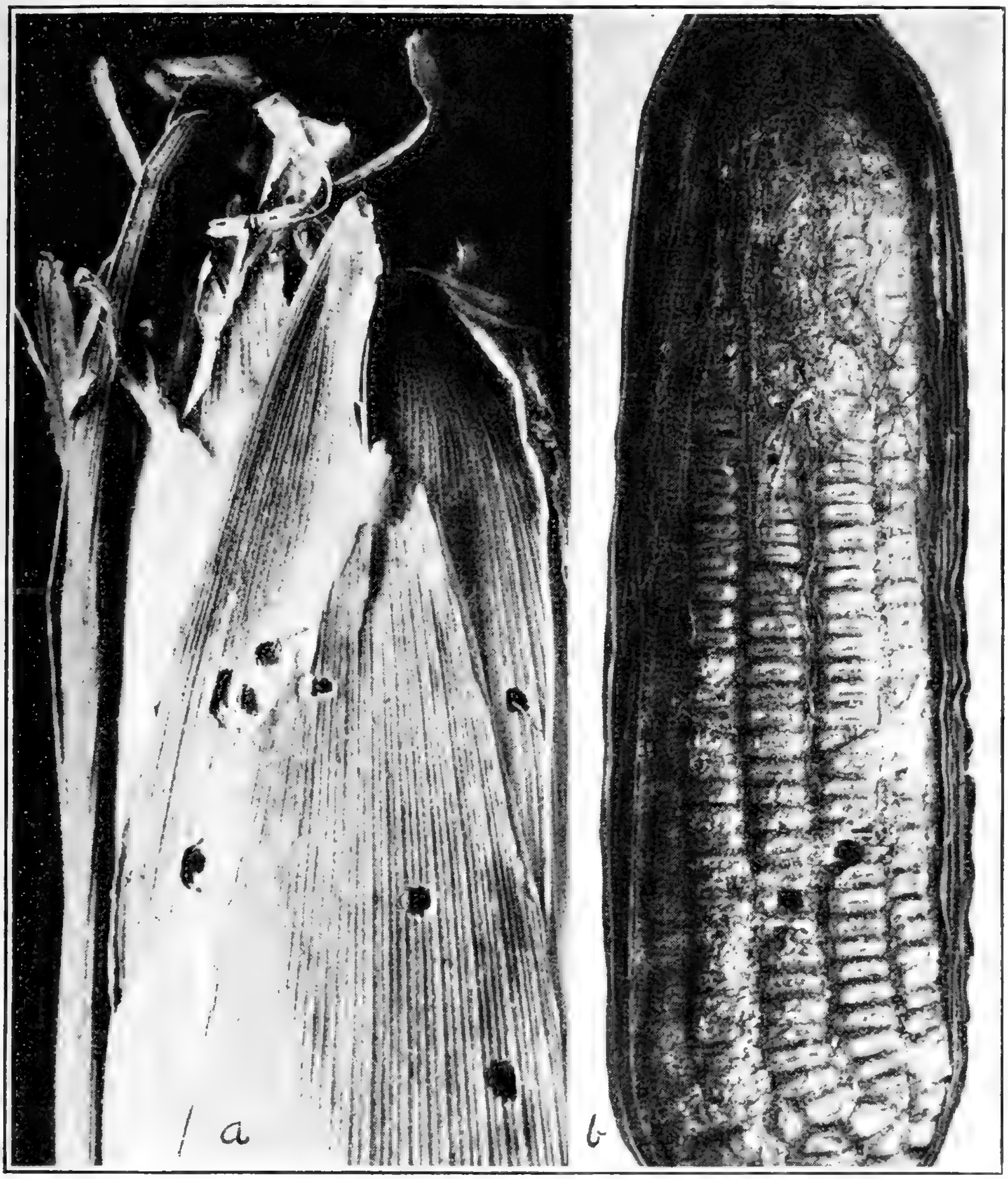


FIG. 10.—Work of the coffee-bean weevil: *a*, Holes made in corn shucks by the adult weevils eating their way out from the kernels beneath; *b*, two kernels in which larvæ of this insect have developed. Note that a single larva devours a large portion of a single kernel, which is not true of the rice weevil.

somewhat roughened surface, about one-eighth of an inch long and one thirty-second of an inch wide. Its head is large, prominent, and bent down under the thorax. The larva, pupa, and adult stages are illustrated in figure 11. It belongs to a family[6] of beetles that have

[6] Bostrychidae.

the head turned down under the thorax and are armed with powerful jaws with which they can cut directly into wood. Originally native

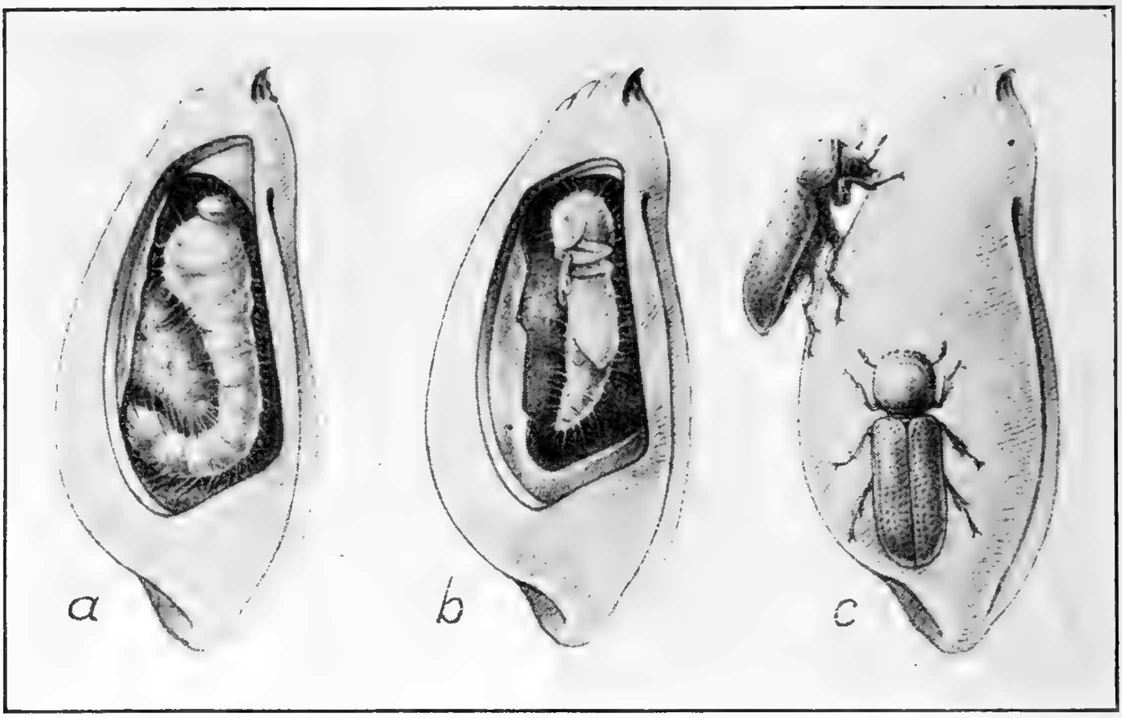


Fig. 11.—The lesser grain borer in wheat kernels: *a*, The well-grown larva; *b*, the pupa; *c*, two adult weevils. Adult borer is shiny roughened dark-brown or black, about one-eighth of an inch long.

to the tropics the lesser grain borer has spread through commerce to all parts of the world.

Both beetles and larvæ cause serious damage in warm climates, attacking a great variety of grains. The destruction of which they

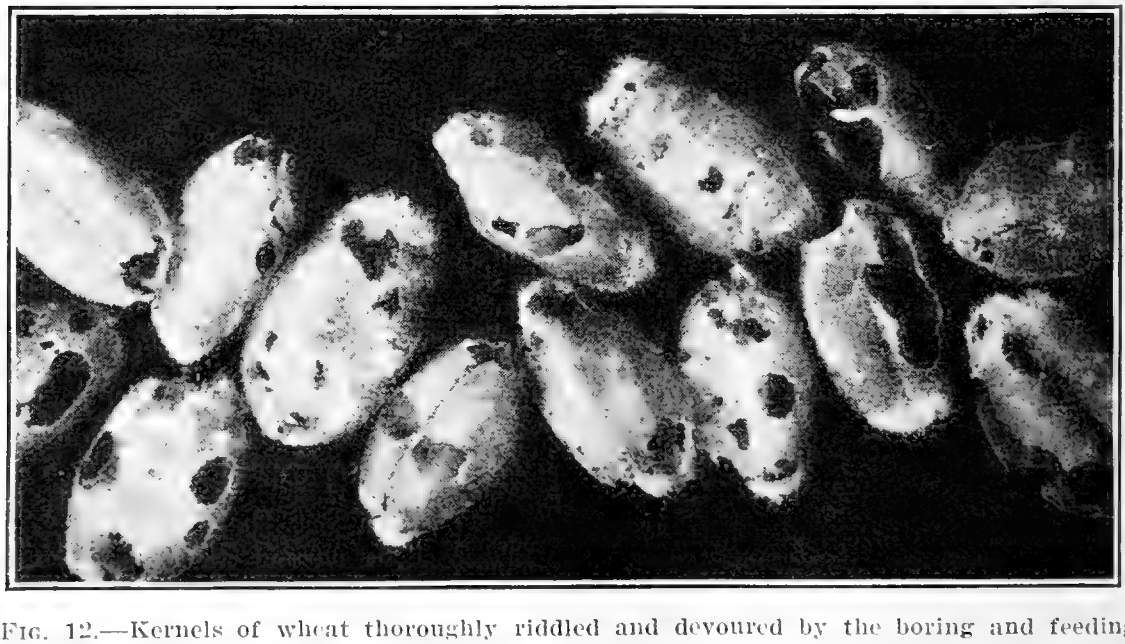


Fig. 12.—Kernels of wheat thoroughly riddled and devoured by the boring and feeding of the lesser grain borer and its larva. Such damaged kernels are always surrounded by much powder or flour-like material which the insects have chewed up and pushed out from the kernels.

are capable is shown by the wheat kernels of figure 12, which are literally riddled by the boring adults and their young. The females lay from 300 to 500 eggs each, dropping them singly or in clusters in the loose grain. The eggs hatch in a few days and the small whitish grubs crawl actively about the grain, feeding on the flour produced by the boring of the beetles, or boring directly into grains that have been slightly damaged. They complete their growth within the grain, transform to white pupæ, and in time change to adult beetles which cut their way out of the grain. The period from egg to adult in summer is said to be about a month.

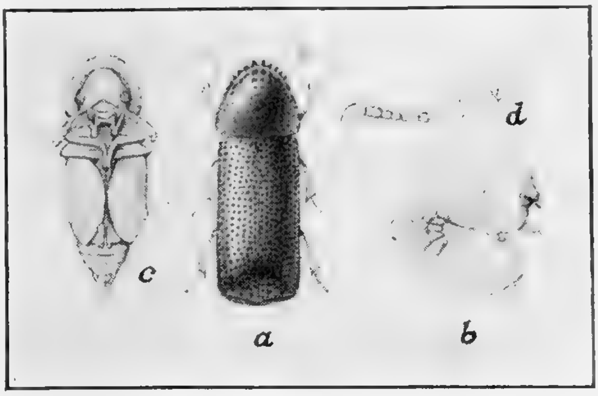


FIG. 13.—The larger grain borer: *a*, Adult insect; *b*, larva; *c*, pupa; *d*, antenna of adult. Adult borer is shiny polished dark brown, about one-sixth of an inch long. *a*, *b*, *c*, About six times natural size; *d*, highly magnified. (Chittenden.)

LARGER GRAIN BORER.[7]

The larger grain borer is a small, dark brown, elongate-cylindrical beetle about one-sixth of an inch long. As may be seen in figure 13, it is very similar in appearance to the lesser grain borer, but may be distinguished by its larger size and comparatively smooth, polished surface.

This beetle is a tropical insect not as yet widely distributed in this country. It is occasionally found infesting corn (fig. 14) in the Southern States. Its habits are similar to those of the lesser grain borer. It, also, has probably acquired its grain-feeding habits rather recently.

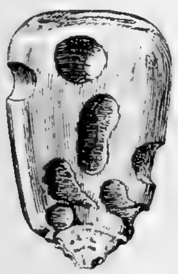


FIG. 14.—Kernel of corn showing work of adult of larger grain borer. The adult borers tunnel in all directions and reduce kernels to powder and shells. Enlarged. (Chittenden.)

GRAIN MOTHS.

The grain moths include only those moths capable of destroying sound, unbroken grain kernels. They are not so abundant as the flour moths, which are principally pests in broken, damaged kernels or milled products.

ANGOUMOIS GRAIN MOTH.[8]

The Angoumois grain moth is a small buff or yellowish brown moth with a wing expanse of about one-half inch. This is the moth most commonly found in infested grain in this country and is not likely to be confused with any other. It attacks all cereal grains, is found in all parts of the world, and is particularly injurious in the South, where it attacks grain both in the field and in storage.

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[7] *Dinoderus truncatus* Horn. [8] *Sitotroga cerealella* Oliv.

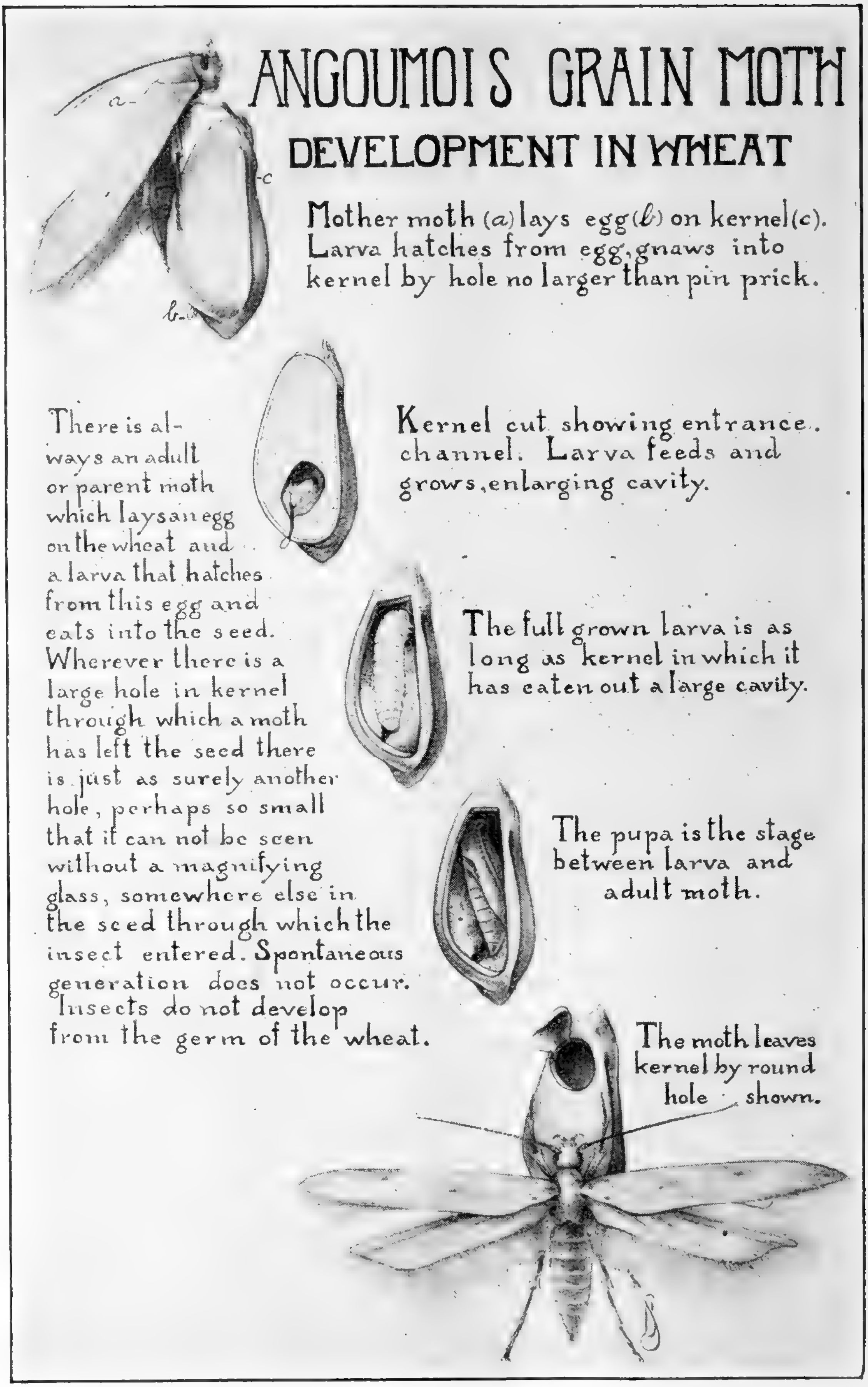

FIG. 15.—Life cycle of Angoumois grain moth on wheat. (Back.)

Each female moth may lay as many as 150 eggs, which are white when first laid but soon change to a reddish color. The eggs are laid on or near the grain. Upon hatching, the minute white larva or caterpillar bores into a kernel of grain and begins feeding on the contents. When full grown it eats out a channel to the outside of the seed but leaves a thin layer of the seed coat intact. It then changes to a reddish brown pupa, and later the adult or moth emerges, pushing aside the thin section of seed coat that covers the exit from the channel. The development from egg to adult may be completed in five weeks. Figures 15 and 16 show the successive stages in the development of

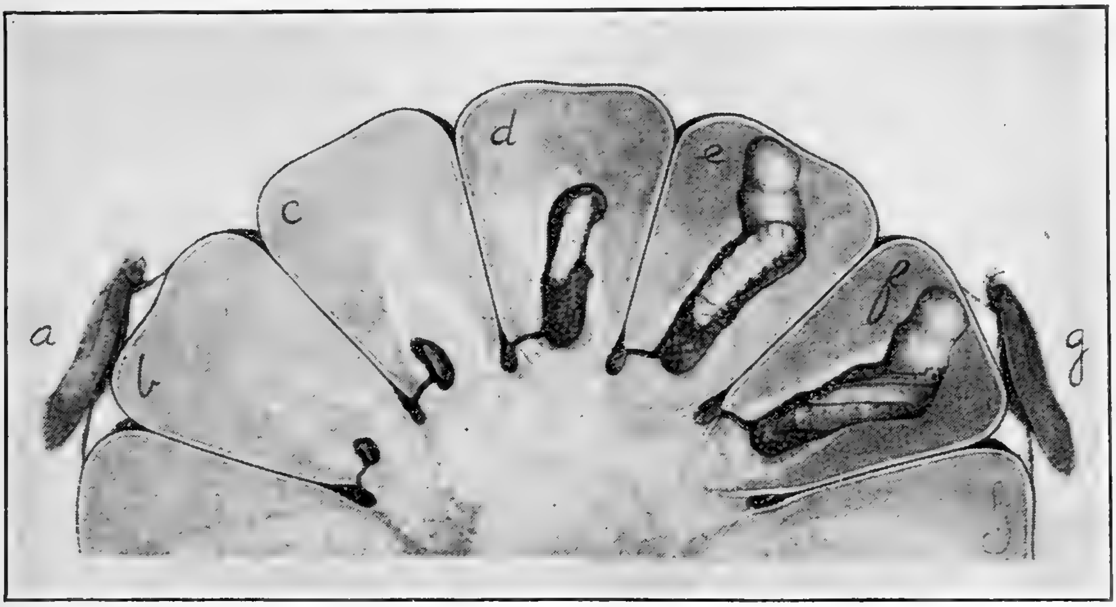

FIG. 16.—Cross section of ear of corn showing development of Angoumois grain moth in corn. The newly hatched larva crawls down to the germ end of the corn and begins feeding upon the soft germ. As it grows older and stronger it eats out into the firmer portion of the kernel and finally, in most instances, eats to the outer end. (Back.)

this insect in a kernel of wheat and of corn from the time the egg is laid until the adult appears. In figure 17 is shown an ear of corn with the external evidence of heavy attack, and in figure 18 are shown wheat kernels with the emergence holes of the moth. For a further discussion of this pest see Farmers' Bulletin 1156, "The Angoumois Grain Moth."

WOLF MOTH.[9]

The wolf moth is a small moth about the size of the Angoumois grain moth, creamy white and thickly mottled with brown. The mottled appearance distinguishes it from the Angoumois grain moth. It infests all kinds of grain, both in the field and in storage. The larva feeds on the grain and webs the kernels together.

[9] *Tinea granella* L.

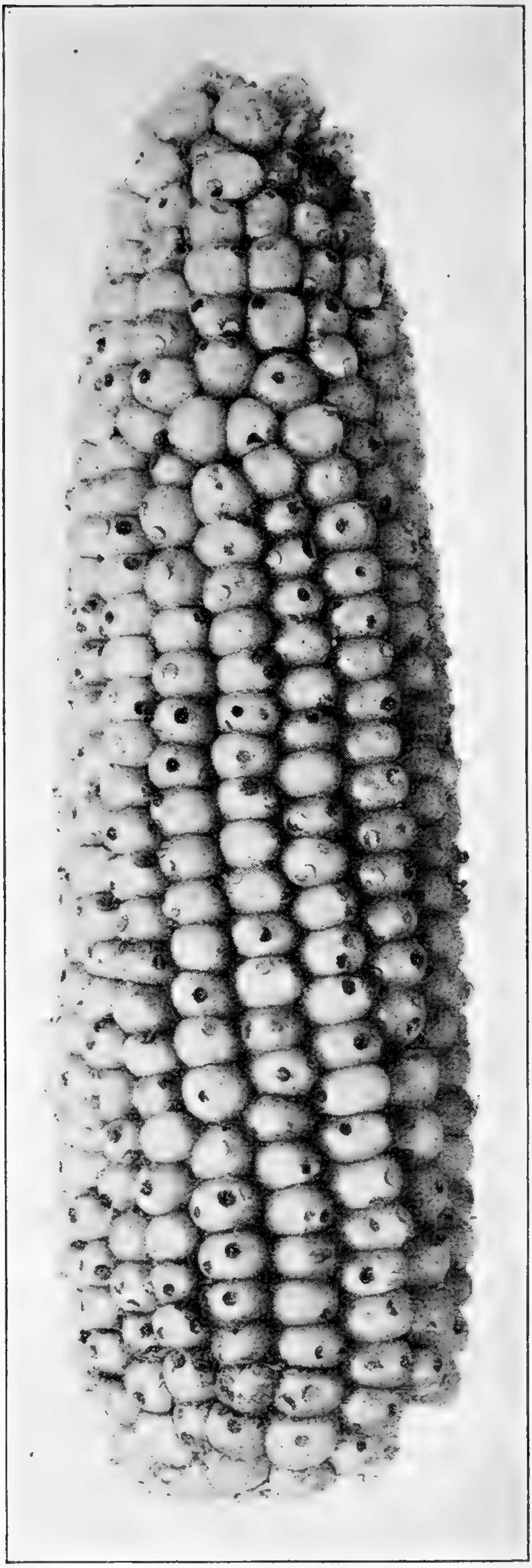

FIG. 17.—Ear of popcorn showing heavy infestation by the Angoumois grain moth. Note that certain of the kernels have three emergence holes, and that many have served as food for two moths. The development of a single insect in a kernel causes a loss of from 13 to 24 per cent in weight.

The wolf moth is distributed throughout the Northern States but is not very abundant and can not be compared with the Angoumois grain moth for destructiveness.

PINK CORNWORM.[10]

The pink cornworm is the larva or caterpillar of a small moth (fig. 19). It is about five-sixteenths of an inch long when full grown; pink in color, with head and thoracic shield pale brown. Figure 20 gives a good idea of its appearance. The moth which develops from this worm or larva is smaller than the Angoumois grain moth, with a wing expanse of slightly less than half an inch. The forewings are banded and mottled with yellow, reddish brown, and black, as shown by figure 19. The pale grayish hindwings are very slender and are edged with long fringes. The pupa is shown in figure 21.

This insect is common in the South, where it causes considerable injury to

[10] *Pyroderces rileyi* Wals.

corn, both in the field and in storage. Infestation begins in the field and is continued after the corn is placed in storage. The very characteristic injury is shown in figures 22 and 23. The large amount of frass that is loosely webbed together and fills the interstices between the kernels or is crowded into the cavities of kernels that have been eaten out is a reliable indication of the presence of this pest. The pearly white eggs are laid singly or occasionally in twos or threes. The pinkish larvæ feed on the seed, husk, and cob with equal relish. Though capable of serious injury to corn, in particular as it comes

FIG. 18.—Kernels of wheat showing the small round emergence holes that prove that the Angoumois grain moth has developed in the seed, thus reducing the weight somewhat over 50 per cent. (Back.)

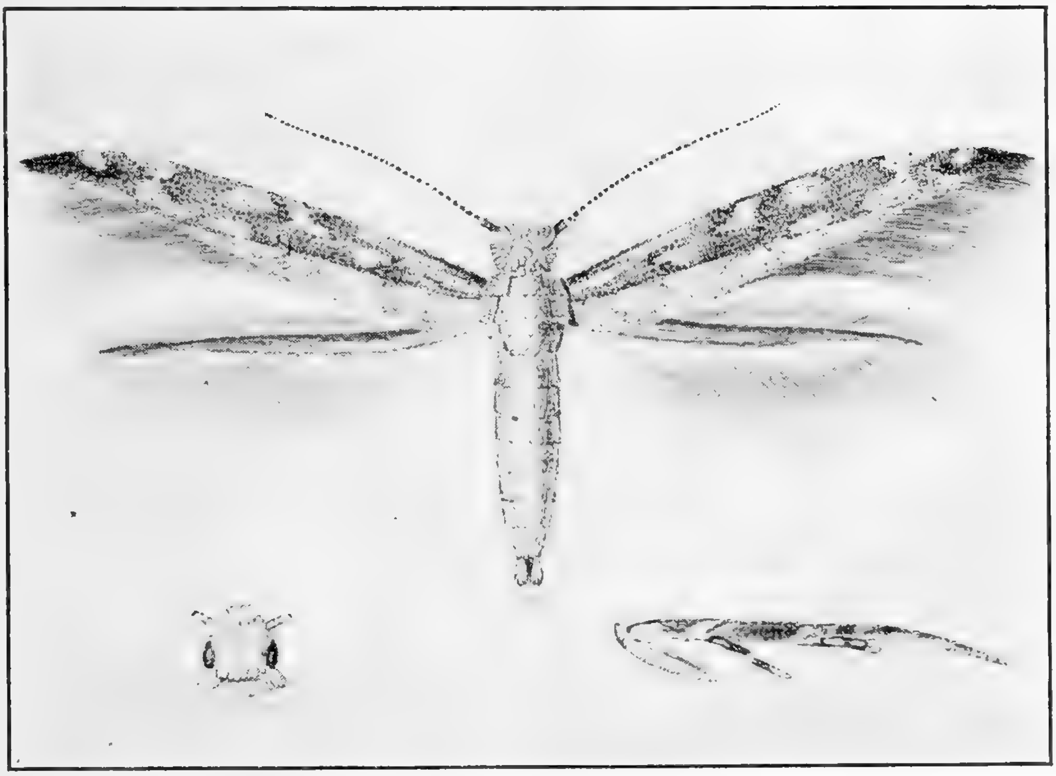

FIG. 19.—The pink cornworm: Moth, much enlarged; head and leg more enlarged. The moth has a wing spread of a little less than half an inch. (Chittenden.)

to maturity in the field, and while in the cribs on Southern farms, the pink cornworm is seldom a serious pest of commercial shipments.

RICE MOTH.[11]

The rice moth has a wing expanse of about half an inch and is of a pale grayish brown or tawny color. Its characteristic appearance is shown in figure 24. The larva (fig. 25) resembles somewhat that of the Indian meal moth, being when full grown about half an inch

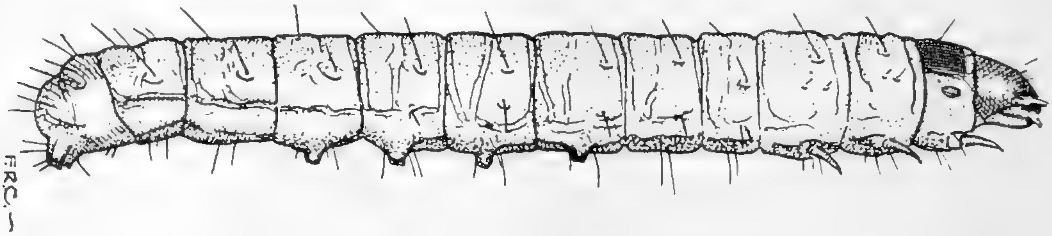

FIG. 20.—The pink cornworm: Full-grown larva, side view, greatly enlarged. When full grown the larva is pink and about five-sixteenths of an inch long. (Chittenden.)

long and varying in color from white to a dirty, slightly bluish gray with occasional tints of green. Damage by the pest, as in the case of all moth pests, is done by the larvæ, which feed upon rice, cocoa, chocolate, ships biscuits, etc. The larvæ produce a dense webbing as they become well grown. When feeding upon grains they spin dense silken tubes, webbing the grain kernels into the walls of the tubes. The pupa is shown in figure 26. The rice moth is seldom found in this country and has not become very widely disseminated.

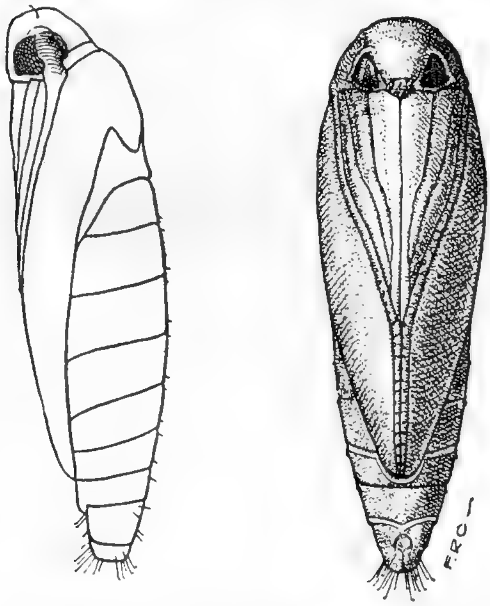

FIG. 21.—The pink cornworm: Pupa, ventral view at right, lateral view at left. Enlarged. (Chittenden.)

FLOUR MOTHS.

Among the flour moths are some of the commonest and most serious pests of grain products. They are designated as flour moths not because they feed entirely upon flour or milled products, but because they seldom attack sound grain kernels. They prefer broken grains, grains injured by major grain pests, and more especially cereal milled products such as flour, breakfast foods, meals, etc. All three of the flour moths are commonly found in grain warehouses, but the Indian meal moth and the meal snout moth are probably the most frequently reported. These two moths may, under specially favorable conditions, become established in whole grain and other seeds and cause injury especially by eating out the germ.

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[11] *Corcyra cephalonica* Staint.

INDIAN MEAL MOTH.[12]

The Indian meal moth is a rather handsome moth with a wing expanse of nearly three-fourths of an inch. It is easily distinguished from other grain pests by the peculiar marking of its forewings. These are reddish brown with a coppery luster on the outer two-thirds, but whitish-gray on the inner or body end. Moths and larvæ are shown in figure 27. The female moths lay from 300 to 400 eggs,

FIG. 22.—Ear of corn cut to show characteristic feeding and destruction by pink cornworm larvæ. Note that the larvæ eat from one kernel to another, often severing the kernels from the cob. The larvæ sometimes eat into the cob and there transform to the pupa stage. The pupæ are about one-third as long as the kernels shown.

singly or in groups, on food material. The eggs hatch within a few days into small whitish larvæ or caterpillars. These larvæ feed upon grains, grain products, dried fruits, nuts, and a rather wide variety of foodstuffs. When full grown, the larvæ are about half an inch long, dirty white in color, varying sometimes to greenish and pinkish hues. A full-grown larva is shown in figure 28, clinging to a kernel

[12] *Plodia interpunctella* Hbn.

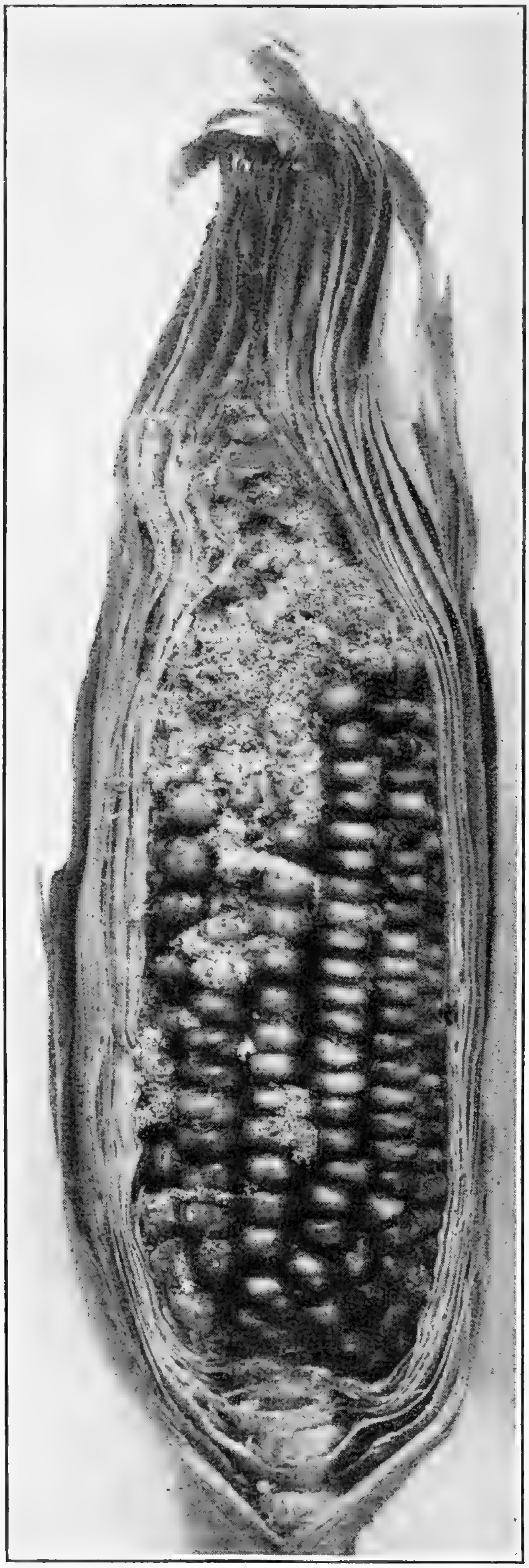

FIG. 28.—Ear of corn with portion of shuck removed to show surface feeding by larvæ of the pink cornworm. Often many kernels drop from the ear when the shucks are removed because of the feeding of the pink cornworm larvæ.

of wheat. This larva spins a silken cocoon and transforms to a light-brown pupa from which the parent moth later emerges. The Indian meal moth may pass through its egg, larva, and pupa stages in about four weeks—during warm weather.

The larva of the Indian meal moth spins a web as it becomes full-grown, and leaves behind a silken thread wherever it crawls. When sacks of cracked corn, meal, or corn in the ear that has been previously injured by other pests become heavily infested, this webbing often is sufficiently abundant to attract attention. The loosely clinging web shown on the ear of corn in figure 29 is characteristic of this pest.

MEDITERRANEAN FLOUR MOTH.[13]

The Mediterranean flour moth has a wing spread of slightly less than one inch. Its hindwings are a dirty white, but its forewings, which alone show when the moth is not flying, are a pale leaden gray with transverse wavy black markings. (See fig. 30.)

[13] *Ephestia kuehniella* Zell.

The Mediterranean flour moth is a native of Europe. Its first discovery in the United States was in California in 1892. Since then it has spread to practically all the States of the Union and is recognized as the most serious pest of flour mills, owing to the silken threads

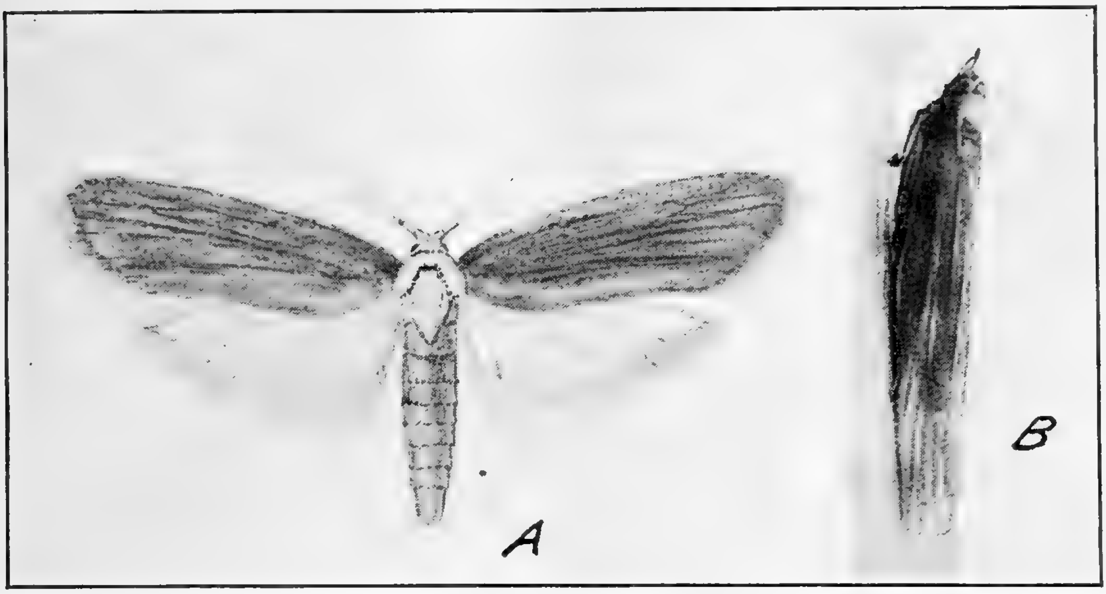

FIG. 24.—The rice moth: *a*, Mature moth, dorsal view, with wings spread; *b*, side view of same moth with wings folded about body. The moth is of a grayish brown or tawny color, with a wing spread of about half an inch. Much enlarged. (Chittenden.)

which the larvæ spin wherever they crawl. These webs mat the flour or meal together and eventually clog machinery so that mills have to shut down for a thorough cleaning and treatment. Although preferring flour and meal, the Mediterranean flour moth attacks grain, bran, and cereal products and is commonly found in storehouses and granaries.

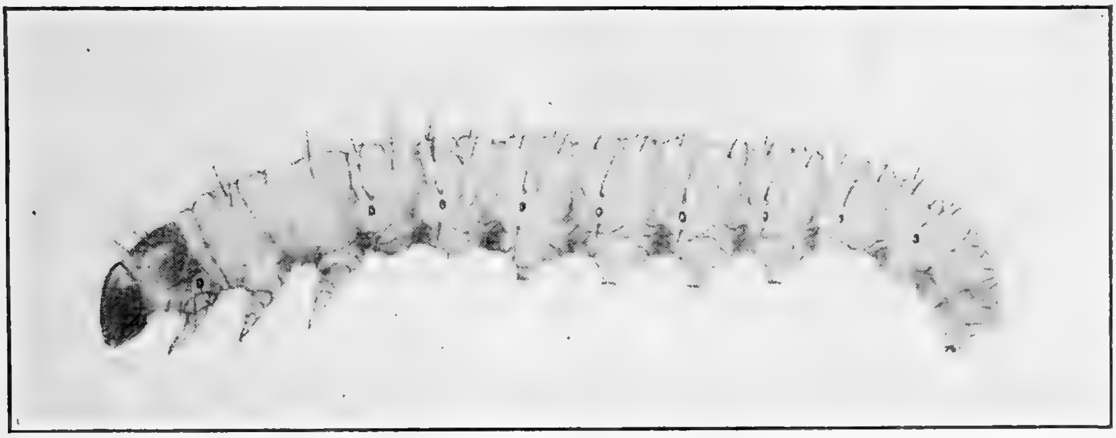

FIG. 25.—Full-grown larva of the rice moth. The full-grown larva is about one-half inch long, and is of a whitish or bluish gray color. Much enlarged. (Chittenden.)

The female moth lays small white eggs in accumulations of flour, meal, or waste grain. From the eggs the small larvæ hatch in a few days. When full grown, these are about half an inch long and are of a whitish or pinkish color with a few small black spots on the body.

The full-grown larva spins a silken cocoon in which the insect transforms to a reddish-brown pupa. Later the parent moth emerges from the pupa. During warm weather, the Mediterranean flour moth requires about nine weeks to pass through its egg, larva, and pupa stages. A more complete discussion of this pest will be found in Bulletin 872 of the United States Department of Agriculture, "Insect Control in Flour Mills."

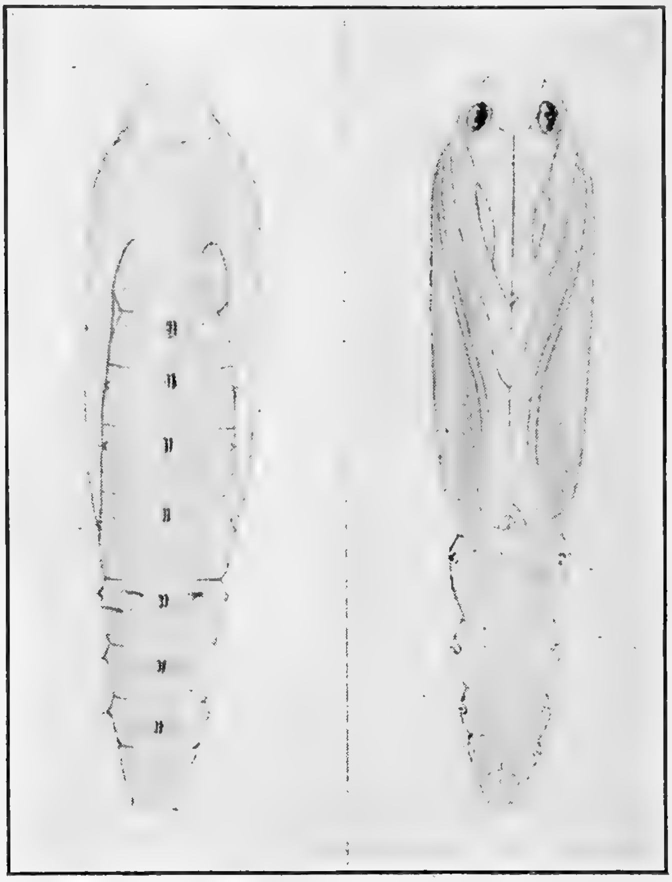

FIG. 26.—Pupa of the rice moth: At left, dorsal view; at right, ventral view. The pupa is found in a dense tough cocoon into the walls of which have been spun particles of the food. The cocoons of the Indian meal moth, on the other hand, are very loosely constructed. Much enlarged. (Chittenden.)

MEAL SNOUT MOTH.[14]

The meal snout moth is brownish in color, somewhat larger than the Indian meal moth, though varying in size, usually having a wing spread of about one inch. Its forewings are marked in a characteristic pattern indicated in figures 31 and 32; they are light brown with dark brown patches at base and tip and each with two wavy transverse white lines. The meal snout moth is widely distributed and a general feeder in the larva stage upon cereals of all kinds both ground and in the berry. It sometimes attracts much attention because of its capacity to web up and bind together seeds of various kinds. The larvæ are whitish and attain a length when full grown of about one inch. The two larger larvæ of figure 31 indicate the normal shape and show the contrast between the black of the head and the first body segment and the white of the remainder of the body. Often the body of the larva is tinged with orange toward each end. The larvæ spin peculiar tubes of silk and particles of the food material. They rest in these tubes, which are very tough, and feed from the openings at the ends. When full grown the larvæ leave the tubes, spin silken cocoons, often covered with food particles, and transform to the pupæ from which later emerge the adult moths.

[14] *Pyralis farinalis* L.

The meal snout moth may require only eight weeks to pass through the egg, larva, and pupa stages.

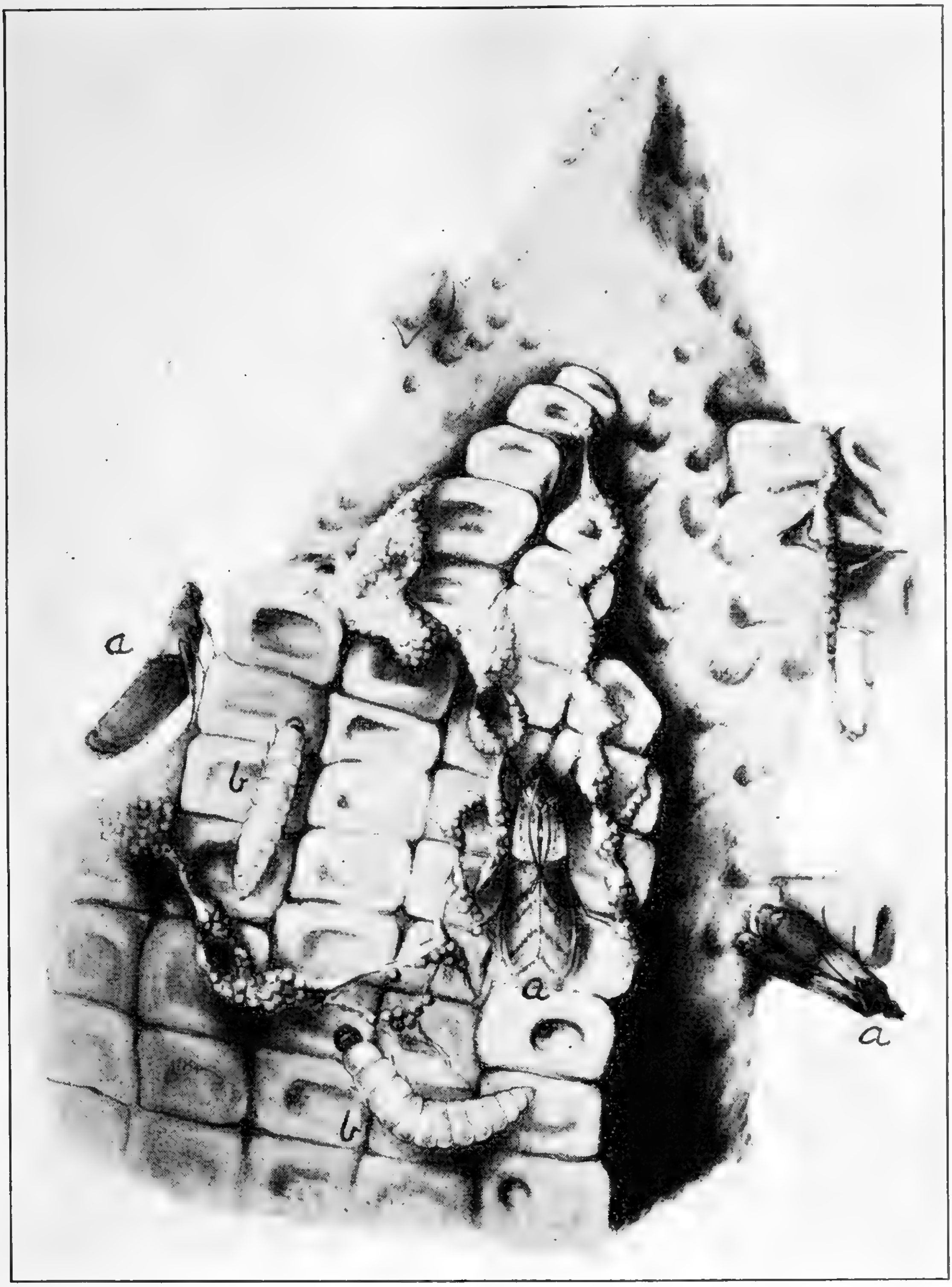

FIG. 27.—The Indian meal moth: Tip of ear of corn showing, *a*, three moths with their characteristic light and dark markings, and *b*, two well-grown larvæ. The adult moth is distinguished from all other grain-infesting moths by having the outer two-thirds of its wings brownish and the inner third whitish gray. It has a wing spread of about three-fourths of an inch.

The meal snout moth is primarily a pest of seeds that are held for some time in cool and damp localities. Outbreaks that have come to the attention of the authors have always been centered in grain that was harvested during rainy weather or so stored that the moisture content was unusually high. Attempts to rear the moth in dry, warm laboratories have failed. The larvæ cut through burlap sacking and can damage sacks greatly when heavy infestations develop in sacked material. Figure 33 shows the characteristic webbing together of infested seeds—in this instance navy beans—and figure 32 shows the tendency for larvæ to spin their whitish silken cocoons on the outside of grain sacks where the sacks touch each other.

FIG. 28.—Well-grown larva of the Indian meal moth, crawling on kernel of wheat. These worms are white or greenish in color and frequently eat out the germ end of wheat. They attain a length of about half an inch.

MEALWORMS.

There are two species of mealworms in the United States. The adults are the largest of the beetles found in grain and their larvæ are conspicuous, for they attain a length of about one inch and are as large around as an earthworm.

YELLOW MEALWORM.[15]

The adult of the yellow mealworm is a polished dark-brown or black beetle, somewhat more than half an inch long, with its thorax finely punctured and with its wing covers longitudinally striated or grooved. (See fig. 34, at right.) The females lay bean-shaped white eggs covered with a sticky secretion that causes the flour, meal, or grain waste in which they are placed to adhere to them. The eggs hatch in about two weeks into slender white larvæ, which soon turn yellow and assume the form shown in figure 34. When full grown, the larvæ are about an inch long and yellowish, shading to yellowish-brown toward each end and at the articulation of each segment. The pupa into which the larva transforms before becoming an adult beetle is shown in figure 34.

The yellow mealworm is widespread over the world and is frequently found in stored grains. It belongs to a family of beetles[16] known as the darkling beetles because of their preference for dark places. The adults fly only at night. During daylight they conceal themselves, with the larvæ, beneath sacks of grain, under grain boxes,

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[15] *Tenebrio molitor* L. [16] Tenebrionidae.

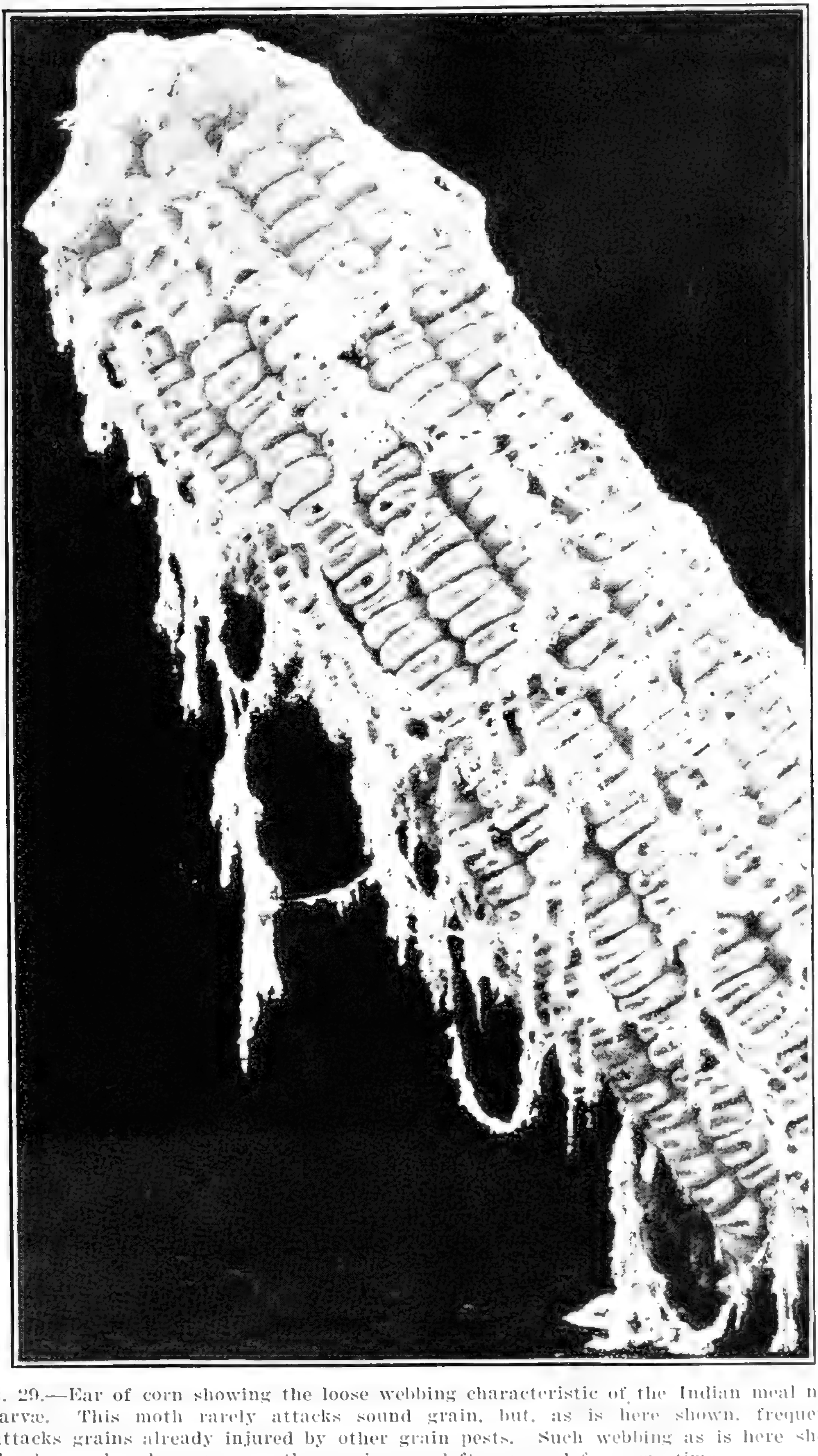

FIG. 29.—Ear of corn showing the loose webbing characteristic of the Indian meal moth larvæ. This moth rarely attacks sound grain, but, as is here shown, frequently attacks grains already injured by other grain pests. Such webbing as is here shown develops only when corn or other grains are left unmoved for some time.

or beneath grain and other food. There is but one generation each year. The adults begin to appear in the latitude of Washington during May and by June have laid most of their eggs and have died.

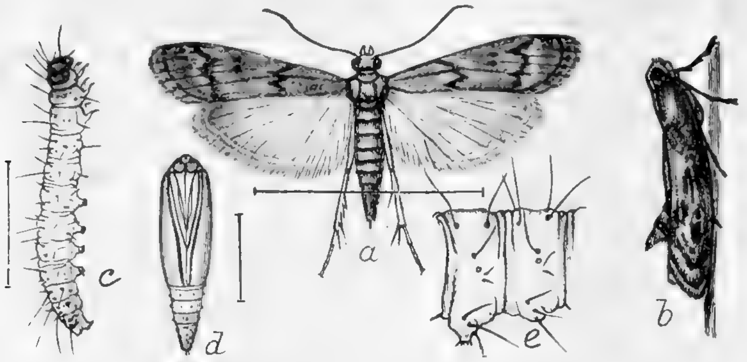

FIG. 30.—The Mediterranean flour moth: *a*, Moth; *b*, same from side, resting; *c*, larva; *d*, pupa (enlarged); *e*, abdominal joint of larva (more enlarged). The adult moth, with a wing expanse of a trifle less than one inch, is leaden gray in color, marked with transverse wavy black markings. The full-grown larva is whitish or pinkish in color, with small black spots, and is about one-half an inch long. (Chittenden.)

Farther north the adults appear during June. The larvæ become full grown in about three months, but instead of transforming then to the adult stage they continue feeding and molting until cold weather and then hibernate as larvæ. The following spring they transform to the pupa stage, in which the insect passes about two weeks. Because the yellow mealworm has but one generation each year, and is entirely an external feeder upon grains, it need not be feared as a serious pest. Screening and fanning

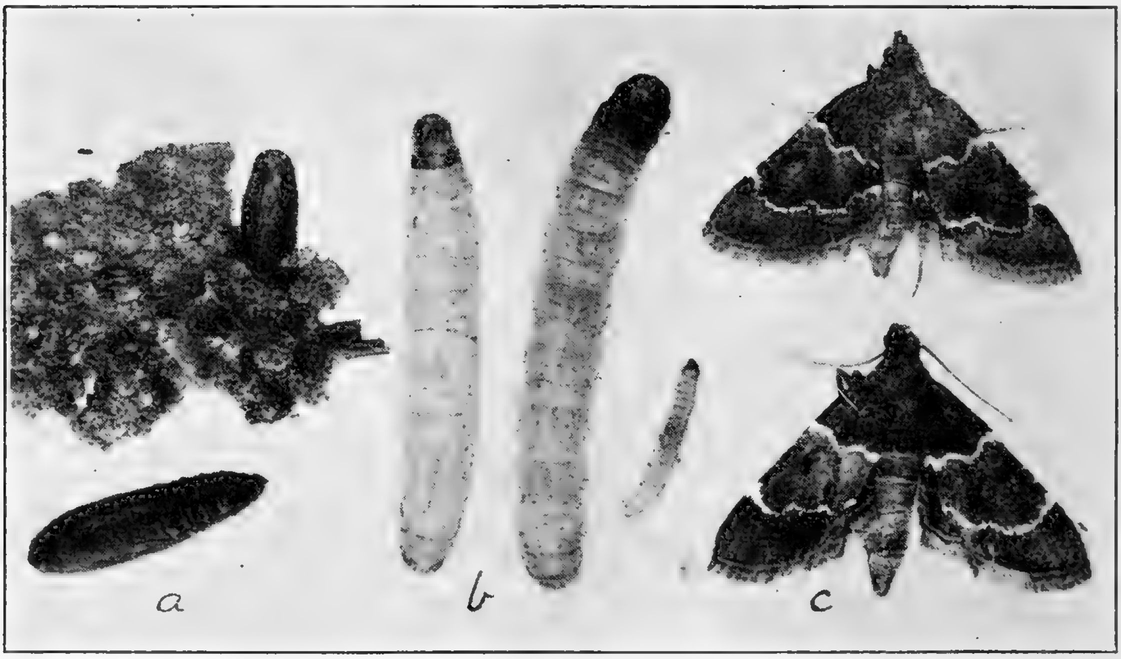

FIG. 31.—The meal snout moth: *a*, Pupa and, above, webbed mass of grain showing portion of pupa protruding; *b*, two well-grown larvæ with a smaller larva at right; *c*, two adult moths. Magnified about one and one-half times. The markings on the forewings easily distinguish this insect from other grain pests.

will remove it easily from grain shipments. The well-grown larvæ, however, can do serious injury to whole grains under certain conditions when grain is held for long periods without being moved.

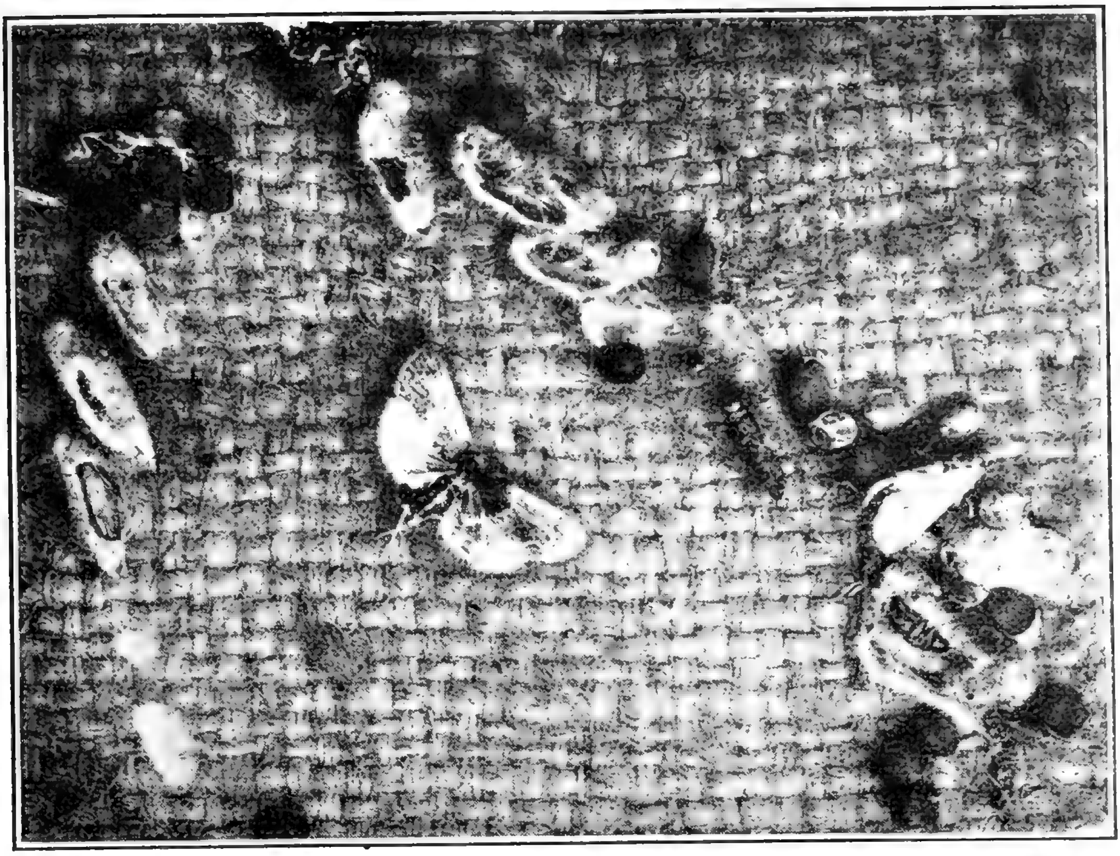

FIG. 32.—Inside of a grain sack that was filled with infested vetch seed. Note vetch seeds sticking to side of bag as a result of the webs of the larvæ of the meal snout moth, the numerous whitish cocoons with dark pupæ within, and, in the center, one adult moth. Natural size.

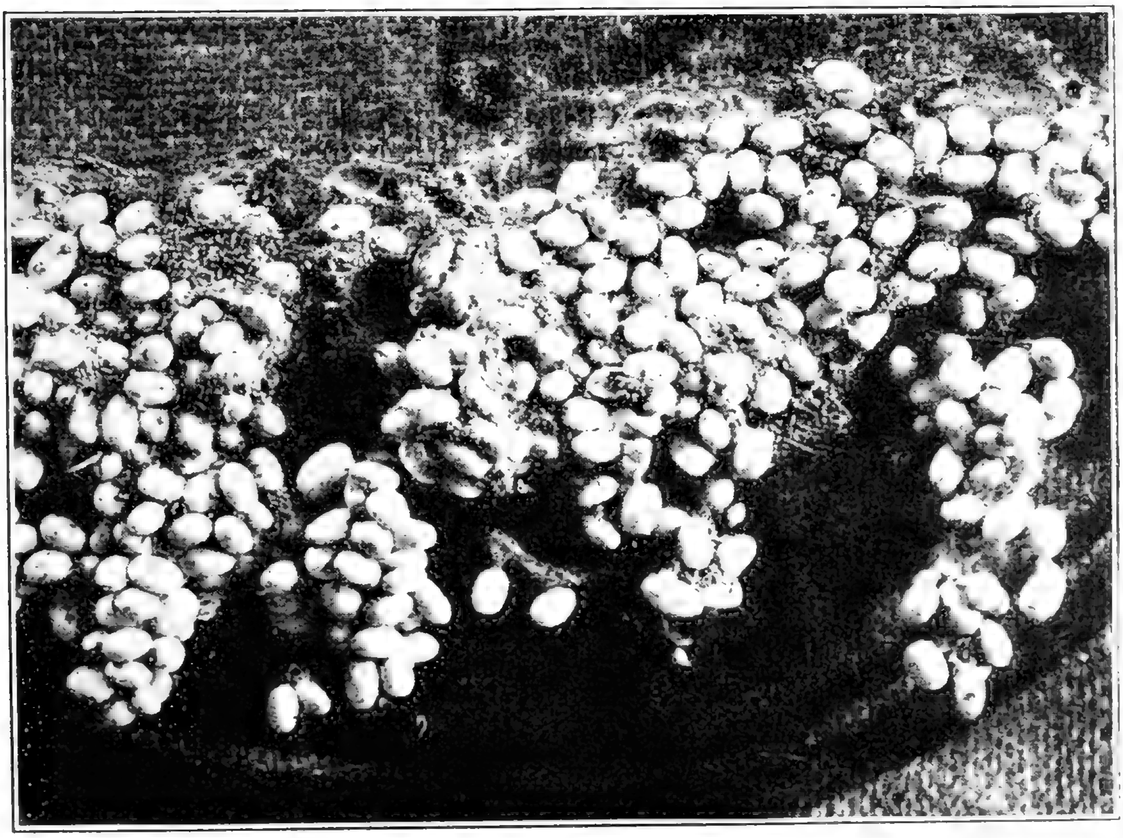

FIG. 33.—Navy beans webbed together by larvæ of the meal snout moth, and adhering to sack. The larvæ often cut sacks so seeds fall out and lodge where sacks touch each other. In these places the seeds are usually more heavily infested.

DARK MEALWORM.[17]

The dark mealworm, as may be seen by the larva, pupa, and adult shown in figure 35, is very similar in form, size, and color to the yellow mealworm, to which it is closely related. The adult beetle differs, however, in being dull pitchy black, in contrast to the shiny or polished dark brown or black of the yellow mealworm. Its larva so closely resembles the larva of the yellow mealworm that it can be distinguished most easily by its much darker color. The two

FIG. 34.—The yellow mealworm. Four well-grown larvæ, two pupæ, and the black adult beetle, with five kernels of wheat to indicate relative size. The larvæ when full grown are about one inch long and yellowish. The adult beetles are shiny black and slightly more than half an inch long.

species of mealworm are often found associated, and what has been said of the stages of the yellow mealworm applies equally well to the dark mealworm.

GRAIN AND FLOUR BEETLES.

CADELLE.[18]

The cadelle is an elongate, oblong, flattened, black or blackish beetle about one-third of an inch long. It resembles the mealworms

[17] *Tenebrio obscurus* Fab.

[18] *Tenebroides mauritanicus* L.

in appearance, but is much smaller and the thorax and abdomen are loosely joined. (See fig. 36.)

The larva of the cadelle is one of the largest of the grain-infesting insects and is easily recognized. It is about three-quarters of an inch long, fleshy, with the abdomen terminating in two dark horny points. The larva is a dirty or chalk white, with head, thoracic shield, and the two horny points at end of body black, as shown in figure 37.

This insect is widespread over the world and is frequently found in mills, granaries, and storehouses, where it infests flour, meal, grain, etc. Both larva and adult feed on grain and have the destructive habit of going from kernel to kernel and devouring the embryo.

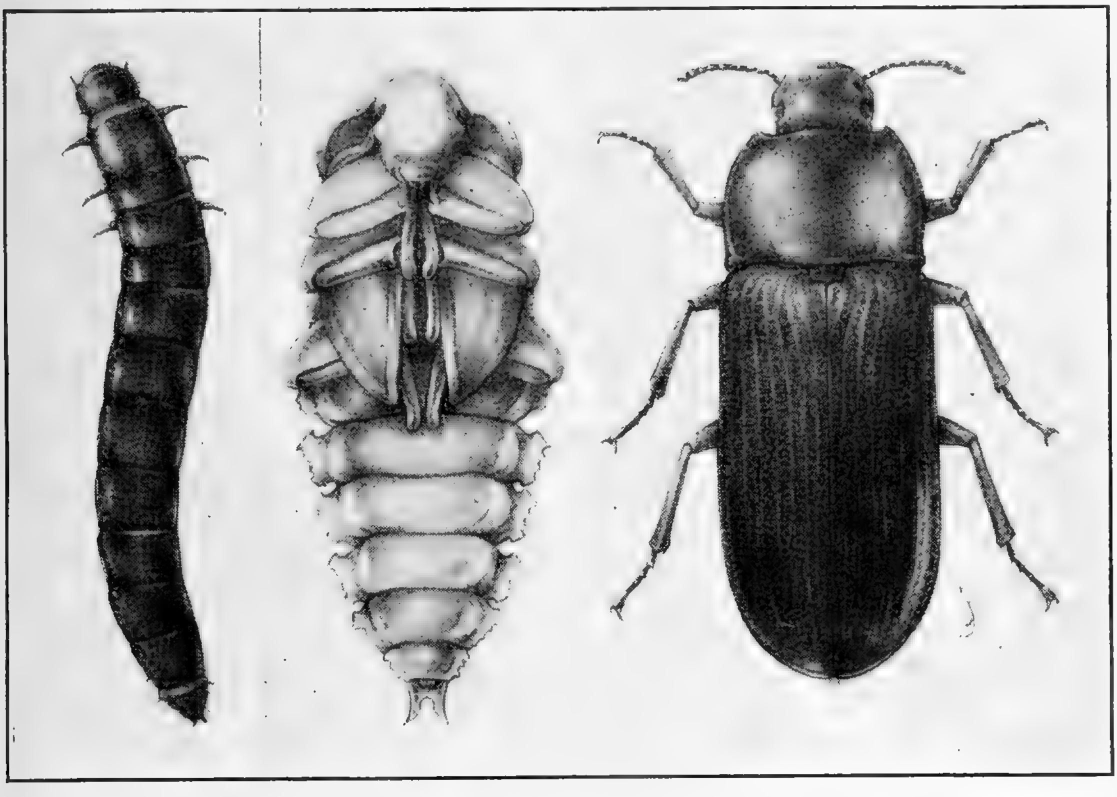

FIG. 35.—The dark mealworm: *a*, Full-grown larva; *b*, pupa; *c*, adult beetle. Distinguished from the yellow mealworm by the dark brown color of the larva and the dull, not shiny appearance of the adult beetle. For true relative size of the larva, pupa, and adult compare with figure 34.

The cadelle often becomes well established in ear corn (fig. 38) that has first been injured by the Angoumois grain moth or by the weevils. The long slits in corn kernels shown in figure 38 are characteristic of cadelle infestation. Were it not for the fact that there is not more than one generation of this insect each year the cadelle would be one of the most serious enemies of stored grain. As it is it is probably the longest lived of the insects that attack stored grain, and frequently causes severe losses.

The white eggs are laid in clusters in the food material selected and hatch in about 10 days. When the larvæ become fully grown they seek some secluded place in which to transform to the pupa (fig. 39), frequently boring into the timbers of the bin or other re-

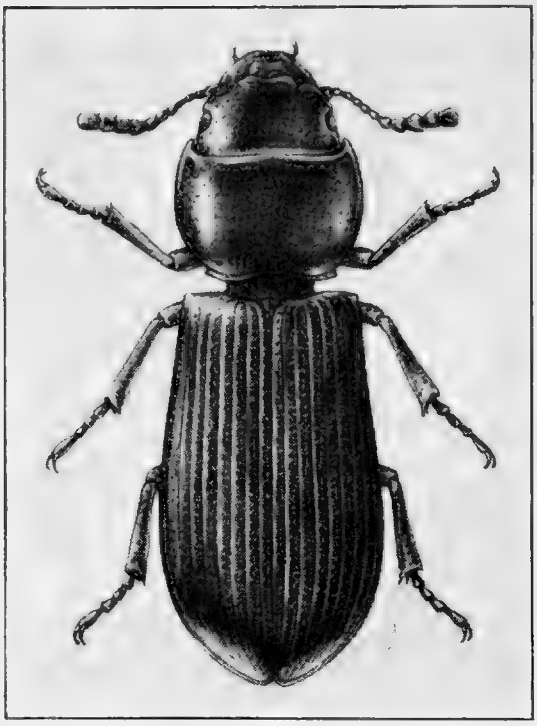

FIG. 36.—The cadelle: Adult beetle. The cadelle is a flattened, black beetle about one-third of an inch long.

ceptacle that holds the infested material. Both larvæ and beetles feed to some extent on other grain-infesting insects, hence are partly predacious.

SAW-TOOTHED GRAIN BEETLE.[19]

The saw-toothed grain beetle gains its name from the peculiar structure of the thorax, which bears six sawtoothlike projections on each side (fig. 40). This character is a ready means of distinguishing this beetle from others that infest stored grain. It is about one-tenth of an inch long, slender, much flattened, and dark chocolate brown in color. A cosmopolitan beetle, extremely abundant at times, it is nearly omnivorous, infesting grains, flours, meals, dried fruits, seeds, etc. Both beetle and larva are very active.

The small slender eggs hatch in a few days. The emerging larvæ do not spend their lives within a single grain but crawl about actively, feeding here and there. When full grown (fig. 40), they are whitish, with dark markings, somewhat flattened in form, and have three pairs of legs and an abdominal proleg. When ready to pupate they construct delicate cocoon-like coverings by joining together small grains or fragments of foodstuffs with a sticky secretion and within this the pupa (fig. 40) and later the adult form are assumed. Development from egg to adult may take place in 24 days in summer.

FIG. 37.—The cadelle: Larva. Commonly found crawling among grain kernels. It may appear glistening white or dull and powdered according to the material in which it is crawling. When full grown it is about three-fourths of an inch long.

SQUARE-NECKED GRAIN BEETLE.[20]

The square-necked grain beetle is closely related to the saw-toothed grain beetle, which it greatly resembles in form, size, and color. It is a flattened, oblong, polished, reddish brown beetle about one-tenth of an inch long. It differs from the saw-toothed grain beetle

[19] *Oryzaephilus surinamensis* L.

[20] *Silvanus gemellatus* Duv.

by having the thorax almost square in shape and lacking the sawtoothlike projections. (Fig. 41.)

This beetle is chiefly abundant in the South, where it is found in great numbers outdoors infesting the seed pods of a great variety of plants. It is one of the most common beetles in stored corn in the South and in the cornfields is always to be found on damaged or exposed ears. The immature stages closely resemble those of the preceding species both in form and in habit. The larvæ have the bad habit of devouring the germ of the seed in which they breed. They can develop from egg to adult in about three weeks.

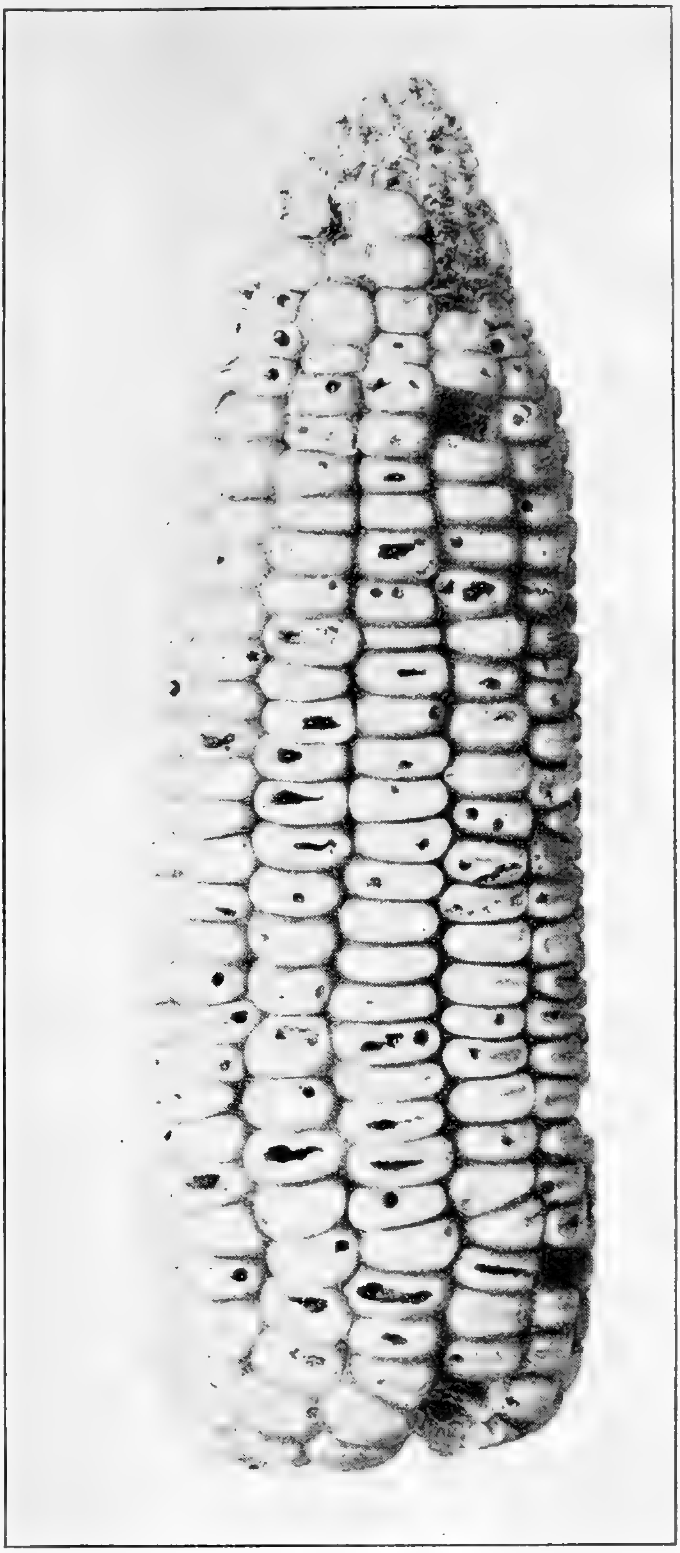

FIG. 38.—Ear of corn infested by the Angoumois grain moth (round holes in kernels) and the cadelle. The elongated slits in the kernels are characteristic of cadelle feeding and emergence. Only ear corn stored for several years will develop this evidence of cadelle attack.

FOREIGN GRAIN BEETLE.[21]

The foreign grain beetle is a small reddish brown beetle somewhat similar in appearance to the preceding species, to which it is closely related. It differs from it by being smaller and more robust. (Fig. 42.) Although of world-wide distribution, it is of little consequence as an enemy of stored grains. It is attracted to damp and moldy grains and feeds on the molds developing in such grains. It is rarely found in clean grain.

[21] *Cathartus advena* Waltl.

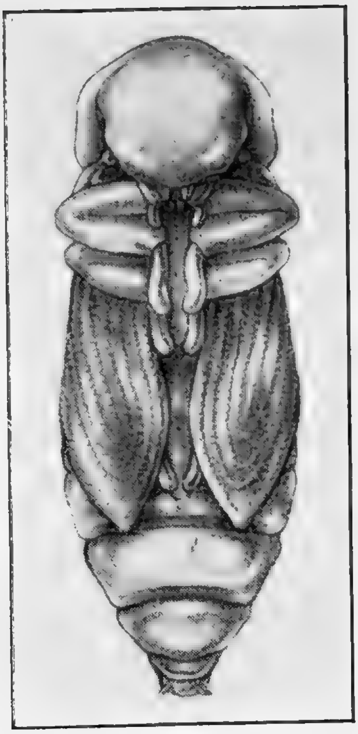

FIG. 39.—The cadelle: Pupa, much enlarged. The pupa is seldom seen as this stage of the cadelle's life cycle is spent in a cell made in an inaccessible place.

MEXICAN GRAIN BEETLE.[22]

The Mexican grain beetle is a highly polished, deep brown beetle about three-sixteenths of an inch long. While resembling somewhat the confused flour beetle in general appearance, it can be readily distinguished by its more polished surface and by its longer antennæ. (Fig. 43.)

This insect is common in Mexico, where it breeds in grain and grain products. It was found in this country in grain exhibits at the World's Columbian Exposition, but is not known to be permanently established in this country as yet. It may be found in grain in the extreme South.

SIAMESE GRAIN BEETLE.[23]

The Siamese grain beetle is an elongate, flattened, reddish-brown beetle slightly less than an eighth of an inch long characterized

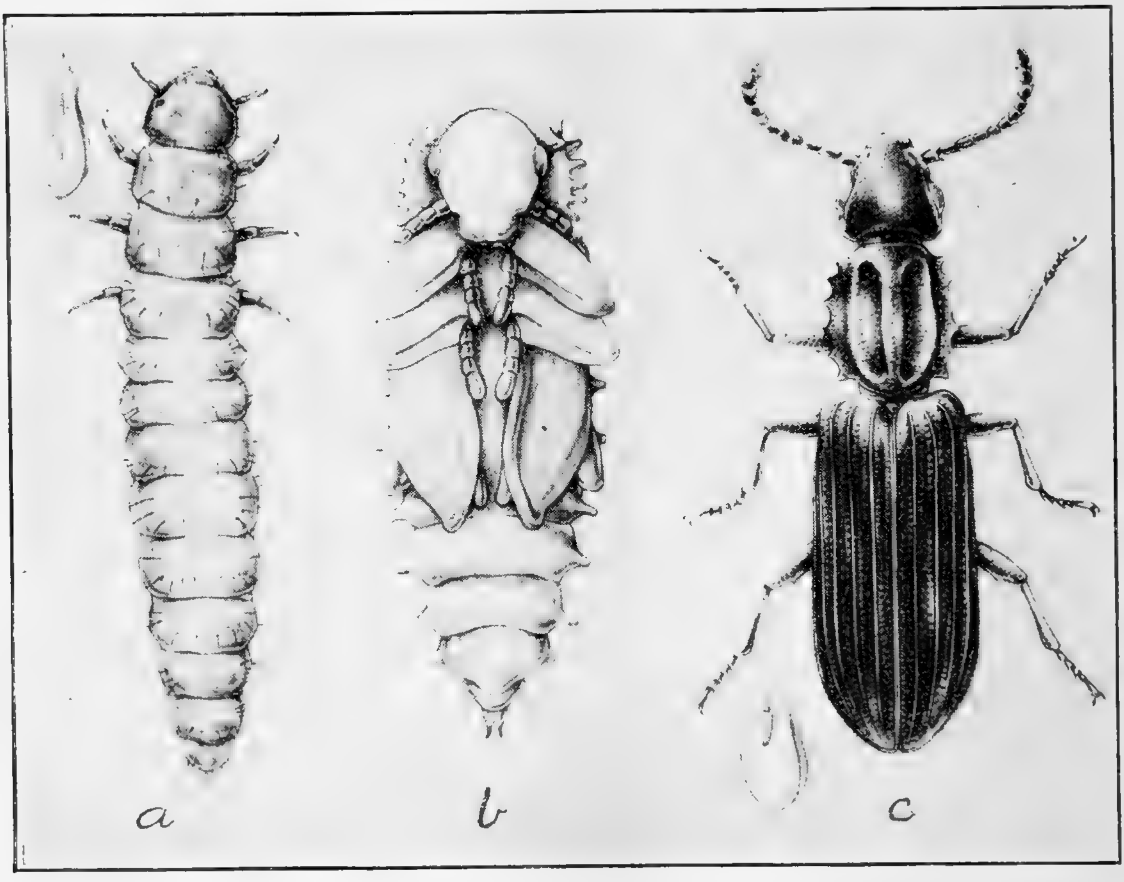

FIG. 40.—The sawtoothed grain beetle: *a*, Well-grown larva, with kernel of wheat to show its relative size; *b*, pupa; *c*, adult beetle with kernel of wheat to show its relative size. The adult beetle, about one-tenth of an inch in length, can be easily recognized by the six toothlike projections on the sides of the thorax.

[22] *Pharaxonotha kirschi* Reitt. [23] *Lophocateres pusillus* Klug.

by the much flattened margins of the thorax and wing covers (fig. 44).

First appearing in exhibits of rice and cereals from Siam, Liberia, and Ceylon at the World's Columbian Exposition, it has since been reported as injurious to stored grain and grain products in South Carolina and Texas. It is likely to be found in seaport towns and in the Southern States, but as yet it is not abundant or widespread.

FIG. 41.—The square-necked grain beetle. (Chittenden.)

FLAT GRAIN BEETLE.[24]

The flat grain beetle is a small, flattened, oblong, reddish-brown beetle about one-sixteenth of an inch long, with elongate antennæ somewhat longer than half the length of its body. (Fig. 45.) It is readily distinguished because it is the smallest beetle commonly found in stored grain in this country. It is cosmopolitan in distribution, is very generally found in stored corn in the South, and is often screened from wheat shipments. Little is known of its habits or of its early stages, though it is thought to be a scavenger or predacious on other insects. The full-grown larvæ form cocoons of a gelatinous substance to which food particles adhere. While it is present sometimes in unbelievable numbers in grain shipments, it appears to do little damage to whole grains. The larvæ have been found destroying the germ in kernels of wheat.

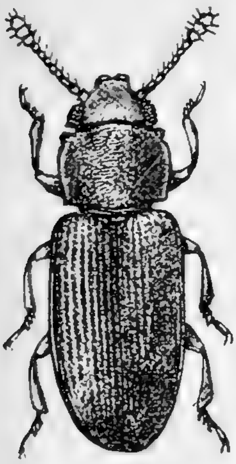

FIG. 42.—The foreign grain beetle. (Chittenden.)

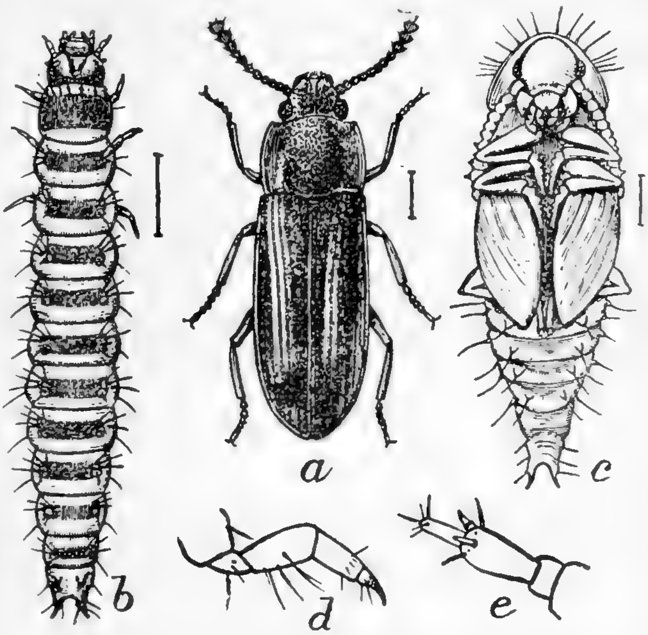

FIG. 43.—The Mexican grain beetle. *a*, Beetle; *b*, larva; *c*, pupa; *d*, leg of larva; *e*, antenna of larva. *a*, *b*, *c*, Much enlarged; *d*, *e*, more enlarged.

[24] *Cryptolestes pusillus* Schon.

CONFUSED FLOUR BEETLE.[25]

The confused flour beetle (fig. 46) is a shiny, reddish-brown beetle about one-sixth of an inch long, flattened and oval in form, with head and upper parts of thorax densely covered with minute punctures and with wing covers ridged lengthwise and sparsely punctured between the ridges. It is generally distributed over the world and is very abundant in all parts of this country. It is known as one of the flour beetles owing to its frequent occurrence in flour. It is a general feeder on starchy foods and is probably the worst insect pest of prepared cereal foods. It is constantly found in granaries, mills, and storehouses, and grain shipments.

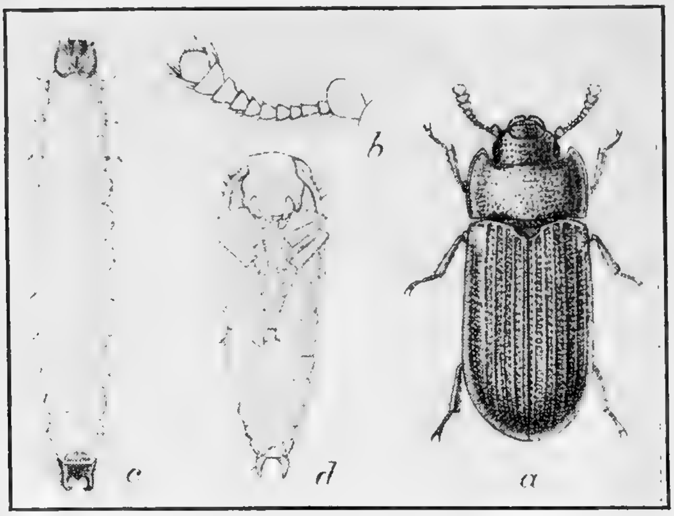

Fig. 44.—The Siamese grain beetle. *a*, Beetle; *b*, antenna of same; *c*, larva; *d*, pupa. *a*, *c*, *d*. About ten times natural size; *b*, greatly enlarged.

The minute white eggs of this beetle are laid in the cracks and crevices of bins, barrels, boxes, or other containers of the foodstuffs attacked by this insect. They are covered with a sticky secretion so that they become covered with flour, meal, etc., and readily adhere to the sides of sacks, boxes, and other containers so that fresh material placed in them is rapidly infested. The eggs hatch into small wormlike larvæ, slender, cylindrical, and wiry in appearance. When fully grown they are about three-sixteenths of an inch long, and in color are white, tinged with yellowish. These larvæ feed on flour or other material such as grain dust and the broken surfaces of grain kernels. When full grown they transform to small naked pupæ. At first white, the pupæ gradually change to yellow and then brown, and shortly afterwards transform to beetles. The period from egg to adult in summer is about four weeks under most favorable weather conditions, though the

Fig. 45.—Adult of the flat grain beetle, showing characteristic long antennæ. Not more than one-sixteenth of an inch long. This beetle is one of the very smallest found in grain shipments.

[25] *Tribolium confusum* Duv.

life cycle is greatly prolonged by cold weather, as is true of all grain pests.

RUST-RED FLOUR BEETLE.[26]

The rust-red flour beetle is almost identical in appearance with the preceding species, to which it is closely related. It can be distinguished from the confused flour beetle only with the aid of a magnifying glass. The segments of the antennæ of the confused flour beetle increase in size gradually from the base to the tip, while in the rust-red flour beetle the last few segments of the antennæ are abruptly much larger than the preceding ones, giving the antennæ the appearance of being suddenly enlarged at the tip. In addition, the margins of the head of the confused flour beetle are expanded and notched at the eyes, while the margins of the head of this species are nearly continuous at the eyes. The differences between the two species are clearly shown in figure 46, *e* and *f*.

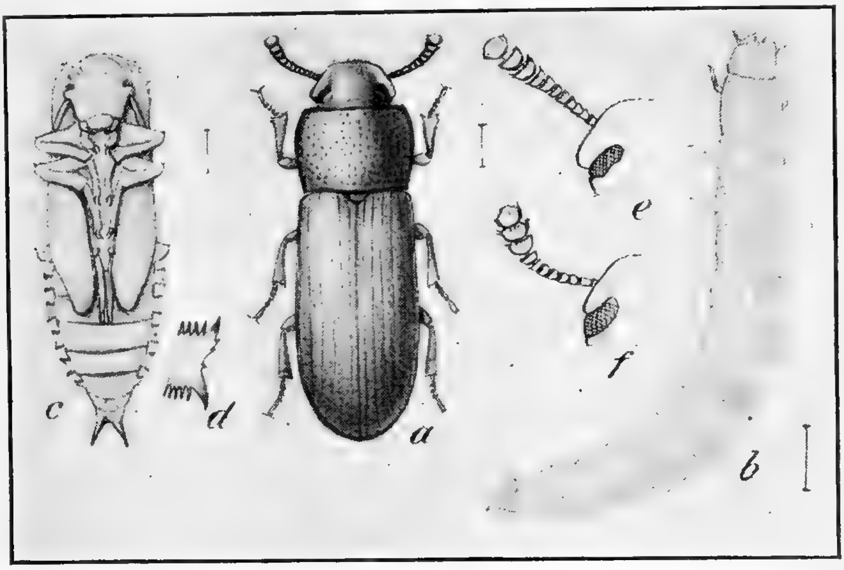

FIG. 46.—The confused flour beetle, the commonest insect recovered from grain shipments. It is about one-sixth of an inch long. *a*, Beetle; *b*, larva; *c*, pupa; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of the rust-red flour beetle. (Chittenden.)

This insect is similar to the confused flour beetle in feeding and breeding habits, and it is impossible to distinguish between the early stages of the two insects. Although cosmopolitan in distribution, it is found more commonly in the South, where it causes very serious damage to grain products. In addition to the actual damage caused by its feeding activities, serious losses are caused by the nauseous smell and taste that it imparts to the material it infests. Like the confused flour beetle, the rust-red flour beetle is primarily a pest of milled products, and while present in grain shipments it confines its attack in these to grain dust and the surface of broken grains, hence is not a primary pest of commercial shipments.

LONG-HEADED FLOUR BEETLE.[27]

The long-headed flour beetle is a slender, flattened beetle, slightly less than an eighth of an inch long, somewhat similar in form to the

[26] *Tribolium ferrugineum* Fab.

[27] *Latheticus oryzae* Waterh. A closely related species, *Latheticus prosopsis* Chittn., is shown in figure 48.

confused flour beetle but pale yellow and further differentiated by the peculiarly shaped antennæ shown in figure 47 and by the minute canthus behind each eye. It has been reported from most parts of the world infesting wheat, rice, corn, barley, rye, flour, etc. It was first recognized in this country about 13 years ago from specimens taken in Texas. It is not known to be very widely distributed in the United States but is likely to be found in mills and granaries in the South.

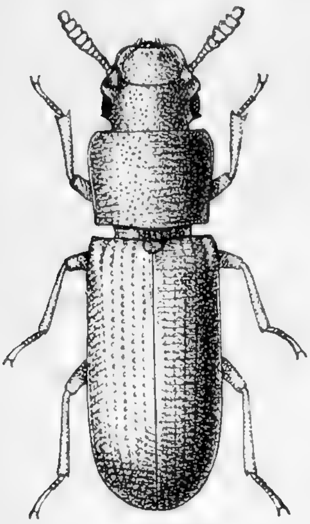

FIG. 47.—Long-headed flour beetle. (Chittenden.)

SLENDER-HORNED FLOUR BEETLE.[28]

The slender-horned flour beetle owes its name to the peculiar structure of the mandibles or jaws of the male, which are armed with a pair of slender incurved horns as shown in figure 49. The beetle is about one-eighth of an inch long, flattened and brownish, closely resembling the other flour beetles in appearance but easily distinguished by the peculiar structure of the jaws. It is distributed over the world and of frequent occurrence in the Southern States. It prefers to feed in flour and meal, but is found in a variety of grains.

BROAD-HORNED FLOUR BEETLE.[29]

The broad-horned flour beetle is closely related to the preceding species and is of similar form and appearance. It may be distinguished from it by the shape of the horns with which the mandibles or jaws of the males are armed. In this species (fig. 50) the horns are broad and stout in contrast to the slender incurved horns of the preceding species. Its habits are similar to those of the slender-horned flour beetle, and it is often found in seaport towns in shipments of grain and grain products.

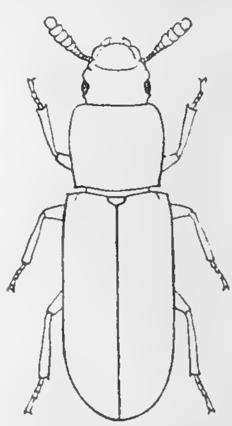

FIG. 48.—*Lathetieus prosopis.* (Chittenden.)

SMALL-EYED FLOUR BEETLE.[30]

The small-eyed flour beetle (fig. 51) is the smallest of the so-called flour beetles that infest grain and grain products in this country. It is a tiny, flattened, shiny, reddish-brown beetle, somewhat oblong in form and measuring about one-twelfth of an inch in length. It occurs throughout the world and is widely distributed in this country. It prefers ground products in which to breed, but is not infrequently found in stored grains.

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[28] *Gnathocerus maxillosus* Fab. [29] *Gnathocerus cornutus* Fab. [30] *Palorus ratzeburgi* Wism.

A closely related species[31] more common in Europe but occasionally found in this country is very similar in appearance and habits to the small-eyed flour beetle.

TOBACCO BEETLE.[32]

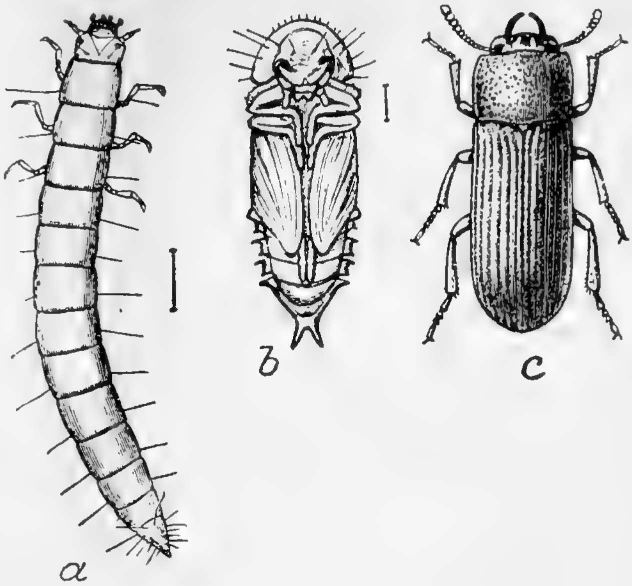

FIG. 49.—The slender-horned flour beetle: *a*, Larva; *b*, pupa; *c*, beetle. (Chittenden.)

The tobacco beetle is a small, robust, oval, reddish-yellow or brownish red beetle. with head bent down nearly at right angles to the body, giving the beetle a humped appearance when viewed from the side as shown in figure 52. It varies in size, but is usually about one-tenth of an inch long. It is found in all temperate, subtropical, and tropical regions and infests tobacco and many other stored products. It breeds in a variety of seeds and may occasionally be found attacking grains left long in storage in original sacks.

DRUG-STORE BEETLE.[33]

The drug-store beetle is very similar in appearance to the tobacco beetle, to which it is closely allied, but differs from it by being more elongate in proportion and in having the wing covers distinctly striated. It is about one-tenth of an inch long. It is cylindrical and uniform light brown; its body is covered with a fine silky pubescence. (See fig. 54.) The larva or grub is very much less hairy than that of the cigarette or tobacco beetle, as a comparison of figures 53 and 55 will show. It is known as the drug-store beetle from its habits of feeding on almost all drugs found in pharmacies. It is a very general feeder, attacking a great variety of stored foods, seeds, and other materials, and has been said to "eat anything except cast iron." It is frequently found in storehouses and granaries in all parts of the world.

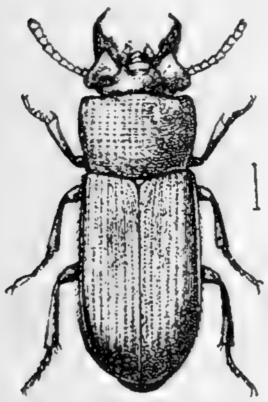

FIG. 50.—The broad-horned flour beetle. (Chittenden.)

The eggs of this beetle are laid in almost any dry organic substance. The small white grubs emerging from the eggs tunnel through these substances and when full grown pupate in small cocoons. The entire life cycle may be passed in less than two months.

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[31] *P. depressus* Fab. [32] *Lasioderma serricorne* Fab. [33] *Sitodrepa panicea* L.

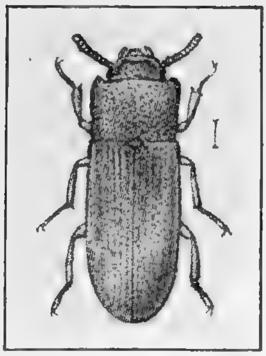

FIG. 51.—The small-eyed flour beetle. (Chittenden.)

BLACK CARPET BEETLE.[34]

The black carpet beetle is a small oval beetle between two-sixteenths and three-sixteenths of an inch long. The head and thorax are black, but the wing covers may be either black or dark reddish brown, and clothed with short hairs. Its legs and antennæ are dark yellowish in color. The larva is very characteristic and can be readily recognized. It is reddish or golden brown, clothed with short scale-like appressed hairs and provided with a tuft of long hairs at the end of the body, as shown in figure 56.

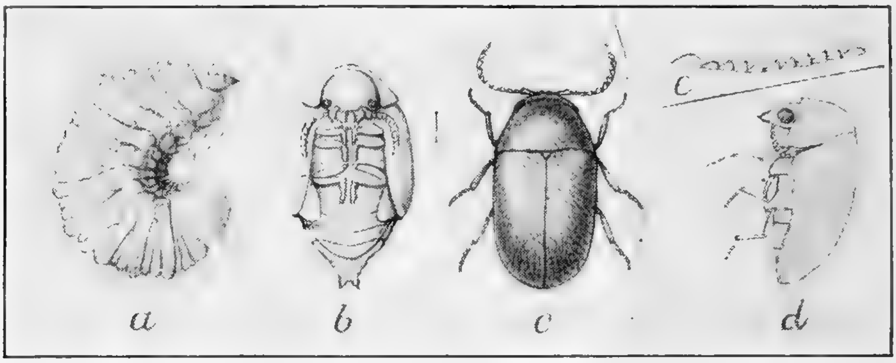

FIG. 52.—The tobacco beetle never attacks grain unless it has been stored for long periods. *a*, Larva; *b*, pupa; *c*, beetle, dorsal view; *d*, beetle, side view; *e*, antenna of beetle. (Chittenden.)

As the name indicates, this insect injures carpets, but in addition it is known to breed in grains and cereals, both whole and ground. The larval stages develop very slowly, and there is but one generation each year. The adults appear in greatest numbers during the spring and early summer. It occurs in Europe and Asia and has been reported from all parts of this country. It is of very common occurrence in houses.

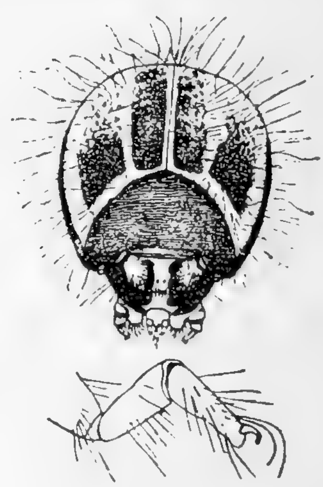

FIG. 53.—The tobacco beetle: Head and leg of larva. (Chittenden.)

LARGER CABINET BEETLE.[35]

The larger cabinet beetle is a small, oval beetle about one-eighth of an inch long, its ground color black mottled with reddish brown, covered with gray and light brown scale-like hairs forming a distinct pattern on the wing covers. The larva somewhat resem-

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[34] *Attagenus piceus* Oliv.

[35] *Trogoderma tarsale* Melsh.

bles that of the black carpet beetle in appearance. It is about one-eighth of an inch long, reddish brown above and whitish beneath, with body covered with short yellowish brown hairs and with a tuft of short hairs at the tail end. (See fig. 57.) It is well known for its habit of breeding in dead insects and animal substances and is not infrequently found living in grain, flax-seed, castor beans, pumpkin seed, etc. It often becomes a nuisance in laboratories by attacking sample lots of corn, wheat, etc.

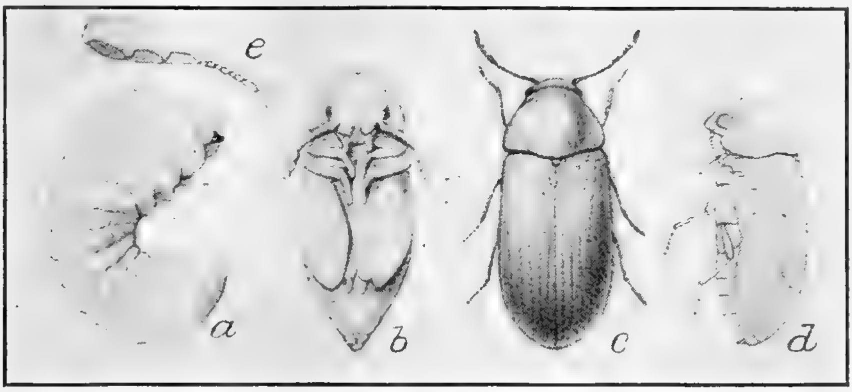

FIG. 54.—The drug-store beetle never attacks grain unless it is stored for long periods unmolested. *a*, Larva ; *b*, pupa ; *c*, beetle, dorsal view ; *d*, beetle, side view ; *e*, antenna of beetle. (Chittenden.)

SMALL CABINET BEETLE.[36]

The small cabinet beetle is somewhat similar in appearance to the larger cabinet beetle but smaller and of different color. It varies in length from one-sixteenth to two-sixteenths of an inch, and is black with yellowish white scales that form a broad band across the back and give the body a mottled appearance. The habits of the adult and early stages of this insect are similar to those of the larger cabinet beetle. It is occasionally found in flour mills and granaries, where it infests grain and grain products.

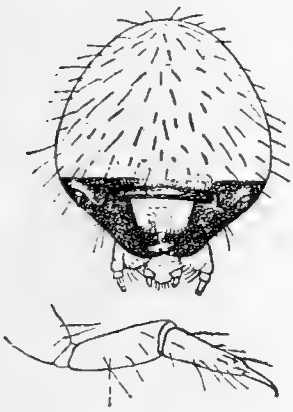

FIG. 55.—The drug-store beetle: Head and leg of larva. (Chittenden.)

MUSEUM BEETLE.[37]

The museum beetle is closely allied to the preceding beetle and resembles it in size and form. Its body is black, covered with yellowish and whitish scales, giving it a spotted appearance. It is a small plump beetle varying in size from one-sixteenth to one-eighth of an inch in length. The larvæ are small active hairy grubs with habits similar to those of the two preceding species. They are occasionally found in grains, both whole and ground, but do not cause noticeable damage.

TWO-BANDED FUNGUS BEETLE.[38]

The two-banded fungus beetle is a handsome little elongate-oval beetle slightly less than an eighth of an inch long. It is red-brown with two broad black bands across the wing covers. Its character-

[36] *Anthrenus verbasci* L. [37] *Anthrenus museorum* L. [38] *Alphitophagus bifasciatus* Say.

istic color pattern is shown in fig. 58. It is distributed over the world and is in general a feeder on fungi and molds, being a scavenger in refuse grain and grain products, decaying vegetable matter, etc. It is frequently found around mills and storehouses where waste material is allowed to accumulate. The larvæ have been bred from moist cornmeal and in spoiled cereals. The insect is often found in the holds of grain ships in wet or damaged grain.

BLACK FUNGUS BEETLE.[39]

The black fungus beetle (fig. 59) resembles the mealworm beetles in form and color but is considerably smaller. It is black or a very dark reddish brown and measures from three-sixteenths to four-sixteenths of an inch in length. The larva (fig. 59, *a*) is yellowish

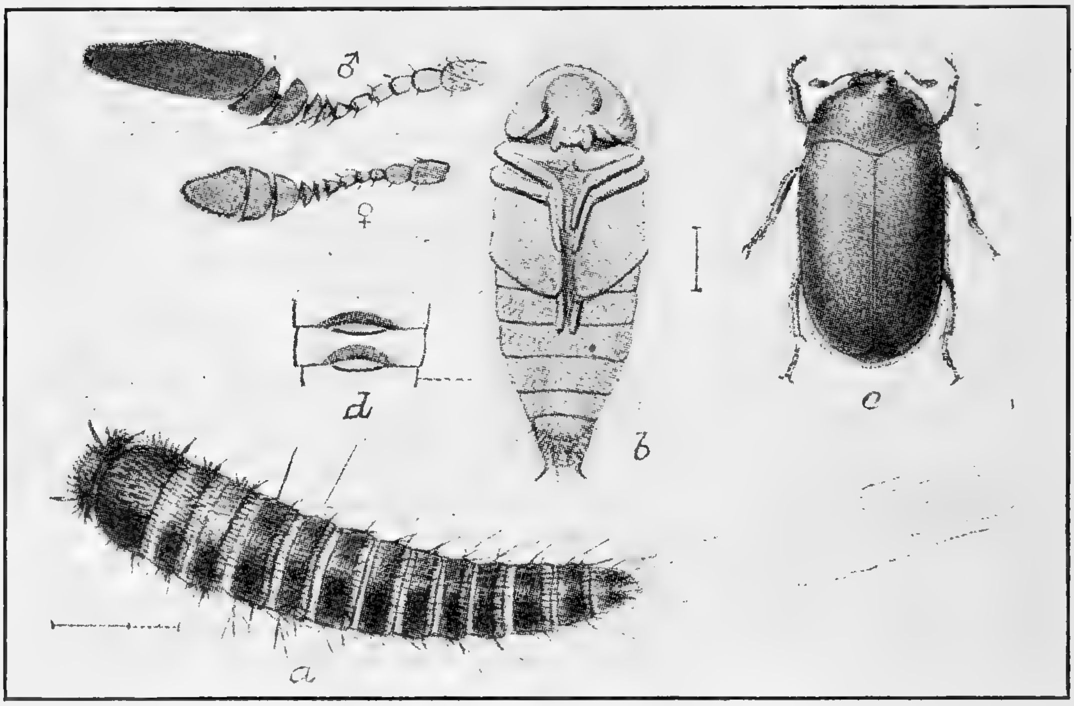

FIG. 56.—The black carpet beetle is chiefly a pest of sample grains, or found in grain dust about elevators or storage bins. *a*, Larva; *b*, pupa; *c*, beetle; *d*, dorsal abdominal segments of pupa; ♂, antenna of male beetle; ♀, antenna of female beetle. (Howard.)

brown and is very similar in form and appearance to young larvæ of the mealworms. This beetle is often found in the same situations as the red-banded fungus beetle. It breeds in damp moldy grain but causes no injury to grain that is sound and dry.

CORN SAP-BEETLE.[40]

The corn sap-beetle may be readily recognized by its peculiar wing covers, which are short and truncate, leaving the tip of the abdomen exposed as shown in figure 60. It is a small dark brown beetle with lighter colored wing covers, oblong-ovoid in shape, and varying in length from one-tenth to one-eighth of an inch. It normally feeds in

[39] *Alphitobius piceus* Oliv.   [40] *Carpophilus dimidiatus* Fab.

rotting and decaying fruit and vegetation and in the sap exuding from injured plants. It is quite numerous in cornfields in the South, swarming over the damaged ears and feeding and breeding in the decaying kernels. It is attracted to damp and decaying grain but is seldom found in grain that is clean and dry.[41]

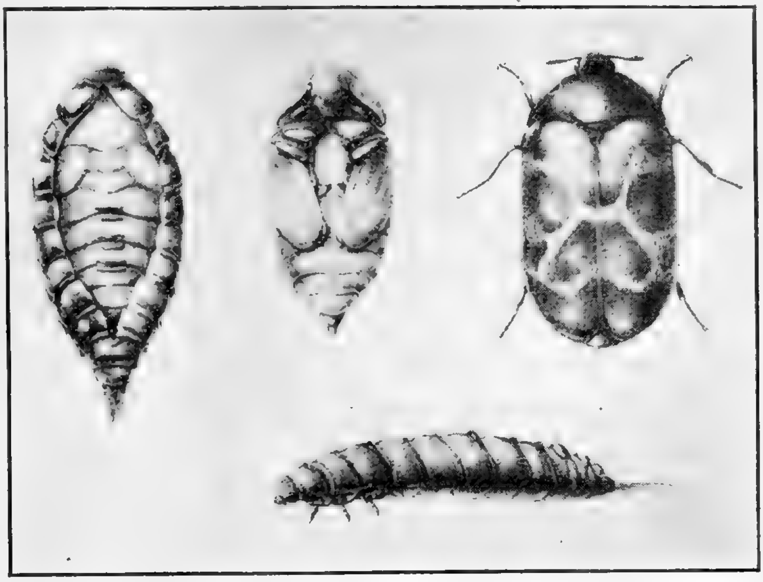

FIG. 57.—The larger cabinet beetle: At left, pupa within larval skin; in center, pupa; at right, beetle; below, well-grown larva.

A closely related beetle[42] that has been introduced from abroad and is becoming more and more abundant is similar in form to the corn sap-beetle, but is slightly larger and is a uniform, shiny, dark brown all over. Its habits are very similar to those of the preceding species.

BOOK-LICE OR PSOCIDS.[43]

Book-lice or psocids are minute, pale, soft-bodied, louse-like insects, about one thirty-second of an inch long, with long, slender antennæ, differing greatly in appearance from other grain-infesting insects. (See fig. 61.) They may be whitish, almost transparent, or quite dark.

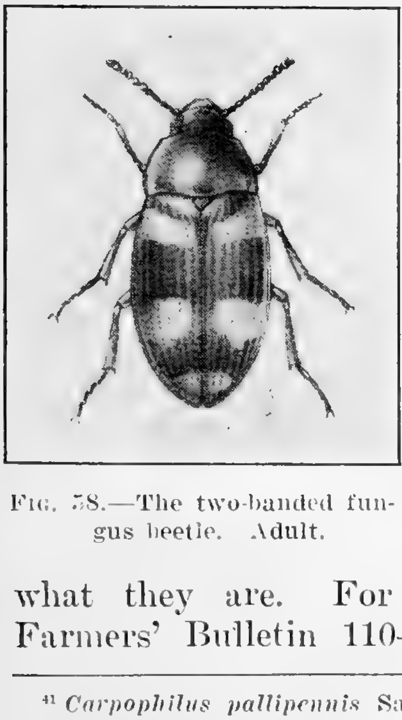

FIG. 58.—The two-banded fungus beetle. Adult.

Psocids are of very common occurrence and may be found in nearly any situation. They are almost omnivorous, feeding on any animal or vegetable matter. They are frequently found in grain, but while they have jaws and are capable of feeding upon solid materials, they may be disregarded as pests of grain. They are frequently very abundant in grain and are here recorded because of the curiosity of persons to know what they are. For further information regarding them see Farmers' Bulletin 1104, "Book-Lice or Psocids."

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[41] *Carpophilus pallipennis* Say, a purely flower-infesting beetle, has been occasionally reported as infesting stored corn. In these cases large specimens of the corn sap-beetle which closely resemble this species were probably mistaken for it.

[42] *Carpophilus humeralis* Murray.

[43] *Troctes divinatoria* Fab. *et al.*

MITES.[44]

Mites are pale-colored, soft-bodied creatures provided with numerous long hairs, as illustrated in figure 62. They are microscopic in size. As a low estimate the number of mites that may be found on one square inch has been placed at 100,000. They are often found in stored grain and occasionally increase with such rapidity that the grain seems to be fairly alive with them. During heavy infestations their cast skins and dead bodies accumulate in fluffy light brown masses beneath the sacks of grain. If these accumulations are on a warehouse floor they roll up into piles which are blown about with each gust of wind. No other group of pests in

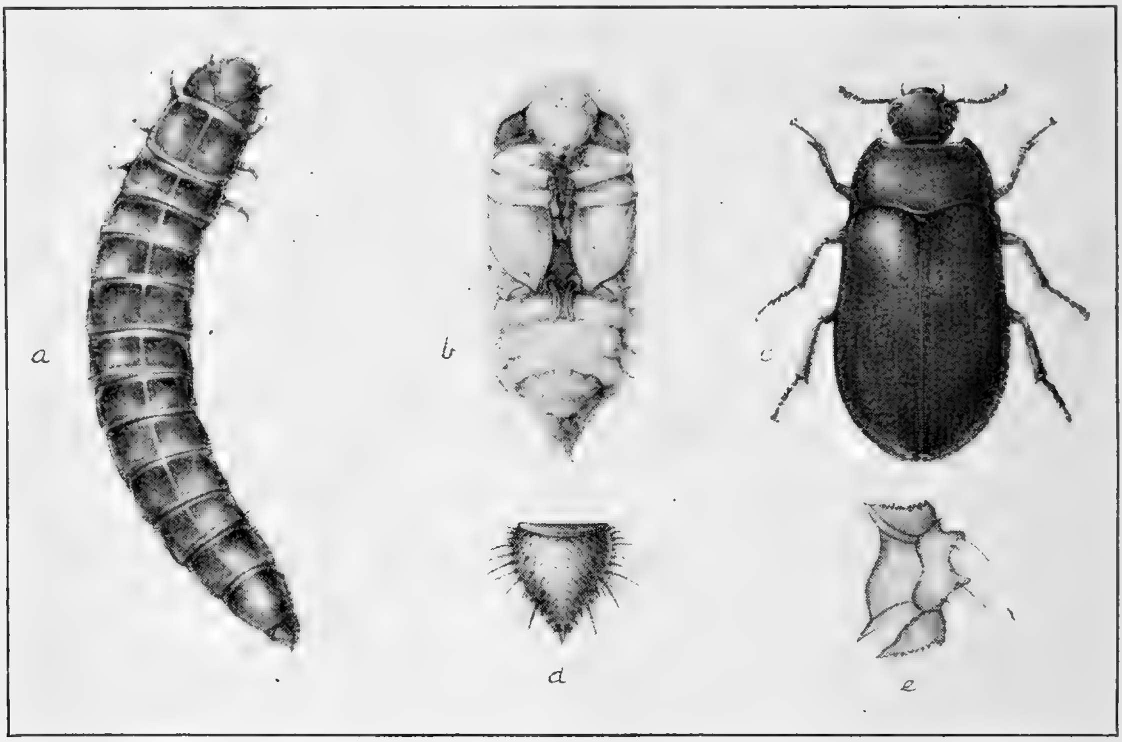

FIG. 59.—The black fungus beetle: *a*, Larva; *b*, pupa; *c*, adult; *d*, caudal segment of larva (Schiödte); *e*, lateral plate of pupa (Schiödte).

grain will produce these masses. When present in large numbers they promote "sweating," impart a disagreeable odor to the grain, and may cause damage by their feeding. Fortunately the mites that attack grain are themselves preyed upon by predacious mites which usually become abundant enough to kill the grain mites in a comparatively short time. If they do not, the screening and fanning of grain will usually reduce mite infestations to a point where no injury takes place.

PARASITES OF GRAIN PESTS.

Grain in bulk is often seen swarming with small black wasplike insects of a size and appearance shown in figure 63. These do

[44] *Tyroglyphus* spp.

not cause injury to grain. On the contrary, they are beneficial, as they are attacking and killing the grain weevils and grain moths. While parasites kill a large number of grain insects, they unfortunately can not be considered of great importance from the standpoint of grain protection, for by the time the grain insects have been controlled by parasites the grain itself has become very badly damaged. For this reason the appearance of a large number of parasites in grain cars or elevators should be disregarded and the grain treated as though parasites were not present.

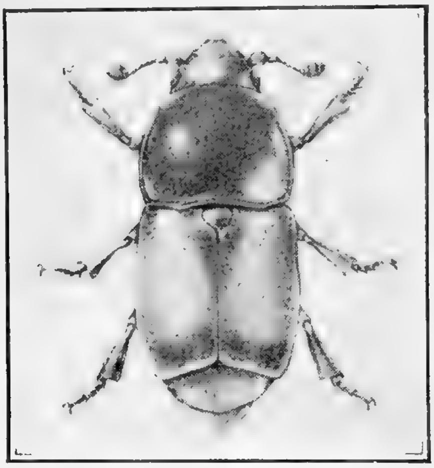

Fig. 60.—The corn sap-beetle. Adult.

Grain dealers frequently find a small threadlike white worm[45] (fig. 64) about three-quarters of an inch long in grain dust beneath sacks or in the bottoms of bins. This is the larva of a small black fly to be found crawling upon windows of granaries and flour mills. Because of this habit it is called the window-pane fly. Its threadlike larva does no harm to grain but is predacious upon the larvæ of grain pests and clothes moths. It is not abundant enough to be of value in protecting grain.

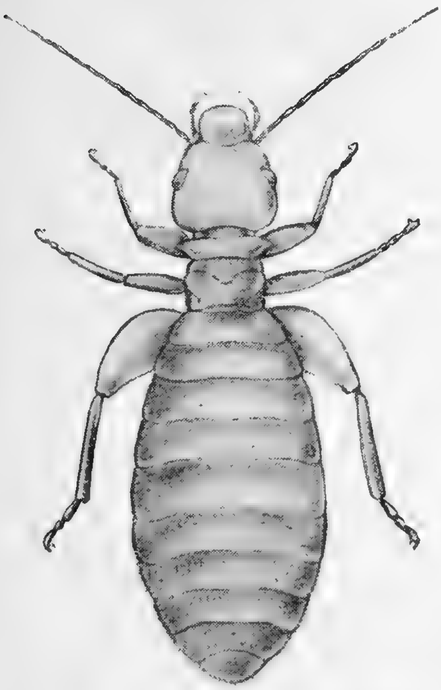

Fig. 61.—Book-louse or psocid.

HOW GRAIN BECOMES INFESTED.

Grain may become infested in a number of ways. It is never possible to settle satisfactorily litigation over responsibility for insect damage to grain without a thorough knowledge of the history of the particular grain shipment involved.

Several of the worst insect pests of grain, notably the Angoumois grain moth and the rice or black weevil, fly to the grain fields from near-by cribs and begin their attack upon the maturing grain. In the case of wheat and similar small grains, the eggs of the insect are laid directly upon the heads of grain. In the case of corn the insects can infest only those kernels that are exposed because of poorly de-

[45] *Scenopinus fenestralis* L.

veloped or damaged shuck covering. In cornfields, especially in the South, where insect infestation occurring in the field is most severe, there are a sufficiently large number of exposed kernels to bring about slight, though widespread, infestation.

It is probably true that in well-grown crops of corn the percentage of kernels infested before the crop is ready for harvest is very small, and throughout the Middle and Northern States is a negligible factor. In the Gulf Coast States, especially in upland fields, the infestation often is very severe. In the case of wheat, grown particularly along the Ohio River, in southern New Jersey, in Pennsylvania,

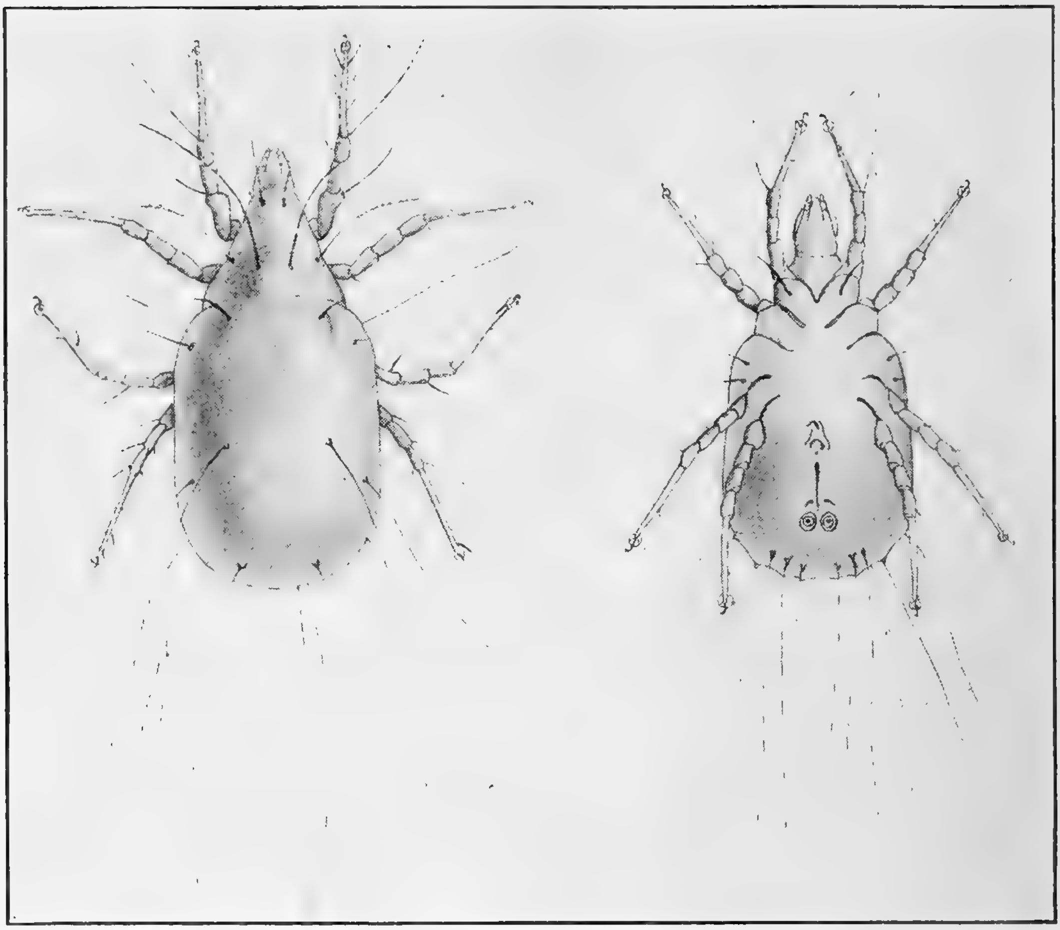

FIG. 62.—Grain mites. (Howard.)

Maryland, Delaware, Virginia, and southward, the field infestation may be much more general than is now believed. Newly thrashed wheat from Maryland arriving in September on the Baltimore market showed infestation ranging up to 6 per cent. While these infestations occurring in the grain before it is harvested are usually unavoidable, they are of great importance as " leaven " which in storage may result in a general infestation of an entire crop, in heating, and in much damage.

After grain has been harvested it is often stored in bins, storehouses, or barns that have held, or still hold, infested grain and which have not been thoroughly cleaned. Wooden bins and wooden partitions in grain storehouses and in the holds of grain-carrying ships become the nesting places for an incredibly large number of grain pests. Certain of these can and do bore into the softer portions of the partitions and timbers that are used over and over again as dunnage, and the excavations they make serve as hiding places not only for themselves but all other species associated with them. Unless such bins and partitions are thoroughly disinfected by fumigants, these hidden insects can not be killed. The mere spraying of contact insecticides upon the walls will not reach them. If uninfested grain is placed in such bins, it naturally will become infested by the insects coming from the bin walls.

FIG. 63.—Hymenopterous parasite of grain pests. Adult parasite resting upon a kernel of wheat. These tiny gnat-like insects are beneficial but their help usually comes too late to prevent damage to the crop in which they are most abundant.

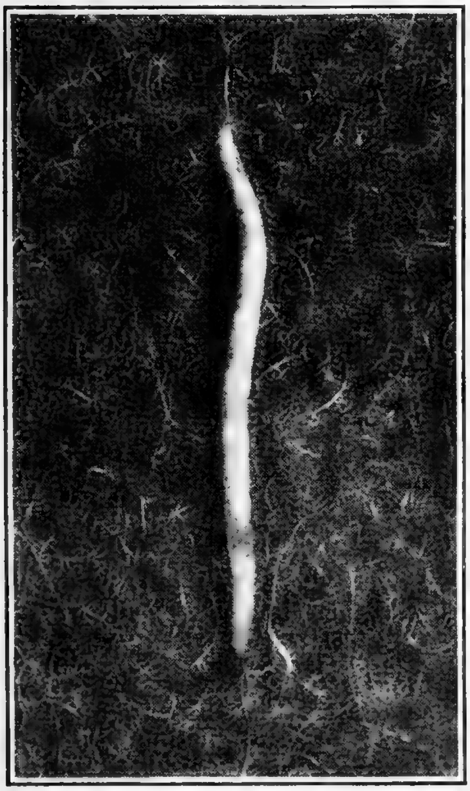

FIG. 64.—Larva of a kind of fly that preys upon grain beetles and mites. This white threadlike worm is sometimes found in grain dust and attains a length of about three-fourths of an inch: while interesting, it is of no practical value.

Likewise, uninfested grain should not be placed for shipment in sacks previously used for grain storage, for, as shown in figure 32, these old sacks often harbor insects unless they have been treated by heat or fumigation. Certain extensive and costly infestations have been traced directly to the use of secondhand untreated grain sacks.

Grain stored in the open or in poorly constructed cribs or bins may become infested by insects flying in from outside sources.

HOW TO PREVENT PRIMARY INFESTATION.

Infestation of grain in the field can not be entirely prevented, but by proper precautions it can be reduced to a minimum. The first generation of insects in the maturing grain is usually small, and if the grain is cut as soon as ripe, thrashed as soon as dry, and then placed in storage in clean, deep bins the damage from this source will be very slight. It is when the grain is left in the field long after it is ripe that serious infestation results, for the insects increase in one or two generations to enormous numbers. In the case of corn in the field, only those ears that are damaged or through poor shuck development have kernels exposed are subject to the attack of grain insects. Farmers should therefore grow a variety of corn that develops a long tight shuck.

Newly harvested small grains should not be stored unthrashed for any length of time, as in this condition they are very susceptible to infestation. If promptly thrashed and stored in deep bins, only a thin layer on top of the bin is likely to become infested. Corn may be stored in the shuck if the husk is long and tight and fully covers the tip, but all ears with loose, broken, short, or damaged husks should be shucked and stored separately.

Clean grain should never be stored in old bins, granaries, or storehouses until they have been thoroughly cleaned and freed from the accumulations of waste grain and other materials harboring grain insects. Timbers in bins, granaries, or holds of ships that have become infested with grain insects should be destroyed or treated before being used again. Steel or concrete bins are highly desirable owing to the ease with which they are cleaned.

Bags of all kinds that have previously held grain should not be allowed in granaries or warehouses or be refilled until they have been sterilized by heat or otherwise freed from insects. The use of tight cribs will keep the grain free from infestation by insects that might fly in from the outside.

THE TREATMENT OF INFESTED GRAINS.

Insects infesting stored grain can be destroyed by the use of heat, or by fumigation with poisonous gases. These remedial measures are mentioned only briefly in this bulletin.

HEAT.

A temperature of 120° to 130° F., maintained for a short time, will kill all stages of grain-infesting insects, without injuring the germinating quality of the grain. Owing to the difficulty of subjecting the grain to such a temperature this method of control is used chiefly by millers and large grain dealers who are equipped with commercial driers suitable for the purpose.

FUMIGATION.

Carbon disulphid, carbon tetrachlorid, and hydrocyanic-acid gas are the fumigants in most common use to-day for treating infested grain. Of these, carbon disulphid is the best for treating grain in bulk. It is heavier than air and if applied at the top of a gas-tight bin of grain will penetrate down through the grain, killing the insects without injury to the grain, providing it is dry. It has the one great disadvantage of being inflammable and will explode if fire in any form is brought near it. It is in general use on farms for the protection of grain in cribs (see U. S. Department of Agriculture, Farmers' Bulletins 799 and 1029.)

Carbon tetrachlorid is not as effective as carbon disulphid and costs more. For these reasons it is not in such general use. It has the great advantage of removing the fire hazard, as it is not inflammable and does not explode in presence or fire.

Hydrocyanic-acid gas is not of value in fumigating bulks of grain. When grain is stored in sacks in warehouses, heavy doses of this gas will control grain pests. This method of fumigation is discussed in Department Bulletin 872.

Fumigation with chloropicrin is not in general use at present.

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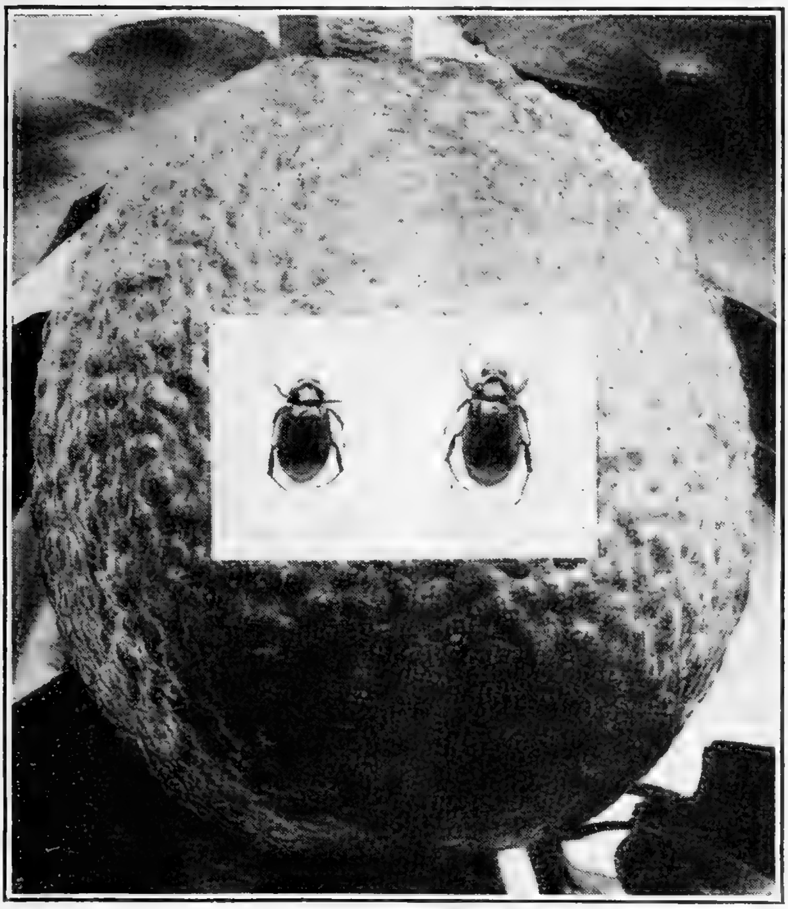
FARMERS' BULLETIN 1261

THE AVOCADO

ITS INSECT ENEMIES AND HOW TO COMBAT THEM

G. F. MOZNETTE

Assistant Entomologist, Tropical and Subtropical Fruit Insect Investigations



UNITED STATES
DEPARTMENT OF AGRICULTURE

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PRACTICALLY EVERY CROP, be it fruit, vegetable, or flower, has an insect enemy, or more than one, apparently bent on its destruction. The avocado is no exception to the rule. It is attacked by several insect pests which at times cause concern to the producer of this valued and highly nutritive fruit. These insects are often responsible for reductions in yield and quality of fruit, but such losses are largely preventable. Often the damage caused by the insects is gradual and it is only the resultant injury that is conspicuous. *It is essential, therefore, that the avocado grower watch his trees carefully for evidences of insect injury and apply remedies promptly.*

The principal insect pests of the avocado occurring in Florida at the present time are the dictyospermum scale, the avocado white fly, the pyriform scale, the blossom Anomala, the avocado lace-bug, the avocado blossom thrips, the avocado leaf-roller, the avocado red spider, and the avocado leaf-infesting thrips. Brief descriptions of these pests, of their life histories, and of the means found most effective, in each case, for combating them are given in this bulletin.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. April, 1922

THE AVOCADO: ITS INSECT ENEMIES AND HOW TO COMBAT THEM.

CONTENTS.

ALL VARIETIES OF AVOCADO SUBJECT TO INSECT ATTACK.

AVOCADO GROWING was established a number of years earlier in Florida than in California, and for this reason considerably more is known about this fruit and its insect enemies in Florida than on the Pacific coast. To those who are growing the avocado in California, however, a discussion of its insect pests in Florida, where the investigations upon which this paper is based were conducted, may not be without interest. Although conditions must largely decide methods and practices in the control of avocado pests, the experience gained in another region can not fail to throw light on certain questions which may arise in California.

The avocados now grown in Florida are mainly varieties of the West Indian race, although varieties of the Guatemalan type are fast gaining in popularity among growers, due to the fact that they will stand a somewhat lower temperature. The Guatemalan race, however, has been grown sufficiently in Florida to show that for the most part the insects which attack the West Indian race of avocado will adapt themselves to the hardier Guatemalan varieties as well. While some of these insect enemies may have been introduced, others probably have long been present on native vegetation and have recently adapted themselves to the newly imported and more attractive avocado.

INJURIOUS INSECTS OF THE AVOCADO IN FLORIDA.

THE DICTYOSPERMUM SCALE.[1]

The avocado, as is the case with deciduous fruits and citrus fruits, has its destructive scale enemies, the most important of which, in Florida, is the dictyospermum scale. The adult scales (fig. 1, *a*) are circular, or slightly elongated, closely resembling other scales of a similar nature. They vary in color from a light yellow to a reddish brown.

CHARACTER OF INJURY.

The dictyospermum scale is a pest in the avocado nursery as well as in the bearing grove and has been found to infest both the West Indian and Guatemalan races of avocados. In the nursery it finds special protection where the trees are crowded together in blocks. In the grove it attacks the twigs and branches and, where numerous, the foliage. The branches so attacked (fig. 1, *b*) are gradually weakened and ultimately become of little use to the tree. The branches at the base of the tree are generally attacked more severely, being more protected from the elements than those toward the top (fig. 3). Where trees have been seriously attacked they in time assume a nude appearance, due to the destruction of the foliage-bearing twigs and branches. Branches and twigs severely infested soon become roughened and crack considerably, affording entrance places for various destructive fungi (fig. 2).

LIFE HISTORY AND DEVELOPMENT OF THE SCALE.

The young of the dictyospermum scale insect are hatched beneath the scale which covers the adult female. They are broadly oval in outline and yellow in color. They are much flattened creatures, provided with six legs, a pair of antennæ, and an apparatus for sucking the juices from the tree. They are exceedingly small, appearing as mere yellow particles. They remain beneath the scale covering a short time and after emerging crawl over the branches and twigs and soon settle down and begin their growth, living at the sole expense of the tree.

Several days after settling the young scale assumes a circular shape and begins to exude a mass of fine white cottony threads which finally cover the entire insect. About four days after birth the scale covering commences to change again, and the cottony-appearing substance is cast away for a more compact scale or nipple-like covering, the center of which is whitish with a grayish tinge, with white outer edges. Underneath this scale covering the insect grows and goes through the process of molting several times. With the first molt the legs and antennæ are shed with the skin. The young

[1] *Chrysomphalus dictyospermi* Morgan.

insect beneath the scale thus becomes a degraded saclike creature, with no organs of locomotion. The mouthparts remain, however, in a highly developed state. They consist of delicate hairlike bristles

FIG. 1.—The dictyospermum scale: *a*, Scales, enlarged eight times; *b*, scales on twig, slightly enlarged.

by means of which the insect is firmly attached to the tree from which it draws its nourishment. Underneath this scale covering the insect remains fixed throughout its existence. On reaching maturity

FIG. 2.—The dictyospermum scale: Branch of avocado with bark cracked due to work of scales, thus affording entrance places for fungi.

FIG. 3.—The dictyospermum scale: Infested tree showing destruction of twigs and branches and nude appearance.

it produces eggs, and the young which are hatched from these eggs give rise to another generation further to infest the tree.

SEASONAL HISTORY.

In Florida the seasonal history of this scale varies somewhat, depending upon the locality, its activities being influenced by changes of temperature. As a general rule, however, the young begin to appear about March 1 and infest the newer growth in great numbers. At this time of year a generation requires approximately seven weeks to mature. As the weather becomes gradually warmer, the generations are a little shorter, and overlap considerably during the summer months. With the approach of cool weather in December and January a generation lengthens and requires over two and a half months in which to develop. In southern Florida, depending upon the locality, this scale may pass through from five to six generations in a year.

HOW THE SCALE MAY BE CONTROLLED.

The best time to control the dictyospermum scale on the avocado is when the trees are dormant, from the middle of December until the 1st of February. Oil emulsions, such as are used against citrus insects, have been found to control the scale effectively. There are a number of oil emulsions on the market, some of which when combined with waters used in spraying in Florida work very satisfactorily. The waters used in southern Florida for spraying purposes are those which come from deep wells in limestone formation and are termed "hard," and those which come from surface wells and are as a rule somewhat brackish. Certain oil emulsions, however, when combined with these "hard" waters may prove at times unsatisfactory, because the lime and magnesium salts usually present in the water tend to break up the emulsion, causing the oil to be set free during spraying. If separation occurs in using an oil emulsion with the water, the water should be first softened by means of caustic potash fish-oil soap. Two to three pounds of caustic potash fish-oil soap to a 125-gallon tank have been found sufficient to soften the ordinary hard water. After the water has been so softened the oil emulsion should be added. In using the oil emulsions on the avocado during the dormant season, the writer has found that a strength of 1 gallon to 70 gallons of water proved the most satisfactory. Two applications with a three-week interval during the dormant period will control this scale insect. In the nursery a strength of 1 gallon to 80 gallons of water should be used on account of the new growth generally present.

THE AVOCADO WHITE FLY.

A pest which attacks the avocado in Florida is the avocado white fly.[2] It is much smaller than any of the white flies which attack citrus fruits, but is similar in habits. The adults (fig. 4) of this species average less than 1 millimeter (one twenty-fifth inch) in length and possess pale yellow bodies with white wings. This white fly may also be recognized on the foliage by the fact that the pupæ possess a characteristic fringe about the margin (fig. 5). It is quite widely distributed in Florida and is to be found wherever avocados are growing. Apparently it is a native insect and has adapted itself to the avocado as a host. It was first recorded from specimens received from Florida by Dr. A. L. Quaintance. At times the writer has collected it on various weeds and also from papaya, banana, guava, and annona.

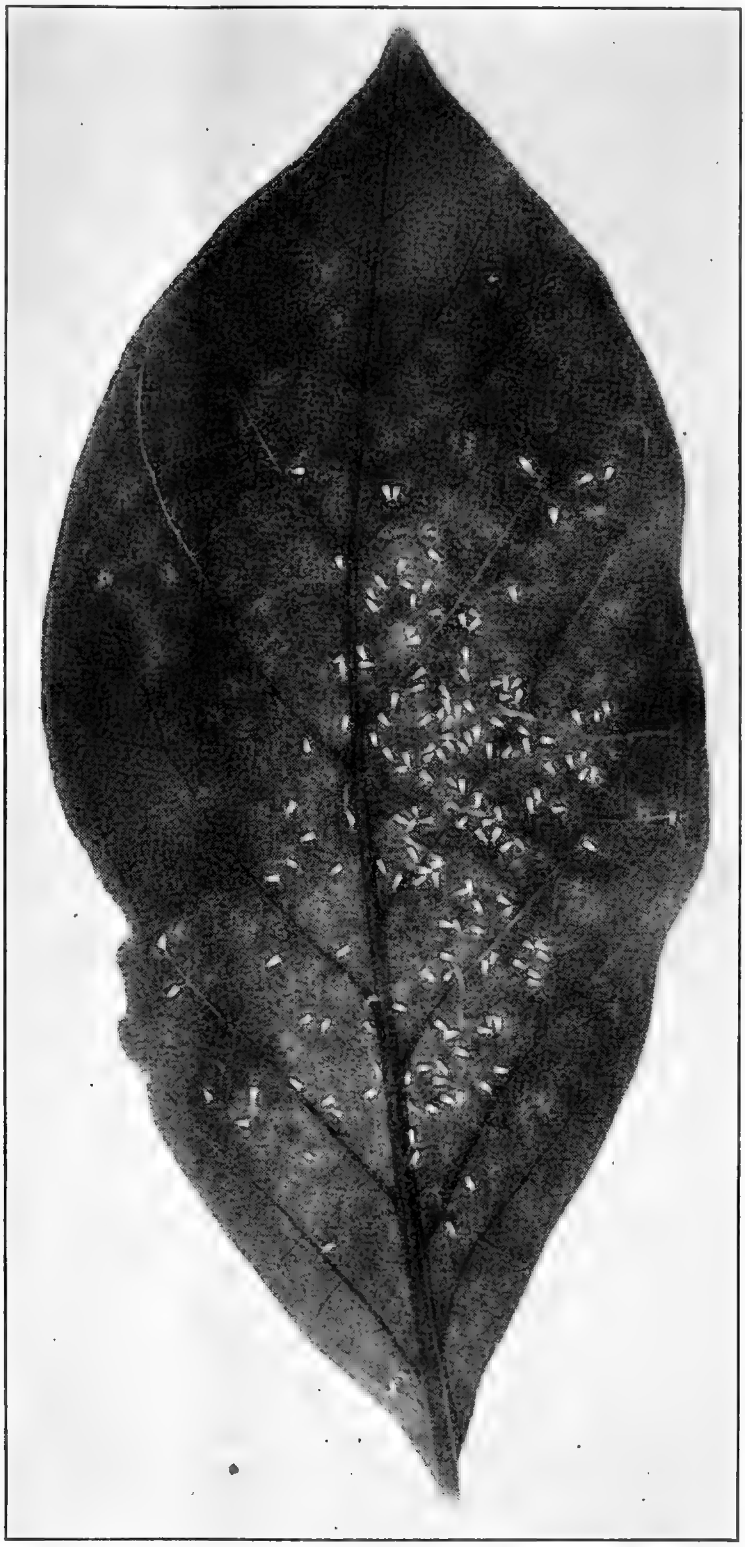

FIG. 4.—The avocado white fly: Adults depositing eggs on lower surface of leaf.

CHARACTER OF INJURY.

The avocado white fly is a pest both in the bearing grove and in the nursery, where it attacks the foliage and also produces honeydew in which the

[2] *Trialeurodes floridensis* Q.

sooty-mold fungus develops, giving the foliage and fruit a blackened appearance (figs. 6 and 7). It attacks both the West Indian and Guatemalan races of avocados. This species is very sensitive to varying changes of temperature and prefers and develops more abundantly in protected places. It is very abundant on trees on the Florida Keys and on islands along the southern coasts of Florida. The direct injury is caused by the white fly in the larval stages extracting the plant juices from the foliage. The indirect injury is caused by the resultant sooty mold on the foliage and fruit. Where this sooty mold is abundant considerable extra labor is required during packing to clean the fruit.

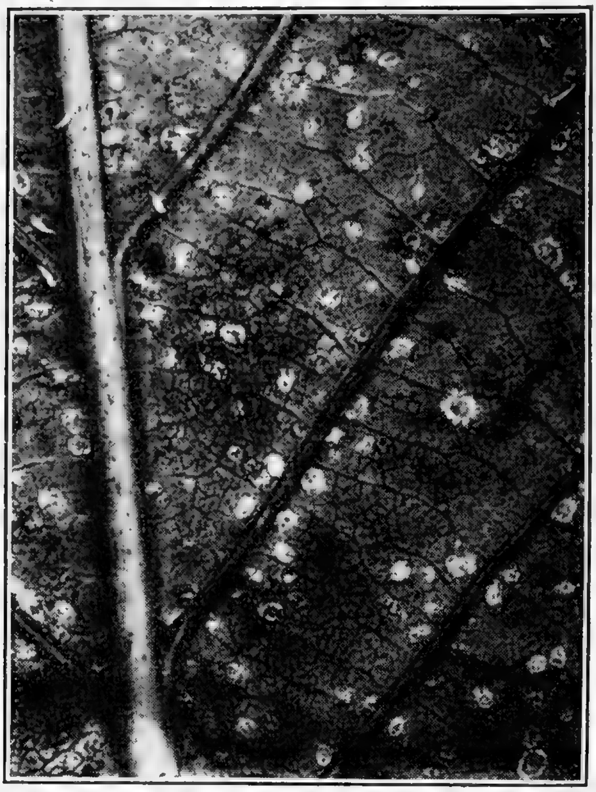

FIG. 5.—The avocado white fly: Pupæ on lower surface of avocado leaf.

SEASONAL HISTORY OF THE WHITE FLY.

During the dormant season of the avocado — December, January, and February—this species is inactive, remaining over on the foliage in the pupa stage (fig. 5). With the beginning of new growth in the spring, its activities commence and the adult is then to be found in great numbers on the new growth, depositing eggs (fig. 4). During the first part of March the adults usually are present and mate, and the females deposit their eggs on the lower surface of the young foliage. The eggs are very small objects, pearly white in color, and are usually placed in circles. During the spring and summer from 8 to 10 days are required for the egg to hatch. About 100 eggs are laid during the little over a week of its existence.

The young when hatched from the eggs are very small, oval in shape, of a yellowish color, and semitransparent, with two orange-colored areas showing in the body region. They soon settle down on some portion of the lower surface of the leaf and commence to extract the plant juices by means of their hairlike mouth parts. The young larvæ molt in about an average of 5 days. As they grow the body becomes more circular in outline, and during the process of growth quantities of honeydew collect on the tops of the individuals. Often these drops of honeydew become many times the size of the insect. The honeydew drops from the body of the larva on to the upper surface of the foliage or fruit, and the sooty-mold fungus is thus furnished with a medium in which to develop. The second molt of the larvæ occurs in an average of from 5 to 6 days, and the third, in an average of 7 days. The pupa stage during the spring and summer months averages from 15 to 30 days, and during the fall and winter from 3 to 6 months. The successive larval stages are quite similar in general appearance, varying only in size.

There are, on an average, three generations with a partial fourth varying according to locality and temperature conditions, much as in the case of the dictyospermum scale. Toward fall, usually the latter part of October, as the foliage becomes dormant, the white fly ceases its activities and goes into the winter in the pupa stage.

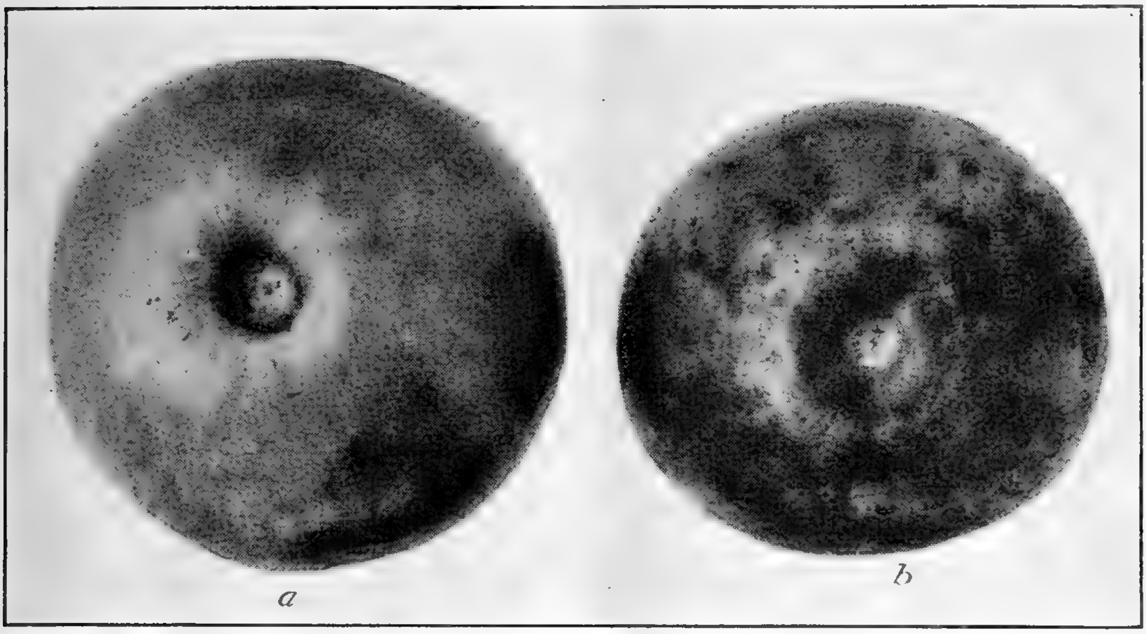

FIG. 6.—The avocado white fly: *a*, Clean fruit; *b*, top of avocado covered with sooty-mold fungus.

HOW IT MAY BE CONTROLLED.

The white fly may be controlled by spraying during the fall with an oil emulsion, preferably just as the foliage is commencing to harden, and repeating the operation some time during the spring after the fruit has set. The fall spraying for white flies should be made with 1 part oil emulsion to 70 parts of water and the spring spray should have the strength of 1 to 80. In spraying for white flies with an oil emulsion it is important that no free oil separates during spraying, and that the spray be directed so as to reach the lower surface of the foliage. Experience has shown that in spraying operations against the white fly spray rods are more satisfactory as it is quite difficult to reach the lower surface of the foliage with the spray gun, because the avocado tree bears branches close to the soil (fig. 8) and the foliage on these branches is more readily reached

FIG. 7.—The avocado white fly: Sooty-mold fungus on upper surface of avocado leaf.

with a spray rod than with a spray gun. Where two applications of oil emulsion are made for the white fly, and the spray is directed toward the twigs and branches which are infested with the scale, it will usually not be necessary to make an additional spray for the dictyospermum scale, provided the branches are well covered.

THE PYRIFORM SCALE.

Another scale insect found occasionally on the avocado in Florida is the pyriform scale.[3] The adult female scale (fig. 9), the stage which is usually observed on the foliage, is slightly convex, pyriform (pear shaped) in outline, transversely corrugated, of a reddish brown color, and about 3 millimeters (one-eighth inch) in length. The cottony matter projecting about the margin of the scale consists of curled waxy filaments. Among the

[3] *Protopulvinaria pyriformis* Ckll.

adult scales may be noted the young. They are small, oval, yellow creatures and do not possess the cottony mass about the margin. The adult male is a very delicate insect. It averages about 2 millimeters in length (one-twelfth inch), has an orange colored body and pale colored legs. The wings are clear and covered with very fine hairs.

CHARACTER OF INJURY.

The scales on the foliage extract the juices from the plant. During the development of the scales there is a rather constant secre-

FIG. 8.—The avocado white fly: Characteristic low branching of avocado tree. Lower branches are generally heavily infested, being more protected from the elements.

tion of honeydew, and frequently an individual scale will be covered with a drop of liquid many times its own size. This honeydew drops from the bodies of the scales onto the upper surface of the foliage and fruit, just as it does with white flies. During the humid summer weather the sooty-mold fungus finds there a suitable medium in which to develop and in course of time gives infested trees a very blackened, sooty appearance. The injury caused by the scale is two-fold: Extraction of the plant juices from the foliage and production of honeydew in which the sooty fungus develops, marring the appearance of the foliage and fruit.

SEASONAL HISTORY AND DEVELOPMENT.

During the dormant season of the avocado the pyriform scale is quite inactive. Infested trees during December, January, and February possess foliage covered with the female scales in a half-grown condition, maturity taking place in the spring. In March the female scales form cottony margins, and ultimately hundreds of eggs will be produced within these cottony masses in process of formation beneath the scales. During April the males emerge from those scales which have no evidence of cottony secretions. The writer has observed at various times in southern Florida males in great numbers during the middle and latter part of April. Evidently fertilization takes place at this time. The cottony masses in May are really little bags packed full of minute, yellowish, oval bodies. These are the eggs, and the white covering is merely an egg sac consisting of waxen filaments excreted from the lower surface of the scale. The eggs commence to hatch in great numbers during May, when rows of young scales may be seen upon the under surface along the lateral veins and ribs of the leaves.

FIG. 9.—The pyriform scale: Lower surface of avocado leaf, showing adult scales with characteristic white fringe; also young scales scattered among them, appearing as mere specks.

Many also occur in the interstices of the leaf surface between the veins. The scale spends its entire life cycle on the foliage, only migrating to the twigs in order to reach and reinfest the newer growth. During May and June great numbers of the young scales migrate to the newer growth, but many are lost with the shedding of the older leaves at this time of year. However, a sufficient number become established on the new growth to perpetuate the species. There are several generations in a year, overlapping considerably.

HOW IT MAY BE CONTROLLED.

The same methods as recommended for the dictyospermum scale may be used in the control of this scale, handling the spray rods so as to reach the underside of the foliage and get the spray to the scales.

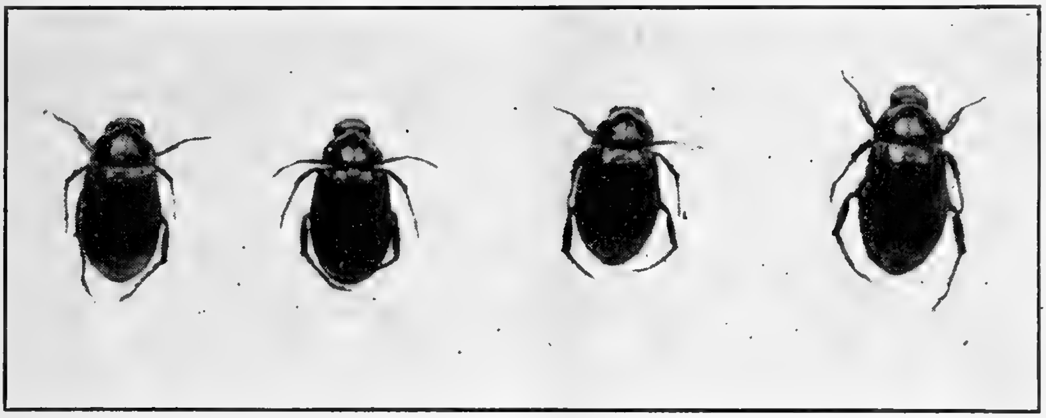

FIG. 10.—The blossom Anomala: Adult beetles. About 2½ times natural size.

THE BLOSSOM ANOMALA.

When the avocado is in bloom it may be visited in swarms by a beetle, the blossom Anomala, which may cause serious damage. Up to this time the writer has not observed this beetle to be generally distributed at blossoming time, though it may be found present in groves in certain localities, while other groves escape. The following year the infested groves of the previous year may escape, and others may be visited by this blossom-devouring pest. The adult beetle[4] (fig. 10) has a black thorax with a yellowish border, the wing covers yellowish brown, with two cross-rows of ill-defined black spots, sometimes almost wanting. It varies in size from one-fourth to five-sixteenths inch in length. Variations of the color may occur, and the writer has found on a number of occasions nearly black forms. The species is closely related to the so-called May beetles. Up to this time the larva form has not been found.

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[4] *Anomala undulata* Mels.

Judging, however, from related species the larvæ must be closely similar, except for their smaller size, to the white grubs, or May beetle larvæ, not only in general appearance but more or less in habits also.

CHARACTER OF INJURY.

When present in groves, these beetles may be found attacking all portions of the blossom spike, in many instances completely stripping the spikes of the individual blossoms (fig. 11). Often the beetles will completely girdle the spike and frequently cut it off as with a knife. Usually the beetles confine their attacks to the more tender floral parts, destroying the individual floral clusters about the spikes. The writer observed that during the day numerous freshly injured floral spikes could be found, but the presence of the destructive pest causing the damage could not be detected about the bloom or anywhere on the trees. It was observed, however, that below the trees numerous small holes were present in the soil. Upon examination it was found that in the soil at a depth of from 1 inch to 2 inches a considerable number of small beetles were present in a quiescent stage as if playing possum. After a few minutes' exposure to the light the beetles became active and immediately dug their way into the soil. Various groves were visited during the dusk and evening, when it was observed that the beetles, found in the soil during the day, were present in great numbers feeding upon the blossom spikes. In other words, the adult beetles are nocturnal in their feeding habits.

FIG. 11.—The blossom Anomala: Showing characteristic stripping of the blossom spikes by the adult beetles.

HOW IT MAY BE CONTROLLED.

The best means of control is to spray the blossom spikes with a poison as soon as any signs of injury to the bloom are detected. By spraying with a solution of 1½ pounds of powdered arsenate of lead to 50 gallons of water the beetles will be killed or forced to seek new feeding grounds. It is essential that the spraying outfit be equipped with a good agitator, as the poison has a tendency to settle rapidly to the bottom of the spray tank unless it is kept in suspension by agitation. The spray should be directed at the blossom parts particularly, as the beetles do not attack the dormant foliage, and little if any new growth is present on the plant at the time of blossoming.

THE AVOCADO LACE-BUG.

An insect which often is on the avocado in considerable numbers during the dry winter months is the avocado lace-bug.[5] The group of insects to which it belongs gets its common name from the characteristic lacelike pattern of the wings (fig. 12). This lace-bug is blackish-brown in color and about 2 millimeters (one-twelfth inch) in length. The wings covering the body are somewhat iridescent and the legs are yellowish white.

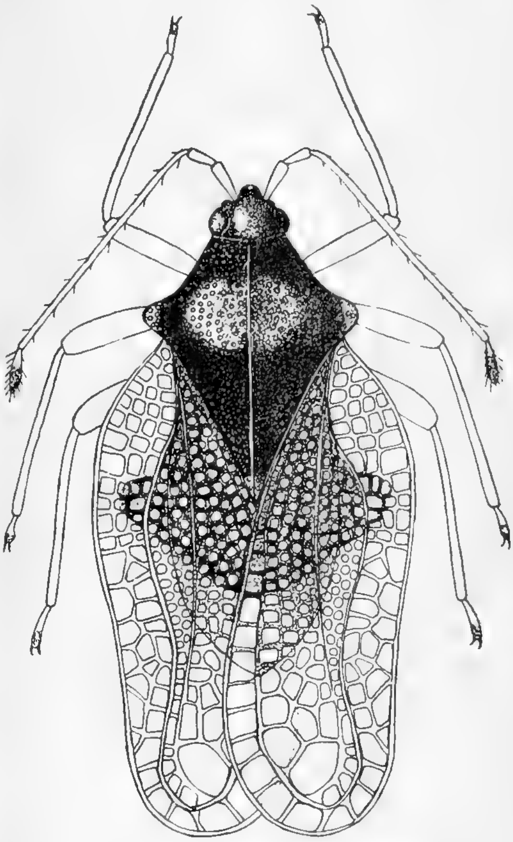

FIG. 12.—The avocado lace-bug: Adult, greatly enlarged.

CHARACTER OF INJURY.

The lace-bug confines its attacks to the lower surface of the foliage, where it feeds by extracting the juices from the plant. It usually lives in colonies, depositing eggs in clusters on the lower surface, which are placed upright in irregular rows. The extraction of the juices from the foliage causes a gradual destruction of the plant cells, resulting in yellow areas which may be observed on the foliage as viewed from above and which indicate the presence of the lace-bugs. Where a colony of these insects is present, the eggs and the lower surface of the leaf are more or less thickly covered by a dark, sticky secretion from the insects (fig. 13). The principal injury, however, is the destruction of the leaf cells due to the sucking habit of the insects.

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[5] *Acysta perseae* Heid.

CONTROL.

By spraying with 40 per cent nicotine sulphate at the rate of 1 part to 900 parts of water, with the addition of 1 or 2 pounds of fish-oil soap to each 50 gallons of the diluted spray solution, the lace-bug is readily controlled. The soap will cause the spray to spread more

FIG. 13.—The avocado lace-bug: Injury to leaf of avocado.

readily over the foliage, to stick, and not to fall off in small drops. If the red spider is present at the same time the lace-bugs are doing their work, the nicotine sulphate solution may be added to the lime-sulphur solution in the same manner as when the leaf-infesting thrips is present.

THE AVOCADO BLOSSOM THRIPS.

During the blossoming period the avocado is visited by a destructive flower thrips.[6] In structural appearance this thrips resembles most other blossom or flower thrips. It averages about a millimeter (one twenty-fifth inch) in length and in general color it is pale yellow. The species was first collected in the mountains at Guadalajara,

FIG. 14.—The avocado blossom thrips: Showing egg punctures and emergence holes caused by adult thrips in petioles of avocado bloom.

Mexico, on a small native acacialike plant. How it gained entrance to this country is not known.

CHARACTER OF INJURY.

The West Indian varieties of avocado seem to be its favorite hosts, particularly the Pollock and related sorts, although the Guatemalan varieties are also attacked during the blooming period. The thrips work extensively in the flowers, and as they gradually increase they deposit eggs in great numbers in the stems bearing the flower cluster and also in the petioles of the individual flowers (fig. 14). In so doing the petioles supporting the individual flowers are much weak-

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[6] *Frankliniella cephalicus* Craw.

ened, and frequently there is a considerable shedding of the bloom due to this work. The principal injury caused by the thrips, however, is due to its feeding on the stamens and the flower parts. The thrips does not attack the fruit.

HOW IT MAY BE CONTROLLED.

The avocado blossom thrips may be controlled by spraying with 40 per cent nicotine sulphate solution at the rate of 1 part to 900 parts of water with the addition of 3 or 4 pounds of soap to each 100 gallons of the diluted spray. The grower should not wait until

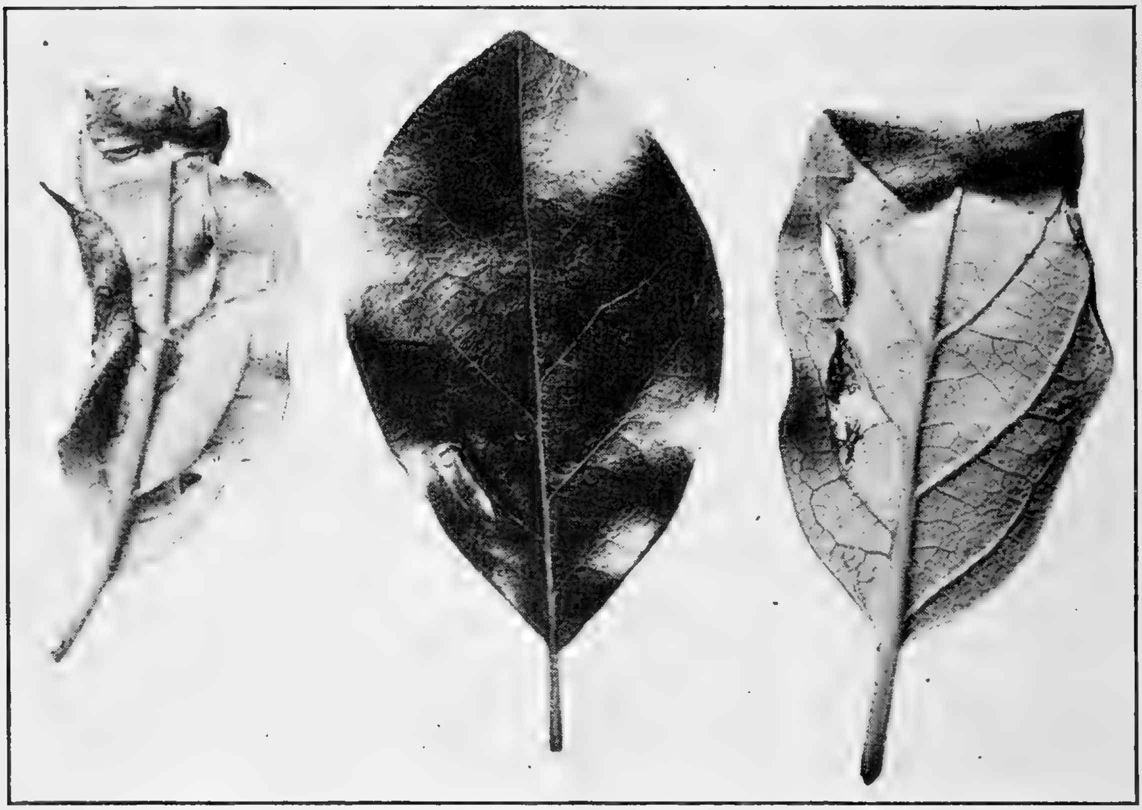

FIG. 15.—The avocado leaf roller: Avocado leaves showing rolling of foliage by the larvæ and cocoons in folds of leaf.

the trees are in full bloom but should start spraying as soon as a number of thrips are observed about the blossom cluster. The spraying should be repeated in from 8 to 10 days, if the thrips are abundant about the bloom. The spraying should be directed so as to enter the blossoms.

THE AVOCADO LEAF-ROLLER.

An insect present on the avocado in June and July is the avocado leaf-roller.[7] It is a very small moth, grayish is color, about one-fourth inch long. It deposits its eggs singly on the new growth, often each young leaf in a terminal cluster bearing a single egg. The young larvæ which emerge from these eggs feed on the lower sur-

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[7] *Gracilaria perseae* Busck.

face of the foliage, and in so doing roll the leaves back from the tip (fig. 15). When the larvæ mature they often construct silken cocoons in the folds of the leaf and there pupate. Often where the leaf-rollers have been numerous in the spring, the foliage eventually presents a very ragged appearance.

HOW IT MAY BE CONTROLLED.

Spraying the new growth with powdered arsenate of lead at the rate of 2 pounds to 100 gallons of water has proved successful in controlling the leaf-roller. The spray tank should be fitted with a good agitator, as the poison has a tendency to settle to the bottom if not kept constantly stirred.

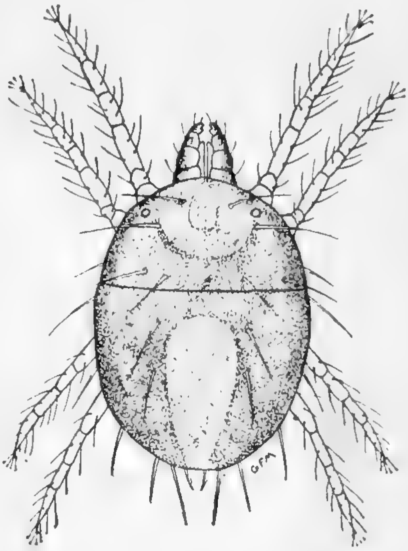

FIG. 16.—The avocado red spider: Adult. Greatly enlarged.

THE AVOCADO RED SPIDER AND THE LEAF-INFESTING THRIPS.

Among the insect pests which attack avocado foliage are two which cause considerable damage during the dry winter months. These two pests are the avocado red spider[8] and a leaf-infesting[9] thrips, commonly known in the North as the greenhouse thrips, but which works on the avocado in the open in Florida. The red spider of the avocado (fig. 16) is similar in shape and appearance to other red spiders, its habits only varying in that it confines its attacks to the upper surface of the foliage. The leaf-infesting thrips is similar to most other thrips, is dark brown in color, and about 1 millimeter (one twenty-fifth inch) in length (fig. 17).

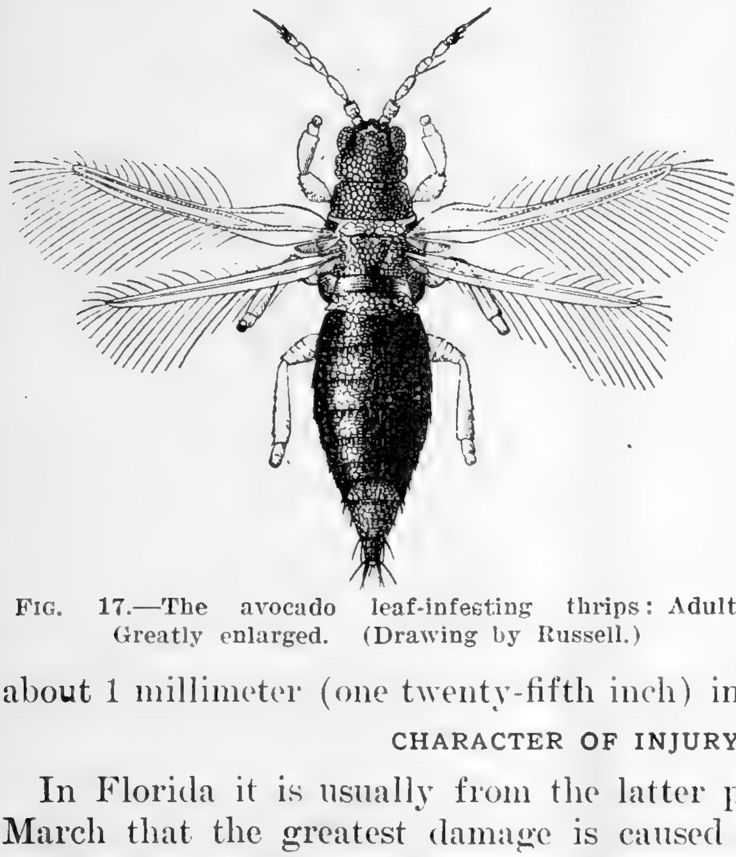

FIG. 17.—The avocado leaf-infesting thrips: Adult. Greatly enlarged. (Drawing by Russell.)

CHARACTER OF INJURY.

In Florida it is usually from the latter part of November until March that the greatest damage is caused to the avocado by the red spider and the leaf thrips. The abundance of either pest

[8] *Tetranychus yothersi* McG.

[9] *Heliothrips haemorrhoidalis* Bouché.

during this period depends chiefly on the existing climatic conditions. Unlike most other red spiders which attack various other fruits, the red spider of the avocado confines its attacks to the upper surface of the foliage. This is also true of the thrips.

Avocado orchards heavily infested with red-spider mites appear in a short time as if scorched by fire. The foliage attacked turns

FIG. 18.—The avocado red spider: Defoliation caused by excessive infestation of these mites on avocado tree.

brown and drops prematurely and frequently there is a heavy denudation as a result of their depredations (fig. 18). Their numbers increase so rapidly that the damage caused by the mites and thrips becomes noticeable in a very short period of time. *The grower should not delay spraying until the trees have commenced to turn brown, but should be on the lookout for the pests. Their presence on the trees in excessive numbers should be the signal for the grower to start control measures while the foliage is still green.*

The red spiders and thrips usually start work at the base of the leaf, and as the succeeding generations appear they extend their feeding grounds until the entire leaf is infested. The first indication of red spiders and thrips on the foliage is the pale spots scattered about over the leaf surface. These represent the feeding places, and as

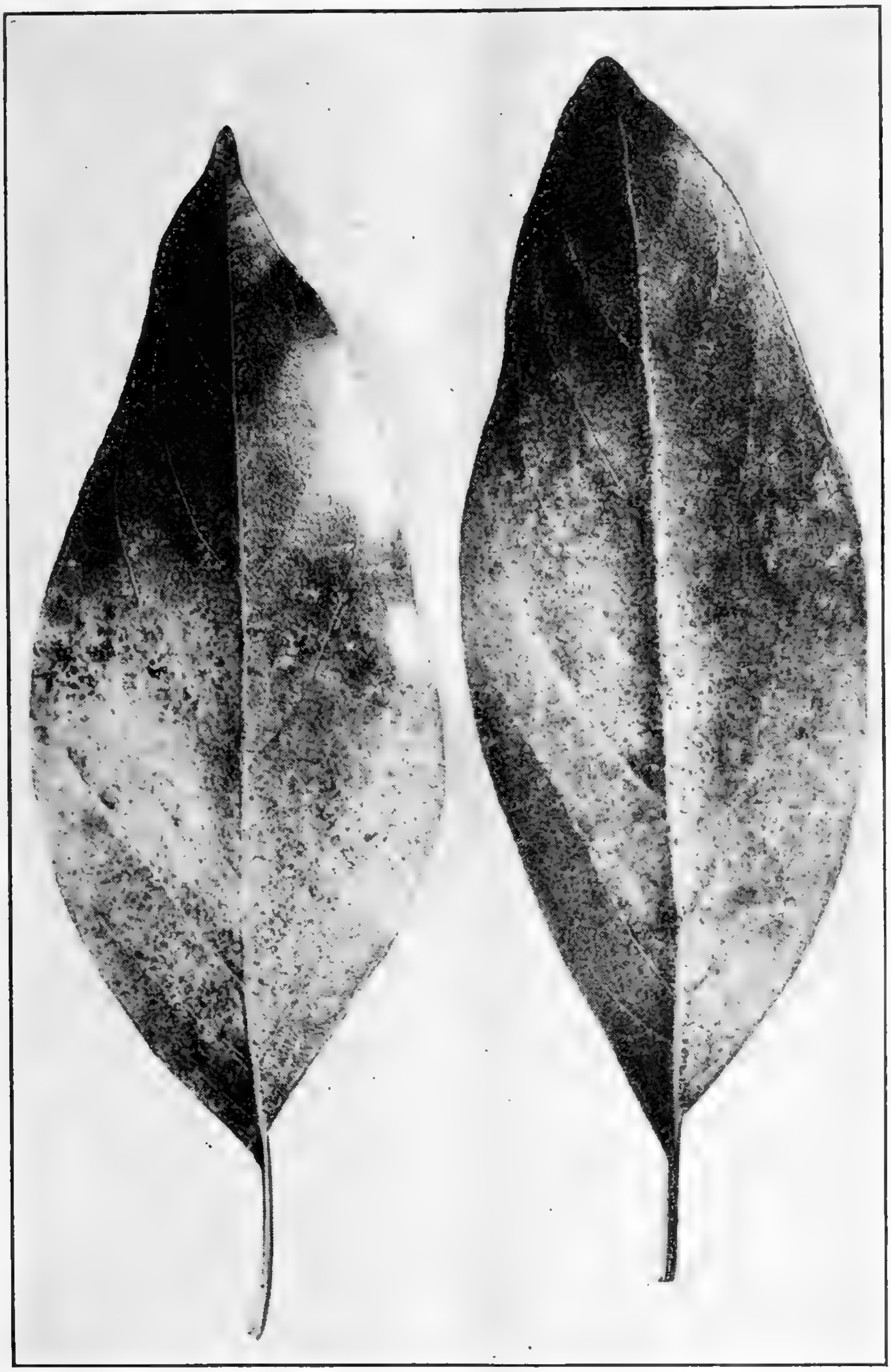

FIG. 19.—The avocado leaf-infesting thrips: Damage to upper surface of avocado foliage.

they become numerous most of the functional green matter in the leaf is absorbed, and in time such a leaf turns brown and is of little use to the tree. Usually the red spiders and the thrips do not work on the same leaf. The attacks of the thrips have not been found by the writer to be as severe as those of the red spider. The leaf-infesting thrips of the avocado is to be found toward the center of the tree, but also on the outer protected branches. It evidently prefers, and multiplies more rapidly in, the sheltered and protected places. The work of the thrips may be distinguished from that of the red spider in that the surface, in addition to possessing the pale-colored spots where the chlorophyll has been extracted by the thrips, also becomes thickly covered with minute drops of blackish fluid voided by them (fig. 19). Where excessive defoliation takes place, abnormal blooming usually occurs the following spring. Where trees obtain a sufficient amount of water and food of the proper kind, usually less trouble is experienced from the red-spider mite. The avocado requires plenty of water and is a heavy feeder.

HOW THE RED SPIDER AND THRIPS MAY BE CONTROLLED.

If red spiders and thrips become active on the avocado while the fruit is still on the trees in the early fall and are doing serious damage, it will be necessary to spray with fish-oil soap at the rate of 5 pounds to 100 gallons of water, plus 40 per cent nicotine sulphate at the rate of 1 part nicotine sulphate to 900 parts of the diluted soap solution. By so spraying the red spider and thrips will be held in check until after the fruit has been harvested. The soap and nicotine spray is only temporarily effective and does not act against the red spider over a period of several weeks as does the lime-sulphur spray, but as lime-sulphur adheres to the fruit and is difficult to remove, the writer recommends the soap while the fruit is still unpicked.

If the red spiders and thrips become abundant in a young grove which has not reached the bearing age, lime-sulphur concentrate should be used at the rate of 1 part to 60 parts water, plus 40 per cent nicotine sulphate at the rate of 1 part nicotine sulphate to 900 parts of the spray. If thrips are not present, the nicotine sulphate solution should be omitted. In using lime-sulphur solution it is advisable to use a strength of 1 gallon of the concentrate to 75 gallons of water during winters when the temperature is above the normal and when the trees do not attain a thoroughly dormant condition.

Fish-oil soap and nicotine generally afford only temporary relief against the red spiders, and if these mites continue to work after the fruit has been picked, it will be necessary to spray again. During the winter after the foliage has hardened no injury from the use of lime-sulphur as recommended above has been noted by the writer. Where the thrips are not present at this time it will not be necessary to use the nicotine-sulphate solution in combination with the lime-sulphur.

Where an avocado grower contemplates combating white flies and scale insects also during the fall or dormant season, application of the

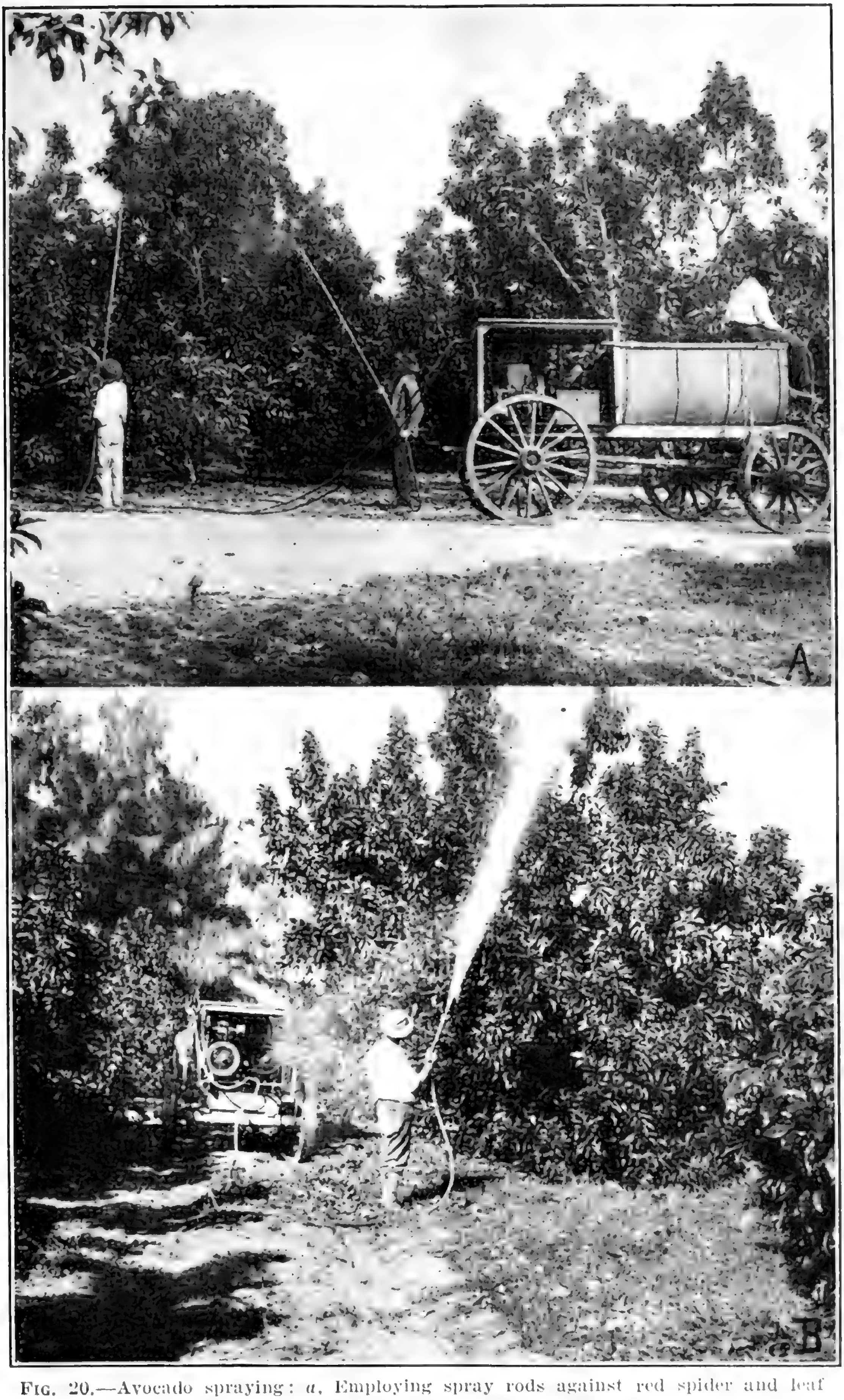

FIG. 20.—Avocado spraying: *a*, Employing spray rods against red spider and leaf thrips; *b*, employing spray gun against the same.

oil-emulsion sprays should be so timed as not to interfere with the lime-sulphur sprays. The oil-emulsion sprays should not be put on immediately following a lime-sulphur spray or foliage injury may be experienced. The two sprays will not mix. The oil emulsions have a cleansing quality and loosen sooty mold, lime, and any foreign matter adhering to the foliage. A great deal of benefit which would have been derived from the lime-sulphur will be lost by applying an oil emulsion over it.

There are a number of ordinary commercial lime-sulphur concentrates on the market which are satisfactory, or the grower can make his own lime-sulphur concentrate if he is prepared to do so. Since the lime-sulphur spray kills the mites largely by contact, it is important that the spray be thoroughly applied in order to reach all of them. This is also true in the case of the thrips when the nicotine sulphate is incorporated with the lime-sulphur spray or is used with the fish-oil soap. From the writer's observations, the lime-sulphur is not effective against the eggs of the red spider, as it kills only a small portion of them. The lime-sulphur is not dependent for its efficiency entirely on contact. Its effectiveness is more or less lasting, and consequently the young which may hatch from eggs not killed will succumb soon after. In about three weeks after spraying avocados for red spiders and thrips another spraying will usually be necessary to protect the trees from further attack. Subsequent applications will depend upon weather conditions and the activities of the pests during the winter season. Usually two sprayings, or three at the most, during the winter will suffice for both the red spiders and thrips.

The writer in comparing the spray gun (fig. 20, *b*) with spray rods (fig. 20, *a*) has found that the spray gun gave better satisfaction, especially on large avocado trees. Where the rods were used, considerable inefficient spraying was done on the upper half of the tree. This was seen to occur especially during the latter part of the day, when the spray rod became heavy to the operator. In spraying the young grove, however, the rods work to a somewhat better advantage.

DUSTING VERSUS SPRAYING FOR THE CONTROL OF THE AVOCADO RED SPIDER AND LEAF THRIPS.

Certain contact insecticides which are being used in the liquid form for combating insects are also being manufactured in the dry powdered form as contact insecticides. These are being manufactured separately, and in combinations to be applied for a number of evils existing at the same time. Recently a number of orchard tests have been made by the writer to ascertain the relative merits of several contact insecticides in the dust or powdered form, alone and in combination, and similar contact insecticides in the liquid form, in the control of these two pests of the avocado.

In conducting the dusting operations the equipment used was a large power duster (fig. 21), which is provided with a gasoline engine driving a fan capable of rotating approximately 2.500 revolutions per minute and of producing a forced current of air which is directed through the bottom of a hopper holding the dusting material. It picks up the dust particles, forcing the material out through a long pipe and producing a dense, smokelike cloud. The

Fig. 21.—Power duster in operation against red spider on avocado trees.

spraying work was performed the same day, a power outfit being employed, using one of the spray guns (fig. 20, *b*) at a pressure ranging from 225 to 250 pounds. At the time when the materials were applied the foliage was dry and the temperature averaged 75° F.

In the dusting experiments several kinds of material were used, among them an impalpable sulphur dust. This sulphur dust is nearly pure sulphur, very finely pulverized, capable of going through a 200-mesh screen. The other material used was a combination consisting of the above sulphur dust impregnated with a quantity of 40 per cent nicotine-sulphate solution. In the spraying work several sprays were tried out in comparison with the foregoing dusts, viz—lime-sulphur concentrate, 1 part to 60 parts water, alone and in combination with 40 per cent nicotine sulphate, at the rate of 1 to 900 in the diluted lime-sulphur solution. A portion of a block was reserved as a check.

Subsequent examination of the dusted and sprayed portions of the grove showed that the dusting method, where the dry dusting sulphur in an exceedingly pulverized form was used, was equally as effective as spraying with lime-sulphur against the avocado red spider. The mites were not killed immediately on the dusted trees, but after 30 minutes were practically all dead. On examination of the foliage with a hand lens the sulphur was found very evenly applied, no portion of the upper surface of the foliage being free from the fine sulphur. The dry sulphur dust adhered remarkably well to the avocado foliage, which has a slightly pubescent surface. The dry sulphur dust remained on the foliage effectively over as long a period of time as did the liquid lime-sulphur against the red-spider mite. This showed that the foliage did not have to be wet with dew, but that the sulphur dust could be applied effectively to the dry foliage.

Where a large acreage of avocados exists, and the red spider is the only pest with which the grower has to contend, dusting is much the quicker method of control. Where the lime-sulphur solution was applied it killed the red spiders by contact almost immediately.

Neither the dry sulphur dust nor the liquid lime-sulphur solution had any effect in ridding the foliage of the thrips present in considerable numbers on the trees. When the red spiders are present there are usually other pests, such as the leaf thrips and avocado lace-bug. To control these by the dusting method the writer procured a dusting material consisting of the finely pulverized sulphur charged with 40 per cent nicotine sulphate. This material was dusted in the same manner as was the dry dusting sulphur. This combination readily killed the adult and immature red spiders, the leaf thrips, and such lace-bugs as were present. The material, however, did not adhere to the foliage for any length of time, even heavy dews removing most of the dust. This apparently was due to the incorporation of the liquid nicotine sulphate into the dry, finely pulverized sulphur, which caused the sulphur particles to aggregate and also formed a wettable sulphur. In the case of the dry sulphur dust the sulphur is in such a dry and impalpable state on the foliage that it adheres effectively. The continued heavy dews gradually removed most of the combination contact insecticide from the foliage and in a short time after application the red spiders were again present on the trees in as great numbers as before, having been hatched from the eggs which were not destroyed by the dust. It is essential that the dust remain on the foliage for a sufficient length of time after application to destroy the young mites subsequently hatched.

A combination of the lime-sulphur concentrate, at the rate of 1 part to 60 parts of water, plus the 40 per cent nicotine sulphate solution, at the rate of 1 to 900 in the diluted lime-sulphur solution, proved an excellent spray in killing the red spider, thrips, and lace-bug. It also wet thoroughly the branches and killed the young of the dictyospermum scale with which it came in contact. The lime-sulphur solution in this combination proved effective over as long a time as did the lime-sulphur used alone against the red spider on the trees.

CONCLUSIONS RELATIVE TO DUSTING AND SPRAYING.

1. The dusting method with dry sulphur dust in a finely divided form was found to be equally as effective in keeping avocado trees free from red spiders as the spraying method with liquid lime-sulphur solution. When the red spider is the only pest present in the avocado grove the dusting method will prove effective, especially at critical times, as it is much the quicker method. It is not necessary that the foliage of the avocado be wet with dew in order effectively to apply the dry sulphur dust.

2. Sulphur in any of the combinations used did not control the leaf thrips or leafhoppers, but nicotine sulphate solution when combined with either lime-sulphur solution or dry dusting sulphur will destroy them.

3. Dry sulphur dust when charged with nicotine sulphate in the form of 40 per cent nicotine sulphate and applied to avocado foliage was readily removed by heavy dews and light rains after application. Apparently the addition of the liquid nicotine sulphate caused a wettable sulphur. Soon after the first heavy dews, red spiders appeared on the trees where this material had been used, nothing remaining to destroy the young mites as they were hatched from the eggs.

4. Liquid lime-sulphur solution when combined with nicotine sulphate proved to be the most satisfactory combination used in killing both the red spider and leaf thrips and also the lace-bug. The combination remained effective over as long a period as did the lime-sulphur alone against the red spider.

5. Where a grower has a medium sized grove of avocados in which a number of insect pests occur, spraying is the more effective method in combating the evils with which he has to contend.

SUMMARY OF RECOMMENDATIONS.

The dictyospermum scale may be controlled by spraying with an oil-emulsion spray during December, January, and February, using a strength of 1 part emulsion to 70 parts of water. Two applications with a three-week interval are recommended. The same treatment is recommended for the pyriform scale.

The avocado white fly may be controlled by spraying as the foliage is hardening in the fall, usually September, with an oil emulsion at a strength of 1 part to 70 of water and repeating the spray during the spring after the fruit has set, using a strength of 1 to 80. Where the branches are covered with the spray these two applications will suffice against the dictyospermum scale and the pyriform scale.

The blossom Anomala may be controlled by spraying with powdered arsenate of lead at the rate of 1½ pounds to 50 gallons of water. Care should be taken that the spraying outfit is fitted with a suitable agitator.

The avocado blossom thrips may be controlled by spraying with 40 per cent nicotine sulphate solution at the rate of 1 part to 900 parts of water plus 3 pounds of soap to each 100 gallons of the diluted solution. If thrips are abundant spraying should be repeated in from 8 to 10 days.

The avocado leaf-roller may be controlled by spraying with powdered arsenate of lead at the rate of 2 pounds to 100 gallons of water. A good agitator should be fitted to the spray tank to keep the poison in suspension.

The avocado lace-bug may be controlled by spraying with 40 per cent nicotine sulphate solution at the rate of 1 part to 900 parts of water with the addition of 1 or 2 pounds of fish-oil soap to each 50 gallons of the diluted spray.

The avocado red spider and leaf thrips may be controlled while the fruit is still unpicked by using fish-oil soap at the rate of 5 pounds to 100 gallons of water plus 40 per cent nicotine sulphate at the rate of 1 part to 900 parts of the diluted soap solution. After the fruit has been picked and the red spider and thrips are again becoming injurious, lime-sulphur concentrate, 1 part to 60 parts of water or 1 to 75, depending on weather conditions, with the nicotine sulphate solution incorporated at the rate of 1 part to 900 parts of the diluted lime-sulphur solution, may be used. It is recommended that the oil-emulsion sprays should not follow immediately after a spraying of lime-sulphur as the oil-emulsion sprays possess a cleansing quality and remove the lime-sulphur from the foliage. Burning is also likely to result. It is advisable to allow a three-week interval before application of any oil-emulsion spray, in order that the full benefit from the lime-sulphur application may be derived.

Care should be taken when using oil emulsions with "hard" or brackish waters to see that no free oil separation occurs during spraying. Free oil is detrimental to the foliage of the avocado. Where considerable free oil forms in the spray tank, much of the efficiency of the spray is lost, as the oil is the principal killing agent in the oil emulsion.

FOREIGN INSECT ENEMIES OF THE AVOCADO.

The avocado in its native lands has a number of very destructive insect enemies, which, were they to gain entrance to the United States, would prove unquestionably more destructive than any existing in this country at the present time. The Department of Agriculture, being fully aware of the possibilities of the introduction of dangerous foreign avocado pests, has, with the cooperation of the several States where the avocado is now being grown, established rigid quarantines and is doing everything possible to protect this valuable fruit industry.

A very destructive pest liable to introduction into the United States is an avocado weevil[10] occurring in Mexico and Guatemala. In general appearance this weevil, which averages three-fifths of an inch in length, is very dark brown, and the wing covers bear two conspicuous transverse bands of densely placed hairs. It infests the seed of the avocado particularly, but will also feed upon the flesh of the fruit. The larvæ breed and tunnel through the tissues of the seed, making the fruit worthless.

Another dangerous weevil[11] of the avocado with similar destructive characteristics occurs in Guatemala. In general appearance it is shining black in color. The wing covers are moderately clothed with hairs of three colors intermixed—rose-red, rather pale brownish, and a few white. It averages about one-fourth inch in length.

Still another pest of prime importance is the Mediterranean fruit fly.[12] This notorious and widespread enemy of cultivated fruits is present and causes havoc in a few foreign countries where the avocado is grown.

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[10] *Heilipus lauri* Boh.
[11] *Conotrachelus perseae* Barber.
[12] *Ceratitis capitata* Wied.

How To Do It

DO YOU WANT practical suggestions on how to build a silo, a hog house, a poultry house, a potato-storage house, or how to make a fireless cooker, or other farm home convenience? Are you seeking ideas on how to prepare vegetables for the table, how to care for food in the home, how to bake bread and cake and other appetizing foods in an efficient and economical manner? Is there some practical question about your corn or wheat or cotton or other crops, or about your poultry or live stock, to which you are seeking an answer? The answers to thousands of such questions and practical suggestions for doing thousands of things about the farm and home are contained in over 500 Farmers' Bulletins, which can be obtained upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C.

FARMERS' BULLETIN 1262
UNITED STATES DEPARTMENT OF AGRICULTURE

The BOLL-WEEVIL PROBLEM

Methods of REDUCING DAMAGE

THIS BULLETIN gives a general account of the boll-weevil problem. It deals with the history of the insect in the United States, the damage it has done in different regions, the reasons for local variations in damage, the indications for the future, the habits of the weevil so far as they affect control measures, and the means of reducing the injury.

By experiments begun by the Bureau of Entomology in 1914 and continued to the present time, it has been found that the application to all parts of the cotton plant of a poison known as powdered calcium arsenate, or arsenate of lime, will control this pest to a large extent. This chemical has come into rather wide use in the cotton belt and when used strictly according to directions it has given excellent results. When directions given by the Bureau of Entomology are not followed, however, failure and loss are sure to result. DO IT RIGHT OR NOT AT ALL.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. February, 1922

THE BOLL-WEEVIL PROBLEM.[1]

W. D. HUNTER, *Entomologist in Charge*, and B. R. COAD, *Entomologist*, *Southern Field-Crop Insect Investigations.*

CONTENTS.

ORIGIN, SPREAD, AND PRESENT DISTRIBUTION OF THE BOLL WEEVIL.

THE COTTON BOLL WEEVIL[2] is not a native of the United States. Its first home was undoubtedly in the plateau region of Mexico or Central America. Previous to 1892 the insect had spread through much of Mexico, but little is known regarding the extent or rapidity of this dispersion. The records indicate, however, that it probably had caused the abandonment of cotton in certain regions. About 1892 the boll weevil crossed the Rio Grande near Brownsville, Tex. It may have flown across or it is possible that it was carried over in seed cotton to be ginned at Brownsville. By 1894 it had spread to half a dozen counties in southern Texas. A preliminary examination, made during that season under the direction of Dr. L. O. Howard, Chief of the then Division of Entomology, by Mr. C. H. T. Townsend, showed the enormous capacity of the pest to do damage. Subsequent events have verified in every way the predictions that were made at that time, when the insect had not attracted much attention in the South. Since 1894 the boll weevil has extended its

[1] This bulletin is a revision of Farmers' Bulletin 848.
[2] *Anthonomus grandis* Boh.; order Coleoptera, family Curculionidae.

range annually from 40 to 160 miles, although in several instances the winter conditions have caused a decrease in the infested area. During the first 10 years after its advent into this country the annual rate of spread of the weevil was 5,640 square miles. From 1901 to 1911 the annual increase in the infested territory averaged 26,880 square miles. In 1916 it reached 71,800 square miles. Of course, the figures given do not refer to the area in cotton. In many parts of the infested territory the area devoted to cotton is much less than 10 per cent of the total area.

The territory in the United States in which the boll weevil occurred at the end of the year 1921 is shown in figure 1. At the end of that year over 600,000 square miles of territory had been infested by the boll weevil, leaving only about 105,000 square miles of cotton-producing territory uninfested. Practically 85 per cent of the cotton belt is now infested by the weevil, and the area now infested produces 94.6 per cent of the cotton crop of the cotton belt of the United States.

A form of the boll weevil is found in the mountains of Arizona feeding upon a wild plant related to cotton. This variety has been under observation for a number of years, and finally was noted in 1920 attacking cultivated cotton north of Tucson, Ariz., between that city and the Santa Catalina Mountains. The State of Arizona is attempting to eradicate this infestation by a noncotton zone in the infested district.

The boll weevil is known throughout the larger portion of Mexico and southward to Guatemala and Costa Rica. It is known to occur also in the eastern half of Cuba.

DAMAGE.

The losses caused by the boll weevil are both direct and indirect, and extend throughout practically the entire financial and economic structure of the cotton belt. It is impossible to estimate the losses due to depreciated land values, closing down of cotton gins and oil mills, and other indirect results of the weevil invasion. All estimates have been made entirely on the basis of the direct loss in nonproduction of cotton lint and seed. The Bureau of Crop Estimates of the United States Department of Agriculture in the fall of 1920 estimated an average annual loss for the last four years of about $300,000,000. Other estimates have differed somewhat, but certainly the annual direct loss is now well in excess of $200,000,000.

The damage in individual fields is influenced by many factors and varies widely, ranging from slight injury to complete destruction of the cotton crop. A fair idea of the possibilities of loss is afforded by the gains which have been secured in recent poisoning experi-

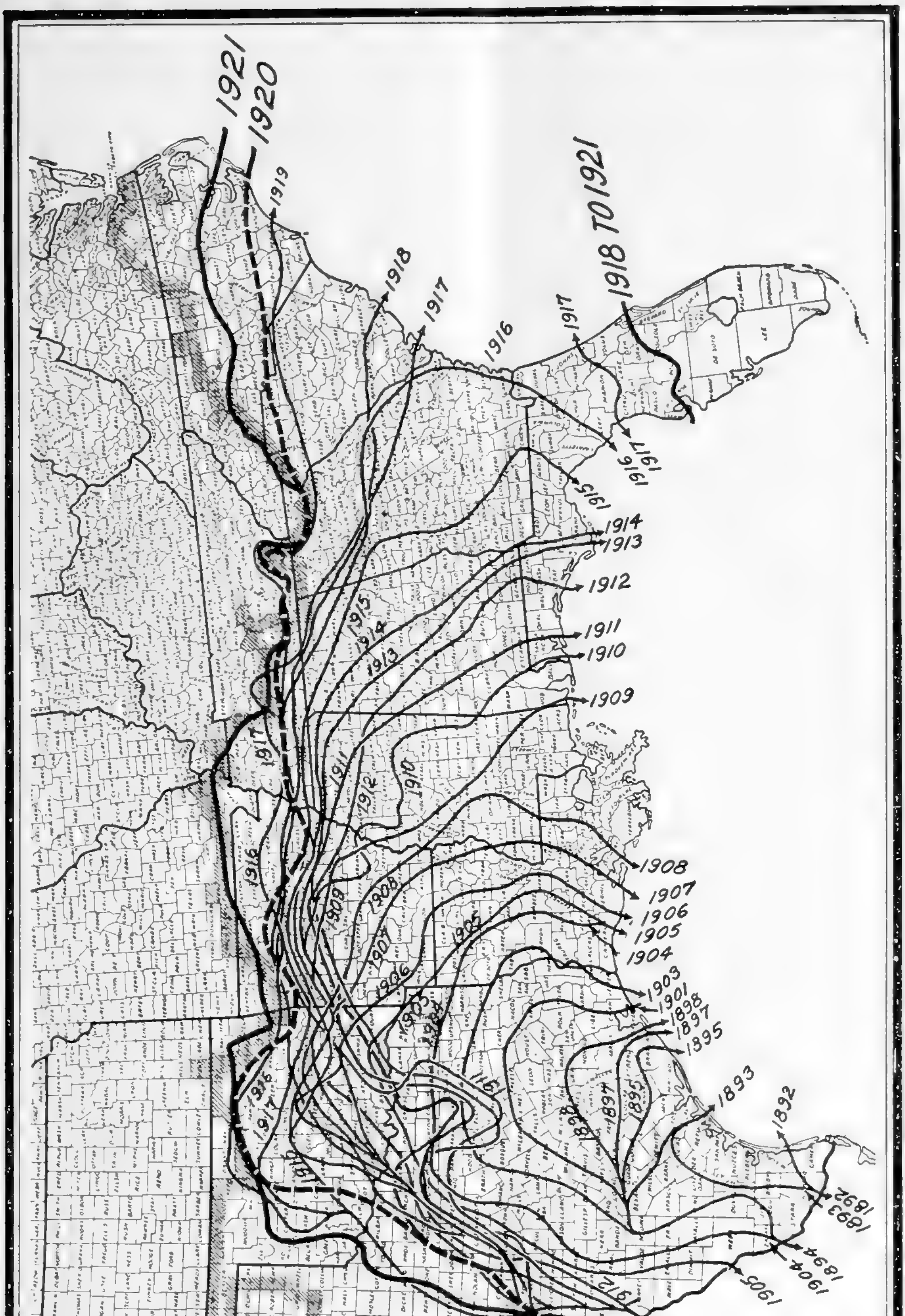

FIG. 1.—Map showing spread of the boll weevil in the United States from 1892 to 1921, inclusive.
NOTE: The outer limits of the cotton belt advance or recede slightly from year to year, and ~~Mexican cotton~~ as shown on the map are not entirely accurate for 1921.

ments where weevil injury has been eliminated. Gains of five, six, or even seven hundred pounds of seed cotton per acre due to poisoning are not unusual, and in exceptional instances gains have exceeded one thousand pounds.

PROSPECTS IN NEWLY INVADED TERRITORY.

The boll weevil is now distributed over almost all of the important cotton-producing sections with the exception of North Carolina. Practically the only other territory remaining uninfested is the zone along the western margin of the cotton belt. Some of this territory has been invaded in the past and the weevils have been driven back by adverse weather conditions. Whether the weevil will ever become seriously injurious in this territory is problematical, but it has shown marked ability to adapt itself to unfavorable conditions. Just how far this adaptation will extend it is impossible to predict.

The progress of the weevil invasion has caused one erroneous impression. When the weevil invades a new district complaint is made of its serious injury to the cotton crop during the first two or three years, and then little more is heard of it. This naturally leaves the impression that the weevil is seriously injurious in a new territory for only a few years and then passes onward. This impression, howver, is not substantiated by facts. It is true that when weevils first invade a community there is nearly always more or less panic and a decided tendency to blame the weevil invasion for all short crops of cotton regardless of the real causes. Furthermore, the successful production of cotton in the presence of weevils requires somewhat different methods from those practised before the advent of the weevil, and it usually takes the farmers two or three years to learn and adopt these methods. After a few years the farmers become accustomed to the weevil injury, learn to distinguish between loss due to the weevil and that attributable to other causes, and are able to reduce weevil injury somewhat by proper farming practices. The first fear has been overcome, and comparatively little is said on the subject. Farmers in the eastern portion of the cotton belt even express the idea that the weevil is no longer doing any damage in Texas. Yet the cotton-growing season of 1921 has shown a total of more weevil damage in the State of Texas than that of any previous year. Once established in a community weevil injury will continue, and when weather conditions favorable to weevil survival and multiplication are experienced serious injury must be expected. Since one of the most favorable conditions for weevils is excessive summer rainfall, the regions with the heaviest precipitation during the cotton-growing months will suffer the greatest damage.

WORK UPON WHICH THIS BULLETIN IS BASED.

The danger from the boll weevil was appreciated from the beginning by the chief of the entomological service of the department. Work on the life history, although at first not extensive, showed the essential steps in the control of the pest. Later Congress made available large appropriations for the exhaustive investigation of the insect and of means of reducing its damage. Work was begun by the establishment of a laboratory at Victoria, Tex., and field experimental work was carried on in direct connection with the laboratory investigations. Later the headquarters of the investigation were moved from Victoria to Dallas, Tex., on account of the continued spread of the insect, and then to Tallulah, La. The Bureau of Entomology has conducted experiments during several seasons on a total of more than 50,000 acres of cotton located on well-known plantations throughout the infested territory. The special requirements in different regions have received particular attention.

Aside from the work relating directly to the boll weevil which has been conducted by the Bureau of Entomology, the Bureau of Plant Industry of this department has carried on investigations dealing with the breeding of cottons to obtain earliness and productiveness. The farm-demonstration service has carried the results of this work directly to the farmers throughout the South.

In addition to the work done by the Department of Agriculture, the State entomologists have dealt with the boll weevil in connection with the numerous other entomological problems of the States. They have contributed valuable results which have been incorporated in this bulletin.

DESCRIPTION AND LIFE HISTORY OF THE BOLL WEEVIL.

The adult boll weevil is about one-fourth of an inch long, varying from one-eighth to one-third of an inch, with a breadth about one-third of the length. This measurement includes the snout, which is approximately half the length of the body. Variation in size is due to the amount of food the insect has obtained in the larva stage. Individuals from bolls are therefore nearly always larger than those from squares. The color (grayish or brownish) depends upon the time that may have elapsed after transformation to the adult stage. The recently emerged individuals are light yellowish in color, but this changes to a gray or nearly black shade in a few weeks' time (fig. 2).

Hundreds of species of weevils in this country may be easily mistaken for the boll weevil. Many erroneous reports about the occurrence of weevils far outside the infested area have been due to this similarity. The only sure way to determine whether an insect is the boll weevil is to send it to an entomologist for examination. In the field the most conspicuous indication of the presence of the boll weevil is the flaring (fig. 4) and falling of numbers of squares. Unfavorable climatic conditions and careless cultivation, however, frequently cause great shedding, which is often mistaken for weevil damage. If excessive shedding be noted and the squares upon being cut open show a white, curved grub (fig. 5) that has fed upon the contents, there is little doubt that the boll weevil is the insect causing the damage.

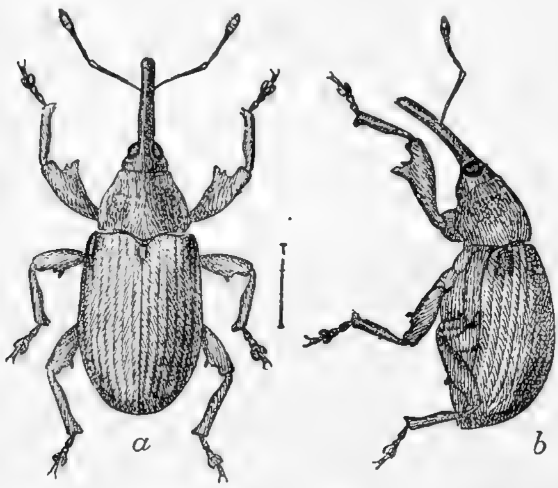

Fig. 2.—Cotton boll weevil: *a*, Beetle, from above; *b*, same, from side. About five times natural size.

The boll weevil passes the winter as an adult or beetle. In the spring and throughout the fruiting season of cotton the eggs are deposited by the female weevils in cavities formed by eating into the fruit of the plant (see fig. 4). An egg hatches under normal conditions in about three days, and the grub immediately begins to feed. In from 7 to 12 days the larva or grub (fig. 3, at left) passes into its pupa stage (fig. 3, at right), corresponding to the cocoon of butterflies and moths. This stage lasts from three to five days. Then the adult issues, and in about five days begins the production of another generation. Climatic conditions cause considerable variation in the duration of the stages, but on an average it requires from two to three weeks for the weevil to develop from the egg to the adult. Males and females are produced in about equal numbers. The males feed upon the squares and bolls without moving until the food begins to deteriorate. The females refrain, throughout most of the season, from depositing in squares visited by other females, but late in the fall, when all of the fruit has become infested, several eggs may be placed in a single square or boll. As many as 15 larvæ have been found in a boll. The squares are greatly preferred as food and as places for depositing eggs. As long as a large supply of squares is present the bolls

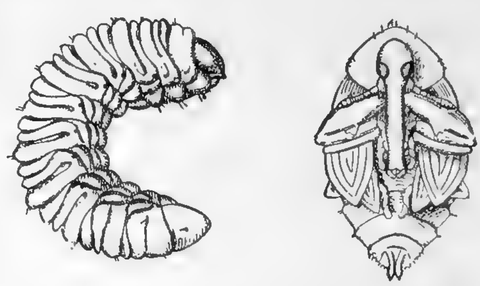

Fig. 3.—Cotton boll weevil: Larva at left, pupa at right. About five times natural size.

are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed.

The cotton boll weevil, so far as known, breeds in no plants other than cotton and the wild cotton of Arizona. At the present time, at least, the insect is restricted to the cotton plant as a means of development.

In laboratory experiments performed by the junior author, a weevil developed in the bud of a wild plant related to cotton. Under natural conditions it has not been found developing in that plant, but the experiments may indicate a tendency for the insect to acquire a new food plant. Adult boll weevils frequently have been found in okra

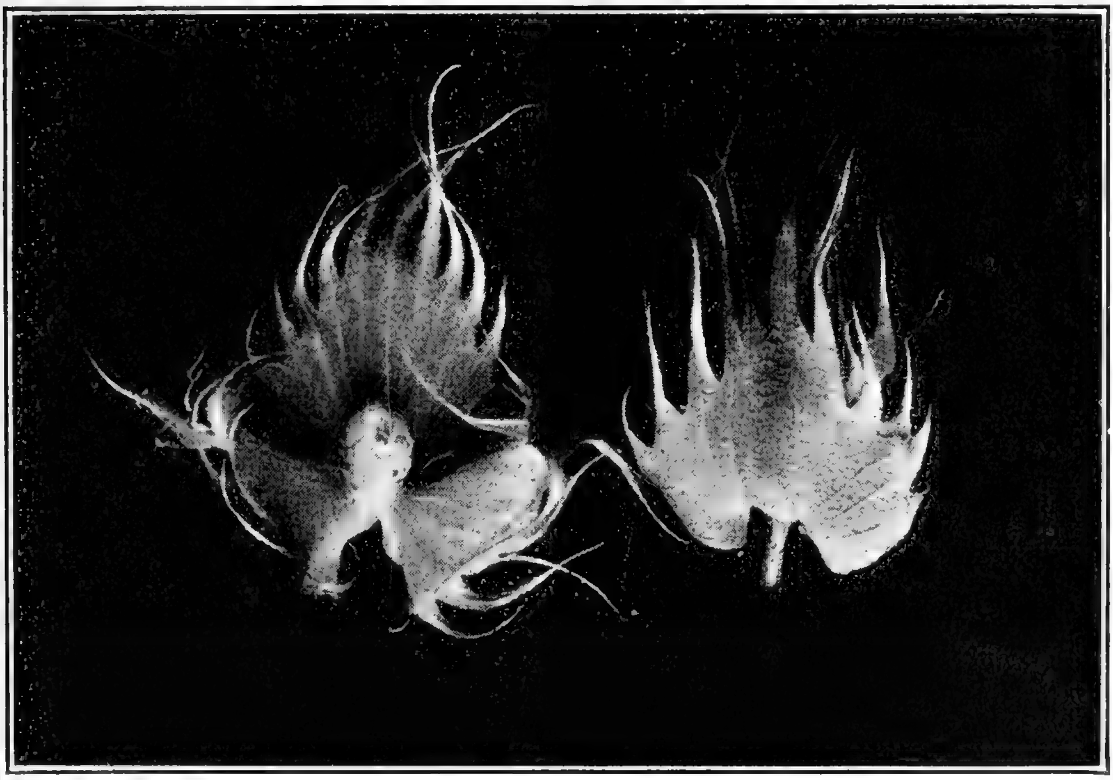

FIG. 4.—Weevil injury to cotton square. The square to the left has been punctured and shows typical "flaring" of bracts, while the one to the right is uninjured.

blooms, but repeated observations and experiments have failed to show that the weevil places its eggs in the pods or can develop in them. When confined in bottles, the adult weevil will feed on various substances, such as apples or bananas, but this is only under the stress of starvation.

The chief activity of the boll weevil is from 9 o'clock in the morning to 5 in the afternoon. It has been found in experiments performed in Louisiana that during this period of the day 65 per cent of the eggs are deposited. Eleven per cent of the eggs are deposited early in the morning—that is, from 5 o'clock to 9. There is some activity at night. Six per cent of the eggs are deposited between 8 o'clock at night and 5 o'clock in the morning.

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Unlike some related insects, the boll weevil is not attracted to light. The fact that somewhat similar species do come to lights in great numbers at times has frequently caused the belief that the pest could be controlled by the use of trap lights.

An interesting habit of the boll weevil is to feign death—that is, to "play possum," or "sull," as it is popularly called. When disturbed, the insects usually contract their limbs and drop to the ground. This habit is not equally strong in all individuals.

The age to which weevils live varies according to conditions. During the winter the longevity is much greater than in the summer. During the summer season the majority of weevils do not live longer than 50 days. During the cooler part of the year many of them live as long as six months. The longest-lived weevil on record lived from December 10 to the following October, a period of about 11 months. Undoubtedly such prolonged life is exceptional in the usual form of the weevil. The Arizona weevil, however, has been known to survive for more than a year.

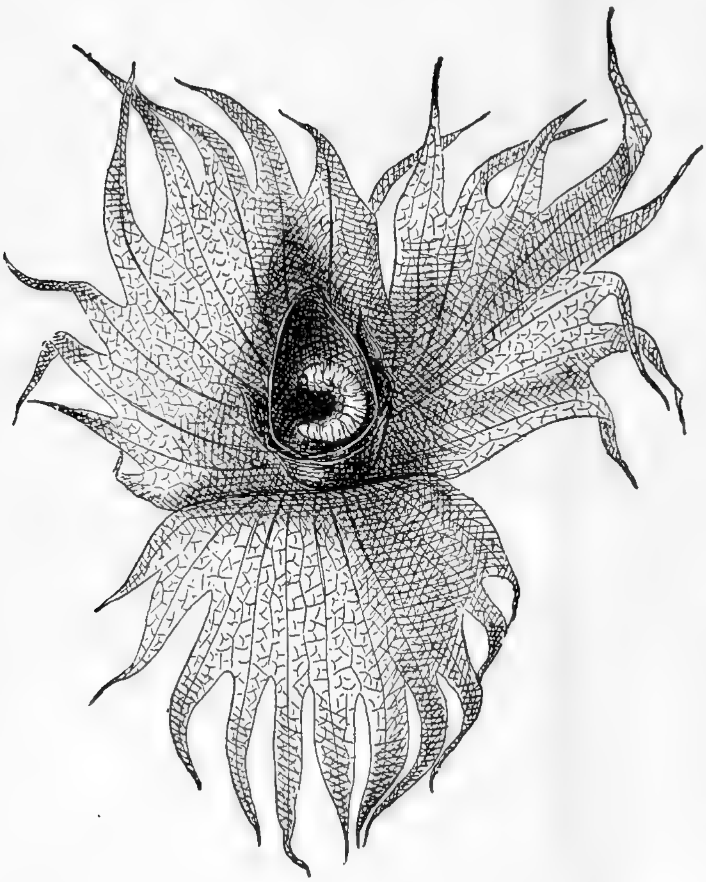

FIG. 5.—Cotton square showing larva of boll weevil in position. Natural size.

HIBERNATION.

As has been pointed out, the boll weevil passes the winter in the adult stage. At the time in the fall when frosts occur immature stages may still be found in the squares or bolls. If the food supply is sufficient, many of these immature stages continue their development at a very slow rate and finally emerge as adults. Thus there may be a somewhat continuous production of adults during the winter. Ordinarily, however, this is not the case, since the frosts that destroy the cotton generally kill practically all of the immature stages of the weevil.

With the advent of cool weather in the fall the adult boll weevils in cotton fields begin to seek protection against the winter. They fly from the fields in every direction, although their movements are governed partially by the prevailing winds. They may fly into hedges, woods, cornfields, haystacks, farm buildings, or other places. Specimens have been found in such situations, and also in considerable numbers in Spanish moss growing some distance above the ground on trees. A number of weevils also obtain hibernating quarters without leaving the cotton fields. These may crawl into cracks in the ground, under grass, weeds and other trash, and into the burrs from which the cotton has been picked. In some cases several thousand weevils per acre have been found hibernating in such situations. Here, however, the mortality is greater than where the protection is better. In fact, hibernation in the fields is not of great importance except in the more southern localities. That the majority of weevils which hibernate successfully do not pass the winter in the cotton fields has been shown by many experimental observations and is demonstrated every year in the infested territory by the appearance of the first damage in the immediate vicinity of woods and in other places where conditions for protection are favorable.

During the winter the weevils take no food and remain practically dormant. On especially warm days they may move about to a certain extent. During the very mild winter of 1906–7 hibernating weevils were found moving about more or less throughout the period from November to March.

The number of weevils that live through the winter has been determined very accurately for different conditions. It varies with the temperature and with the region. Heavily timbered regions, especially where Spanish moss occurs, show the smallest winter mortality. In Louisiana, out of 25,000 weevils, 2.82 per cent survived the winter of 1905–6. These weevils were placed under various conditions that must have approached those which the species encounters naturally. The winter referred to was practically a normal one so far as temperature and precipitation were concerned. In extensive work in Texas during the winter of 1906–7, out of 75,000 weevils 11.5 per cent survived. As in the preceding case, these weevils were placed under diverse conditions in different cages. These conditions ranged from the most favorable to the least favorable; that is, from an abundance of protection to practically none. The survival obtained was undoubtedly very close to that occurring under the diverse natural conditions of that winter. It must be emphasized that the winter of 1906–7 was abnormally warm. The average survival in experiments performed in Texas and Louisiana from 1906 to 1911 was 6 per cent, which must represent about the average survival occurring in nature.

From 1914 to 1920 a rather extensive series of cage experiments has been conducted by the Department of Agriculture at Tallulah, La., utilizing from 20,000 to 30,000 weevils each year. These have been placed in hibernation under a rather wide range of conditions, which probably represent a fair average of those found by the weevil in seeking hibernation quarters around the cotton field. The annual survival in these series has varied from 0.3 per cent to 5.9 per cent.

Emergence from hibernation depends primarily upon temperature and rainfall in the spring, although some minor factors are concerned. In the southern portions of the cotton belt emergence usually begins from the first to the middle of March, but farther north it is somewhat later than this. Naturally, the individuals under the heaviest protection are affected latest by the temperature. The consequence is that emergence from hibernation is prolonged. It has been known to extend from the middle of March to the 28th of June, and in even more extreme cases from the middle of February to about the first of July. There is usually a comparatively short period during which the emergence is most rapid but this may be broken up into several such periods with intervals of slow emergence due to changes in weather conditions.

HOW NATURE ASSISTS IN DESTROYING THE BOLL WEEVIL.

Although the possible production of offspring in a single season by one pair of weevils has been estimated at 12,755,100, nature has provided several means of preventing such excessive multiplication. The most conspicuous of these are heat and insects that prey upon the weevil.

EFFECTS OF HEAT.

When infested squares fall to the ground they may become so heated that the larvæ are killed in a few minutes. The insect in the larva stage can not leave the square, as it has no means of locomotion whatever. Where the infested squares are subjected to the unobstructed rays of the sun the mortality is very high. This explains the well-known fact that dry seasons are unfavorable to the weevil and indicates great difficulty in controlling the insects in regions where precipitation is heavy. Occasionally as many as 90 per cent of the immature weevils in cotton fields inspected have been found to have been destroyed through this agency. The extent of destruction holds a close relation to the amount of shade. When there is no shade practically all of the larvæ and pupæ are killed outright. Some of the important means of control to be described later are based upon this consideration. (See p. 15.)

INSECT PARASITES.

The second of the means provided by nature for the control of the weevil is a large number of insect enemies. Forty-five species which prey upon the boll weevil are known. Of these, 23 are parasites, which by means of their special organs place eggs on the immature stages of the weevil within the square or boll. The young of the parasite develop by feeding upon the boll weevils, which they ultimately kill. Thus parasites instead of boll weevils emerge from the injured fruit. These enemies of the weevil have existed in this country for an indefinite time. Their natural habit has been to prey upon weevils more or less related to the boll weevil which have been present in this country for many years. They never feed upon vegetation. Since the boll weevil offered abundant and favorable opportunities for reproduction, while their original hosts were generally not very numerous, they have naturally turned their attention to the boll weevil. The weevil mortality due to these parasites is exceedingly variable. In many cases no mortality from parasites is observed, while on the other hand fields showing from 50 to 75 per cent of the weevils killed by parasites are by no means rare.

OTHER INSECT ENEMIES.

The boll weevil is attacked by a number of insects which are not parasites in a strict sense but prey upon it as food. The most important of these predatory enemies are ants. Twelve species are known to attack the weevil. They are the minute brown ants and the yellowish ants that occur frequently in cotton fields and are observed running over the plants or on the ground. Their work is not against the adult weevils, but against the immature stages in the squares. Some species devote their attention principally to the squares that have fallen to the ground, while others habitually seek the insects within the squares that remain hanging on the plants. The larva of the weevil, incased in a thin covering, offers food that the ants are not inclined to overlook. They gnaw through the thin shell inclosing the weevil larva, and the latter is soon destroyed. In some cases more than half of the immature stages in fields have been destroyed by ants alone. To find 25 per cent so destroyed is not a rare occurrence.

OTHER FACTORS IN NATURAL CONTROL.

Among minor factors in natural control may be mentioned the development of plant tissue known as proliferation, which sometimes crushes the immature weevils; and determinate growth of the cotton (the tendency to cease squaring about the middle or latter part of the season), which may prevent the development of fall broods of the weevil. Birds are also agents in the destruction of the boll weevil, a fact which has been fully treated in the publications of the Biological Survey of this department.

VARIATION IN NATURAL CONTROL.

Winter killing during hibernation and summer killing due to heat are by far the most important types of natural control. If it were not for these agencies it would be impossible to raise cotton in the presence of the boll weevil. All control agencies, however, vary widely from field to field and season to season in their effect, and this explains the extreme variation in the amount of injury caused by the boll weevil. A mild winter followed by a rainy, cloudy summer favors rapid multiplication of weevils and the damage to the cotton crop is correspondingly increased, while the reverse weather conditions may practically prevent damage to the crop.

DISSEMINATION.

The boll weevil moves from place to place by flight. Although it is a weak flyer compared with many insects, it has been known to cover a distance of more than 40 miles in a very short time. Its flight can not be prolonged, but successive short flights, especially in connection with favorable winds, often carry the insect considerable distances. This is the case, however, only during the so-called dispersion period, which extends from about the middle of August to the end of the season. During the rest of the year the weevil is little inclined to fly. There is always a movement from fields in all directions in search of hibernating quarters in the fall and a corresponding movement from such quarters to the cotton fields in the spring. When the insects reach cotton fields in the spring there is little further movement until the general dispersion begins. Ordinarily between the middle of August and the 1st of September the weevil seems to be seized with the instinct to migrate. It was thought at one time that this movement was forced by excessive reproduction and took place only when all squares and bolls, or the majority of them, became infested. Investigations have shown, however, that the dispersion takes place frequently when the fields are only slightly infested. In other words, the insect has a well-developed instinct for extending its range into new territory. It is this instinct that has caused the extension of the infested area in the United States year by year. The weevil is governed in flight by the wind. If there is no wind, or only a light one, a weevil is as likely to fly in one direction as in another.

The fact that the weevil moves about very little except at one season is of great benefit to the planter. The movement referred to is of little importance after a region has become infested, because it does not begin until after the time when a crop normally is made. The limited movement during the rest of the year makes it possible for any individual farmer to obtain the best results from his own efforts in fighting the pest. The danger that his efforts will be thwarted by the arrival of weevils from fields where no precautions have been taken is not important enough to warrant any farmer in deferring action on account of the indifference of his neighbors.

METHODS OF CONTROL.

Control of the boll weevil is beset with many difficulties. The weevil's insidious methods of work in immature stages within the fruit of the cotton plant, the habit of the adult in seeking protection for the greater part of the time under the bracts of the squares, its enormous power of reproduction and adaptability to new conditions, all place it in a class by itself. These difficulties are further increased by many peculiar requirements of the cotton crop itself and the fact that a successful method of control must naturally be one which is practicable under the average conditions of cotton culture.

In spite of these difficulties, however, satisfactory means of control have been developed. These are the direct and the indirect methods, both of which are of vital importance. The importance of indirect methods is often more difficult for the farmer to appreciate than that of the direct; but, in reality, successful weevil control can not be accomplished unless full advantage is taken of every possible method, and the campaign must be based upon a combination of the different methods rather than concentrating all efforts on direct control.

The farmer is aided in his fight against the weevil by a number of important natural factors which tend to reduce the possible weevil damage. Some of the more important of these which must be taken into consideration in planning a fight on the weevil are as follows:

(1) *The weevil is practically dependent on cotton for reproduction.*

(2) *The mortality of the weevil during the winter is very high.*

(3) *Hot, dry weather during the summer exercises a tremendous control upon the weevil stages, while moist, cloudy weather removes this control and greatly accelerates multiplication.*

(4) *The weevil is attacked by many different species of insect enemies.*

(5) *The emergence from hibernating quarters during the spring is slow and prolonged until well into the summer.*

(6) *Early in the season, on account of comparatively low temperatures, the development of the weevil is much slower than during the midsummer months.*

(7) *The cotton plant produces many more squares than it can carry to maturity as bolls. This surplus is shed by the plant throughout the season, under normal conditions about 60 per cent of the fruit being shed.*

(8) *Up to a certain point weevil puncturing of fruit does not reduce the cotton crop, because large numbers of forms would be shed normally.*

(9) *The weevil has a decided tendency to seek moisture wherever it may be found on the surface of the plant.*

DIRECT CONTROL BY POISONING WITH CALCIUM ARSENATE.

In the years which have elapsed since the advent of the boll weevil into the United States every conceivable means of direct control of the weevil has been tried repeatedly. Owing to the peculiarities of the weevil attack which have been mentioned, most of these attempts have been unsuccessful. Some methods were found which would control the weevil, but these were either impracticable or too expensive for use on a commercial scale. During comparatively recent years, however, a method of poisoning has been developed which has proved very successful. This consists of treatment of the plants with powdered calcium arsenate by a specialized method.

It has long been known that poisoning the boll weevil is possible to a certain extent, but on account of the peculiar habits of the insect it was difficult to develop methods for the application of the poison.

A profitable method, however, has now been developed by the Bureau of Entomology. This has been tested for seven years and is now being adopted rather extensively by the farmers. Only a very brief summary of this successful method is presented here; but several bulletins have been issued on this subject by the Department of Agriculture, and all farmers interested are urged to obtain them and read them carefully before planning to use poison. Furthermore, motion pictures have been prepared that visualize the proper methods of poisoning and show the results which can be produced. Anyone interested can borrow a copy of the picture free of charge, excepting transportation charges, by application to the Motion Picture Office, Division of Publications, United States Department of Agriculture, Washington, D. C.

The first question which occurs to the cotton farmer contemplating poisoning is whether it will pay to do so. From the following any cotton grower should be able to determine the question for himself:

It will pay to poison—

If the weevils are really injuring your crop seriously; and

If your land is sufficiently fertile to yield at least one-half bale per acre with weevil injury eliminated; and

If your farming organization is such that you feel assured that the poison applications will be made at the right time and in the right manner; and

If you are willing to spend the full amount necessary to provide an adequate supply of dusting machinery and poison.

You should not poison if the cost of the calcium arsenate, the cost of the labor to apply it, and the depreciation on the dusting machines will total more per acre than the current value of 100 pounds of seed cotton.

Hand guns should be figured as depreciating 100 per cent in a season and the larger machines about 25 per cent.

The next extremely important question is that of the dusting machinery which should be used. Extensive experience has shown that it is impossible to get satisfactory results by using makeshift devices to apply the poison, and the only safe procedure is to provide an ample supply of the specialized dusting machinery which is now on the market for the treatment of cotton for the control of the boll weevil. Machines of various types, prices, and capacities are now being manufactured which meet the requirements and circumstances of almost all classes of growers. The following is a brief description of the several types and their uses:

The hand gun is the smallest type of cotton-dusting machine, and, as the name implies, must be carried and operated by the laborer. These machines are generally quite unsatisfactory, owing to their necessarily frail construction and laboriousness of operation. The selling price ranges from $12 to $25 each. *They should be used only when no other machine is suitable.* Not more than 8 acres should be allotted to one hand gun, and it has generally been found inadvisable to attempt the treatment of more than 25 acres of cotton in one organization with hand guns.

The one-mule machine is the smallest of the traction type of dusters. It is a one-wheel, one-mule machine which the operator handles as he would a walking cultivator or any other walking implement. The machine has two nozzles and will treat either two or three rows of cotton at a trip, thus covering from 15 to 20 acres of cotton in a night of operation. It should be allotted not more than 60 acres of cotton for treatment throughout a season. This machine is now selling at from $100 to $125.

The cart machine is a two-wheel, two-mule machine which straddles a row of cotton. It has three nozzles and will cover from 25 to 30 acres of cotton in a night of operation. It should be allotted not more than 100 acres of cotton for treatment through the season, and is the type most suitable for large farms. This machine is now selling at from $250 to $400.

In the early stages of the dusting work an engine power machine was tried and a few of these are still in use, but it has been found that they are generally too complicated for satisfactory operation except by expert labor. Still other types of machines to suit different conditions are in the process of development, but the present supply will meet almost any condition fairly well.

The following condensed rules have been prepared for the guidance of those planning to poison:

Use only pure calcium arsenate in the form of a dry powder.

Apply this only in the dust form.

Purchase this to conform to the following specifications:

Not less than 40 per cent total arsenic pentoxid.

Not more than 0.75 per cent water-soluble arsenic pentoxid.

Density not less than 80 or more than 100 cubic inches per pound.

Have your county agent send a sample of your calcium arsenate to the Delta Laboratory, Tallulah, La., for free analysis to make sure that it is satisfactory.

Use only dusting machinery especially constructed for cotton dusting.

Poison only when the air is calm and the plants are moist. Practically this means making only night applications.

Use about 5 to 7 pounds of calcium arsenate per acre for each application.

Start poisoning when the weevils have punctured from 10 to 15 per cent of the squares.

Keep your cotton thoroughly dusted until the weevils are under control. This usually means about three applications at the rate of one every four days.

Then stop poisoning until the weevils again become abundant.

If the weevils become abundant early enough to injure your young bolls, make one or two more applications late in the season.

If you have a heavy rain within 24 hours after dusting, repeat this application immediately.

Do not expect to eradicate the weevils. Poisoning merely controls them sufficiently to permit a full crop of cotton and you can always find weevils in the successfully poisoned field.

Keep your cotton acreage low and do everything possible to increase your yield per acre, as it costs just as much to poison one-quarter bale per acre cotton as bale per acre cotton.

Always leave an occasional portion of a cut unpoisoned for comparison with the adjoining poisoned tract. This will show how much you have increased your yield by poisoning.

INDIRECT MEANS OF CONTROL.

In addition to the use of poison there are numerous other practices which tend to reduce the weevil injury, some of which are of general value, while others can be used only locally. The following pages list a few of the more important of these measures. Even when poisoning is practiced the most thorough attention should be given to the indirect means of control, since they reduce the amount of poisoning which might be necessary and increase the profit which may be secured.

FALL DESTRUCTION OF INFESTED PLANTS.

One of the most important steps toward reducing the weevil infestation, when it can be practiced, is the destruction of the cotton plants in the early fall, before the weevils have hibernated. To be of the greatest value, however, the plants must be completely destroyed by fire or plowed under deeply before the first killing frost, and this limits the use of this control measure to the districts where conditions are such that the entire cotton crop can be picked in time to permit such an early plant destruction.

For many years preceding the development of the calcium-arsenate method of control, removal of the cotton plants from the field as early as practicable in the fall was advocated by this department as the most important step in controlling the weevil. The purpose of this operation is to destroy as many as possible of the immature forms of the weevil still remaining in bolls and squares. These immature forms, if undisturbed, transform into weevils which live over winter and lay eggs the following spring. Fall destruction of plants likewise eliminates hibernating places of the weevil in the field. (See "Destruction of Weevils in Hibernation," p. 20.)

GRAZING.

In some districts where it is impossible to practice fall destruction of the plants, somewhat the same results can be accomplished by grazing the field with cattle, sheep, or goats. This is only a local measure, however, since the supply of live stock in regions where the bulk of the cotton crop is produced is insufficient for the purpose. Even where poisoning is practiced fall grazing is still advisable, and no danger need be apprehended of poisoning the stock, since there is rarely sufficient poison on the plants to injure stock, even immediately after application, and, furthermore, a considerable period of time generally elapses between the last poison application of the season and the earliest grazing.

SPROUT AND VOLUNTEER COTTON.

Considerable local difficulty in the control of the boll weevil is experienced in southern Texas and occasionally in Louisiana, owing to the presence of stumpage or sprout cotton. Sprout plants are sometimes encouraged because they produce a small but very early crop. This may have been defensible before the advent of the boll weevil, but at present the practice is undoubtedly the worst that could possibly be followed. The weevils seek out these large plants in the early spring and produce progeny much earlier than they otherwise could, and these progeny infest the planted cotton at an abnormally early date. Volunteer cotton causes the same results over a considerable portion of the cotton belt. The cotton seed scattered about seed houses and gins and along roadsides frequently produces plants which furnish early-season breeding places for the weevil. Needless to say, all such plants should be destroyed.

DESTRUCTION OF WEEVILS IN HIBERNATION.

It is often possible for the farmer to reduce considerably his spring weevil infestation by proper winter clean-up measures around his fields. The weevils will hibernate successfully in any trash or rubbish, and it is a very good practice to burn over or clean up any such situations around the cotton field during the winter, especially the fence rows and ditch banks.

In addition much can be accomplished by the elimination of hibernation quarters. Especially along the more northerly portions of the weevil zone, the most successful hibernation is largely confined to the timbered areas, and as a result serious weevil injury is only experienced in the fields adjoining such timber. Under such conditions it is of the utmost importance to plan all clearing operations so that the open areas for cultivation are consolidated into as large tracts as possible, thus increasing the amount of land which is sufficiently distant from timber to suffer a minimum amount of weevil injury.

LOCATING FIELDS TO AVOID WEEVIL DAMAGE.

Nearly every farmer who has been raising cotton for a few years in the presence of the boll weevil knows that there are certain fields on his place where the weevils always appear first and in greatest numbers. With this information as a basis, it is sometimes possible to reduce the damage by refraining from planting cotton in such fields and planting the more distant fields. This practice, however, is advisable only when no attempt is made to control the weevil by poisoning. These fields adjoining timber where the weevil infestation is heaviest are usually the new lands of the place and are thus the most fertile and capable of producing the best cotton crop if the weevil injury is eliminated. Furthermore, when such fields adjoin hibernation quarters, the weevils concentrate on them instead of scattering over larger areas and they serve to a certain extent as trap crops, making it possible to poison the weevils on these fields and thus prevent their spread over the remainder of the crop.

PROCURING AN EARLY CROP OF COTTON.

The foregoing facts relative to the life history, hibernation, emergence, and multiplication of the weevil show very plainly the importance of producing the cotton crop just as early in the season as possible. In reality the production of cotton in the presence of weevils is nothing more or less than a race between the setting of bolls on the plant and the multiplication of the weevils, and everything possible should be done to aid the cotton plants in winning this race. The following are some of the more important steps which may be taken.

EARLY REMOVAL OF PLANTS AND PREPARATION OF LAND.

The first step in procuring an early crop is the early removal of the plants, so that the land may be plowed during the fall and winter and the seed bed thoroughly prepared. Just how much can be done is of course a problem for the individual farmer to determine and depends largely upon labor and weather conditions, but the importance of a well-prepared, solid seed bed can hardly be overestimated. Furthermore, unfavorable weather conditions shortly before planting often prevent plowing at that time, and early preparation does away with this risk.

USE OF EARLY VARIETIES OF COTTON.

One of the most important steps which have been taken to reduce the weevil damage has been the development and introduction of varieties of cotton which mature their crops earlier in the season than those varieties which were planted before the weevil invasion. The variety to be planted in order to obtain a profitable crop under weevil conditions will depend upon a number of factors as well as on the severity of the infestation. The soil, climate, and other factors must be considered. In many localities it is extremely important to select varieties which are resistant to diseases. The first effect of the boll weevil invasion was to force the abandonment of the longer staple and large-boll varieties of cotton and the adoption of small-boll, early varieties of very short staple, such as King and its derivative, Simpkins. During recent years, however, numerous other varieties have been developed to the point where they are sufficiently early to mature a crop in the presence of the weevil, and these are being rapidly adopted. The Triumph variety is one of the best known for the western portion of the infested territory. Among the others which have been cultivated with success in various localities are Cleveland Big Boll, Cook's Improved, Rowden, Toole, Brown, Lone Star, Trice, and Columbia.

The long-staple cotton situation is particularly interesting. The Upland long staples, which were cultivated when the weevil arrived, were slow-maturing, nonprolific varieties with a very thin boll wall, and were thus subject to a maximum amount of weevil damage. The weevil soon eliminated practically every one of these varieties, and for some time it appeared that the production of long-staple cotton would be practically prohibited. This situation, however, has been met by the development of several long-staple varieties which are prolific and reasonably early. Among the best known of these are such varieties as Express and Webber.

It should be thoroughly understood that the selection of the cotton variety is purely a local proposition, and the farmer is warned against the extensive planting of a new variety (merely because it has done well elsewhere) before he has tried it on a small scale under his own conditions. Whenever possible, seeds should be obtained from local planters who have given attention to varietal selection. Varieties introduced from different sources require several seasons to adjust themselves to new conditions. The use of seed simply because it comes from a northern locality is a practice which frequently has done great injury. The only case in which the introduction of northern seed is justified is where the seed represents a variety which has been improved with reference to early maturity. Even this practice is not to be recommended except as an emergency measure when locally improved seed is not available.

EARLY PLANTING.

Another step to be taken in obtaining an early crop, and fully as important as those that have been mentioned, is early planting. No set rule can be laid down as to the proper date for planting. There is much variation in the seasons. Sometimes it is impossible to place the fields in readiness as early as is desirable, and much of the effect of early planting is lost unless the seed bed is in good condition. Rather than plant abnormally early it would be better to improve the seed bed. It is not recommended that planting be done at dangerously early dates. Nevertheless, with proper preliminary attention to the fields it would be possible for farmers in most localities to plant from 10 to 20 days earlier than they were accustomed to before the arrival of the weevil. It is much better to run the risk of replanting, provided the seed bed is in good condition, than to defer planting on account of the danger of cold weather. Of course, it is possible to plant entirely too early, so that the plants become stunted during the early days of their growth, and planting should not be done so early as to have this effect upon the plants.

FERTILIZERS.

An important step in procuring an early crop is the use of commercial fertilizers. In many large areas in the cotton belt the land is not impoverished to the extent that it actually needs fertilizers under normal conditions, but it has been demonstrated many times by the different experiment stations in the South that the maturity of cotton frequently can be hastened materially by the use of fertilizers. On impoverished soils, moreover, fertilizers containing a high percentage of nitrogen give increased yields under boll-weevil conditions.

The proper use of fertilizers is a very complicated matter. In fact, in the light of all present knowledge only the most general rules can be laid down. Each farmer must experiment with the soils upon his place and study the results to obtain the greatest benefit from fertilizers at the smallest cost. In the eastern portion of the cotton belt most of the farmers have acquired this experience. In the West, however, this training is lacking. Farmers interested should communicate with the State experiment stations and obtain the latest bulletins regarding experiments with fertilizers in their own regions.

By far the best method of building up soils so that early crops of cotton may be produced is the use of legumes planted either with corn or solid. In the alluvial soils of the Mississippi Valley remarkable results in obtaining increased yields under boll-weevil conditions have followed the growth of cowpeas for a single season. The use of cover crops is also of great importance and worthy of the careful attention of all planters in the infested territory where the practice can be fitted into their plan of operations.

The relation of fertilizers to the determinate growth of the cotton plant should be carefully considered. With certain varieties and certain soils the plants have a decided tendency to cease squaring about the middle or latter part of the season and to mature at that time. This habit has been termed the "determinate growth" of the plant. According to the time it occurs, this may be an advantage or disadvantage in the fight against the weevil. If it occurs too early it is a decided disadvantage, because this cessation of squaring produces a food shortage which causes the weevils to attack the bolls with abnormal severity. Consequently, it is very desirable to have the cotton continue squaring long enough to protect the full crop of bolls to maturity. After the bolls are safe, however, the squares are a liability rather than an asset, since a large number of weevils are produced from them and enter hibernation well prepared for survival. In utilizing fertilizers the farmer should plan to supply his weevils with an abundance of food until his crop of bolls has matured beyond the point of injury and then the sooner his cotton stops squaring the lighter his infestation will be the following season.

SECURING A FULL STAND OF COTTON.

Many theories have been advanced regarding the spacing of cotton and its relation to boll-weevil control. The most profitable spacing varies with the season, soil, variety, and numerous other conditions, but it is generally found that the spacing which secured the best results prior to the arrival of the weevil is still best in the presence of the weevil. The general practice, however, has been exceedingly careless and as a rule very poor stands are secured. It is impossible to make a full crop of cotton unless sufficient plants are on the ground and the first step to secure this result is the adoption of more careful methods of hoeing to a stand.

CULTIVATION.

During the growing season of the crop the fields should be very carefully cultivated, otherwise most of the benefits of early preparation, early planting, and fertilization may be lost. In case of unavoidably delayed planting the best course to pursue is to cultivate the fields in the most thorough manner possible. Under most conditions the old plantation rule "once a week and one in a row" should be applied. This will not result in the direct destruction of many weevils, but it causes the plants to continue uninterruptedly in their growth. By all means such operations as deep cultivation and cultivation close to the plants, which cause shedding, should be avoided. In many instances a fair crop already set and beyond danger from the weevil has been lost by running the plows so close that the side roots were cut and the plants made to shed practically all the fruit. When this happens during the middle or latter part of the season the weevils will certainly prevent the putting on of any more fruit. The general practice of "laying by." by scraping the middles with a wide sweep, leaves a hard surface which causes loss of moisture and shedding. Where the weevil occurs, every precaution must be taken to avoid shedding, as the insect will prevent the maturity of the later fruit and, moreover, will be forced to attack bolls which otherwise would not be injured.

The value of late cultivation has often been discussed. Prior to the advent of the weevil it was an almost universal custom to "lay by" the cotton crops well before the time when the last bolls were set. This practice has been very largely abandoned, however, owing to dire necessity. The importance of keeping the cotton squaring long enough to protect the bolls until safe from injury has been mentioned, and the best way to accomplish this result is to continue cultivation until fairly late in the season, at least two or three weeks beyond the usual time of "laying by." This is, of course, a somewhat dangerous practice, since it is a critical period in the bolling of the cotton plant, and it is very easy to bring on absolute disaster to the crop by improper cultivation at this time. Consequently, all carelessness at this season should be avoided and the plow should not be run too deeply or too close to the plant, or excessive shedding will result. Careful late shallow cultivation is to be very strongly recommended.

DRAINAGE.

The foregoing paragraphs have dealt largely with the necessity of an early crop and have emphasized the importance of expediting the crop by early preparation of the seed bed, early planting, and frequent cultivation. These operations, however, can only be successfully conducted under conditions of good drainage. It is practically impossible to raise a profitable crop of cotton on poorly drained land. On the other hand, the value of good drainage is everywhere apparent. It makes possible the earlier planting of cotton, early germination, and rapid, frequent cultivation. Furthermore, the ground dries out more rapidly after a rain, which increases the control of the weevil by sunshine.

INEFFECTIVE METHODS OF CONTROL.

The extreme seriousness of the boll-weevil problem has called forth hundreds of suggestions in control. These have included changes in manner of planting, attracting the insects to food plants or lights, soaking the seeds to make the plants distasteful, sprays, machines, chemical fumes, and the planting of various plants supposed to be repellent. In many cases these suggestions have been made without due understanding of the habits of the weevil. In other cases practical features, such as the cost of application, have not been considered. The following paragraphs deal with some of the principal ineffective methods that have been proposed.

LATE PLANTING.

Late planting is foremost among the futile means of control. At various times it has been suggested that late planting, especially if following early fall destruction, would so lengthen the hibernating period that no weevils would survive. Very numerous experiments in the field and in cages have proved that the weevils in considerable numbers are able to survive from any reasonable time of early destruction in the fall to beyond the date in the spring when any return whatever could be expected from planting cotton, even if the weevils were entirely eliminated. In a field experiment in Kerr County, Tex., the plants were removed very thoroughly early in November. Neither stumpage nor volunteer plants were allowed to grow during the winter. No other cotton was planted within 9 miles. On the experimental field, planting was deferred until June 10. In spite of this fact weevils appeared as soon as the plants were up and multiplied so rapidly that the production was not sufficient to warrant picking. Similar experiments under different conditions by the State Crop Pest Commission of Louisiana [3] agree in every way with those of the Bureau of Entomology in Texas.

The habits of the insect explain the failure of late planting. In many cage experiments it has been found that the last emerging weevils in the spring appear well into the month of June. In fact, emergence has taken place as late as the 27th and 28th of June. Without any food whatever the emerging weevils are able to survive for some time. The maximum known survival of any hibernated weevil without any food whatever after emergence was 90 days, and a considerable number lived from 6 to 12 weeks after emergence. This ability to survive without food, together with the late emergence, renders it entirely out of the question to exterminate the boll weevil by late planting. Moreover, a considerable number of volunteer plants, which come from seed scattered accidentally or blown from the bolls during the fall, are always to be found along roads, turn rows, in cotton fields, and elsewhere. These plants, starting early in the spring in such numbers as to be beyond control, would furnish a means for the weevils to subsist to the time of planting, however late it might be. In 1906, for instance, at Dallas, Tex., volunteer plants appeared in the spring at the rate of about 1,000 per acre. An investigation showed that the number of such plants increases to the westward as the climate becomes drier. Nevertheless, numbers of plants were found near Memphis, Tenn., and Vicksburg, Miss., in a region of more than 50 inches of annual precipitation. Similar observations have been made each season since 1906.

WEEVIL AND SQUARE COLLECTION.

The possibility of weevil control by hand picking of the adult in the early spring and of the infested squares later in the season has been thoroughly tested on numerous occasions. Undoubtedly this method is efficient when practiced with sufficient thoroughness, but numerous attempts to carry it out on a practical scale have shown that the labor difficulties are almost always prohibitive. This work is of value only comparatively early in the season and thus falls at the same period when there is a very heavy demand for the labor for other purposes, and it is generally impossible to collect the weevils or infested squares without neglecting other more important work.

[3] Described in Bulletin 92 of the Louisiana Agricultural Experiment Station, published in 1907.

Consequently this procedure can only be recommended under rare conditions, when the infestation is not excessively heavy and when an abundance of cheap labor is available.

Many attempts have been made to collect the weevils by means of mechanical devices. Hundreds of such devices have been tested and all are to be condemned. They do not collect an appreciable number of weevils unless they are so violent in the agitation of the cotton plant that they are actually injurious to it.

TRAP ROWS.

The idea of attracting weevils to a few early plants or trap rows has frequently been advanced. Practical experience, however, has shown that the only possibility of success in such a procedure lies in the use of entire fields adjoining hibernation quarters, the fields to be poisoned later (see p. 20). The use of only a few rows as a trap crop has been found to be absolutely valueless.

ATTRACTION TO LIGHTS.

Many insects more or less resembling the boll weevil are attracted to lights. Many attempts have been made to destroy the cotton pest by taking advantage of this supposed habit. The boll weevil, however, is not attracted to lights. Numerous tests have been made in which many thousands of other insects were collected around strong lights in cotton fields, but not a single boll weevil was found, in spite of the fact that there were multitudes of these pests in the fields surrounding the lights.

CHEMICAL TREATMENT OF SEED.

Any money expended by the farmers in attempting to destroy the boll weevil by soaking the planting seed in chemicals in the hope of making the plants that are to grow from them distasteful or poisonous to the insects would be entirely wasted. The same remark applies to the various proposed treatments of the plants or soil with chemicals which are supposed to be taken up by the plants to the detriment of the weevils feeding upon them.

TOPPING OF PLANTS.

The topping of plants is sometimes recommended for fields infested with boll weevils. This practice generally results in more harm than good, since it removes a portion of the plants upon which the weevil is most dependent for food during the latter part of the season, and furthermore practically always produces an exceedingly dense foliage growth which greatly reduces the sun control of the weevil stages and promotes such dangerous diseases as boll-rot.

SWEETENED POISONS.

Many attempts have been made to make poisoned substances attractive to the weevils by introducing sweets and other ingredients. Some known sweets, such as honey, have a slight attraction for the weevil, but not enough to assist in practical control. Numerous tests of such sweetened mixtures have been made and it has always been found that, though they may have a slight value, results are far inferior to those which can be obtained by applying dry calcium arsenate under the same conditions.

CONTACT POISONS.

Poisons designed to kill the boll weevil by suffocating them have been proposed. They can not, of course, be effective against the immature weevils within the cotton fruit. Normally, also, the adult weevils are found inside the bracts of squares, where they can not be reached by sprays. Numerous chemicals have been found which, if placed directly on the weevil, will cause immediate death, but this does not mean that these chemicals are of the slightest value when applied in the field. In the first place, they are nearly always exceedingly injurious to the cotton plant, and furthermore, when applied to the plant under field conditions, do not come in contact with the weevils sufficiently to kill any appreciable number. In spite of the numerous chemicals tested, not a single contact poison has been found to have any practical value in field use against the weevil.

REPELLENTS.

In the same way it has been claimed that numerous chemicals, fumigants, etc., have a repellent value against the boll weevil. Almost every conceivable compound has been tested for this action and not a single one has been found which had the slightest repellent action against the weevil.

OTHER PROPOSED REMEDIES.

Many other remedies have been suggested for the weevil. Literally hundreds of these have been carefully investigated, and it has been found that the claims of their advocates were based on faulty observations or careless experiments. It is true that many of them when placed directly on the weevil will cause immediate death, but they are still found valueless when used in the field. The claims made at different times of the repellent power of tobacco, castor-bean plants, and pepper plants against the boll weevil have no foundation whatever. In fact, none of these plants has the least effect in keeping weevils away from cotton.

EFFECT OF METHODS OF CONTROL OF THE BOLL WEEVIL ON THE CONTROL OF OTHER INSECTS.

THE COTTON BOLLWORM.

The most important enemy of cotton in the United States, aside from the recently introduced pink bollworm [4] and the boll weevil, is the bollworm,[5] which has existed in this country for many years and frequently reduces the crop very considerably. Its annual damage to cotton in the United States has been conservatively estimated at more than $8,000,000. This insect is also a very important enemy of corn, tomato, okra, cowpeas, and some other crops. Careful studies of the bollworm were conducted by Dr. A. L. Quaintance, of the Bureau of Entomology, in connection with large-scale field experiments in many localities. The conclusions drawn from this practical work were that the essential steps to be taken in the control of the boll weevil are exactly the ones that should be followed in the warfare against the bollworm. The following is the statement by Dr. Quaintance on this subject:

> The steps in the production of early cotton include the principal recommendations for the growing of cotton in the presence of boll weevils. It is therefore seen that injury from the cotton bollworm and the cotton boll weevil may be best avoided by the adoption of one and the same course of improved farm practice. The spread of the latter species will render imperative the adoption of these methods in profitable cotton culture, and along with this change the ravages of the bollworm during normal seasons should become less and less.

The development of weevil poisoning adds another interesting phase to the question of control of the cotton bollworm. Years ago experiments were conducted which showed that a certain poisoning procedure would control the bollworm, but it was found that the bollworm damage was not sufficiently heavy to justify the expenditure necessary for this poisoning. Since the development of weevil poisoning, however, it is interesting to note that the procedure recommended for the two insects is practically identical; thus satisfactory bollworm control should be secured as a supplementary benefit to be derived from weevil poisoning.

THE COTTON LEAFWORM.

The relation between the cotton leafworm [6] or the so-called "army worm" and the control of the cotton boll weevil deserves special attention.

Years ago the efforts of entomologists and planters were directed toward some means of destroying the leafworm. The use of Paris

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[4] *Pectinophora gossypiella* Saund.
[5] *Heliothis obsoleta* Fab.
[6] *Alabama argillacea* Hübner.

green and other poisons was found to be very effective. The complication of the situation since the arrival of the boll weevil has caused a decided change of attitude toward the leafworm. This insect usually does not become abundant until late in the season; and unless the boll weevil is controlled, the cotton plants are not setting any bolls at that time. Consequently, the leafworm does not injure the crop and is really often beneficial, because it removes the food supply of the boll weevils. The use of calcium arsenate to control the boll weevil also prevents leafworm damage; thus such poisoned fields are not subject to injury until boll-weevil poisoning has been stopped. Then, the question of whether or not additional applications should be made to control the leafworm is to be determined entirely on the basis of the young fruit on the plants and the possibility of any of this fruit reaching maturity before frost if protected from damage. Under such conditions poisoning solely for the control of the leafworm is very seldom necessary or advisable.

SUMMARY OF CONTROL MEASURES.

The following is an outline of the practical methods of controlling the boll weevil described in detail in the preceding pages. These methods are based upon extensive study and much field experimentation. They represent practically all that is known about combating the most important enemy of the cotton plant. They form a system composed of several parts. A cotton planter can insure success in proportion to the extent to which he combines the different essential parts.

(1) When possible practice early fall destruction of the cotton plants.

(2) Destroy as many weevils as possible in hibernation by cleaning up and burning over hibernation quarters. Also, clear land whenever possible to consolidate open areas and reduce fields subject to early, heavy infestation.

(3) If you are not poisoning, plant in the fields located in situations where weevil damage will be minimized. If you are poisoning, however, plant your fertile soil adjoining hibernation quarters and concentrate your efforts on thorough control of the weevils in these fields.

(4) Prepare the land early and thoroughly in order to obtain an early crop. This means fall plowing and winter working of the land.

(5) Determine the best distances between the rows and between the plants by experiments on local soils. Once this is determined make every effort to obtain a perfect stand at the desired spacing.

(6) Insure an early crop by early planting of early maturing varieties and by fertilizing when necessary.

(7) Continue to procure an early crop by careful chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivating too deeply or too close to the rows.

(8) Study the instructions governing poisoning very carefully, and if your conditions seem suitable for profitable work poison the weevils thoroughly with powdered calcium arsenate.

(9) Before attempting to poison, obtain from the Bureau of Entomology full and detailed instructions based on your local conditions.

How To Do It

DO YOU WANT practical suggestions on how to build a silo, a hog house, a poultry house, a potato-storage house, or how to make a fireless cooker, or other farm convenience? Are you seeking ideas on how to prepare vegetables for the table, how to care for food in the home, how to bake bread and cake and other appetizing foods in an efficient and economical manner? Is there some practical question about your corn or wheat or cotton or other crops, or about your poultry or live stock, to which you are seeking an answer? The answers to thousands of such questions and practical suggestions for doing thousands of things about the farm and home are contained in over 500 Farmers' Bulletins, which can be obtained upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C.

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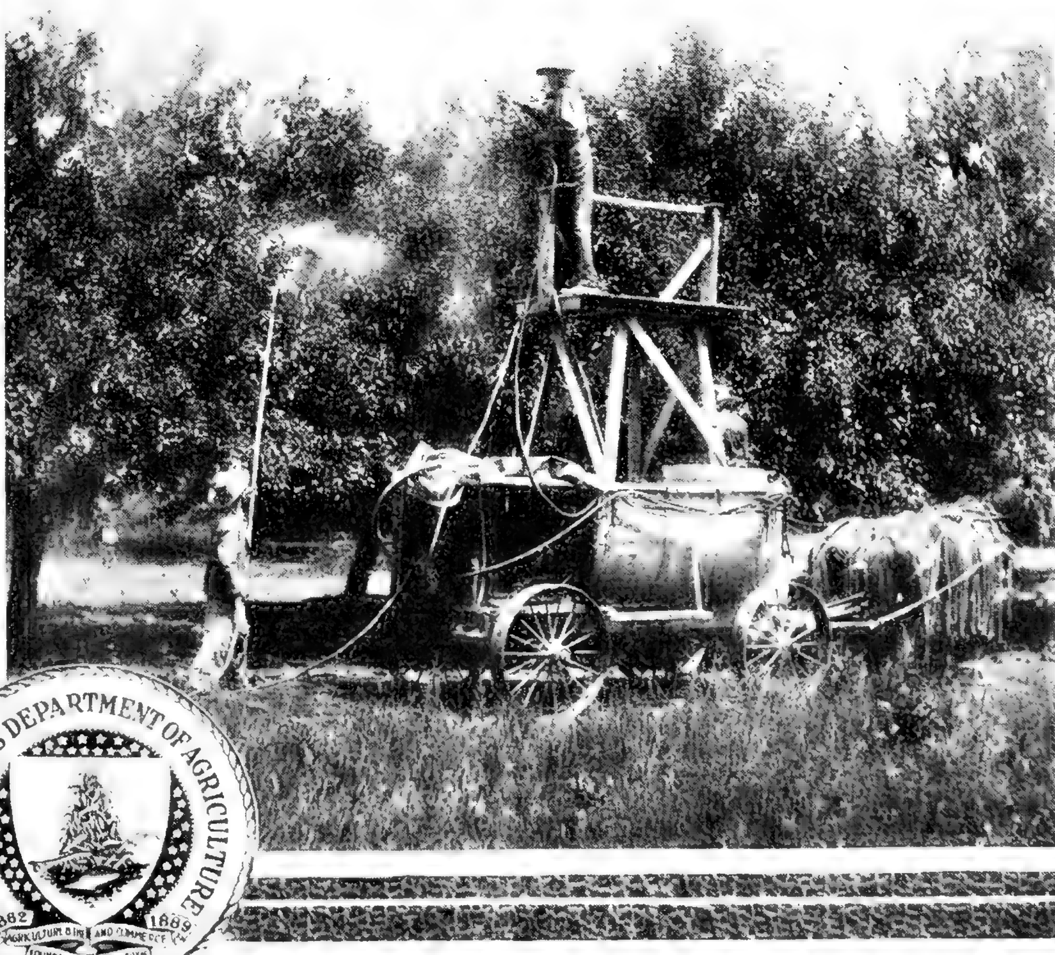
FARMERS' BULLETIN No. 1270

The MORE IMPORTANT APPLE INSECTS



INDEX.

Washington, D. C. September, 1922

THE MORE IMPORTANT APPLE INSECTS.

By A. L. QUAINTANCE, *Entomologist in Charge*, and E. H. SIEGLER, *Entomologist, Fruit Insect Investigations, Bureau of Entomology.*

THE APPLE CROP AND LOSSES FROM INSECTS.

THE APPLE, KING OF FRUITS, has assumed a high rank among American agricultural products. In the United States its average monetary value over the five-year period 1914–18 has been placed at about $185,000,000,[a] or approximately one-half the estimated worth of the potato crop. The financial success of the apple industry is dependent, however, upon several factors, and among these insects play an important rôle. The annual loss to the apple crop through insect ravages is somewhat variable, changing from year to year, not only in the large fruit-growing districts but in individual orchards as well. Although it is extremely difficult to estimate the yearly loss due to insects, a fairly conservative estimate would place it at about 10 to 20 per cent of the crop value, or, at the lower figure, about $18,000,000. To this should be added the loss of the trees themselves as the result of infestations of apple-tree borers, scale insects, etc., and the considerable amount expended for spraying apparatus, insecticides, and labor.

In the present bulletin an attempt has been made to acquaint the fruit grower with the general distribution, description, life history, and control of the apple insects with which he is likely to be troubled. The orchardist would do well to study carefully the insects causing important injury, in order that remedial measures may be intelligently applied.

CODLING MOTH.[1]

The codling moth, or "apple worm" as it is commonly called, is unquestionably the most serious insect enemy of the fruit of the apple and annually destroys or renders unfit for commercial purposes millions of dollars worth of fruit, despite present efforts to control it by spraying. It should not be inferred, however, that spraying measures are ineffective, for it has been amply demonstrated that thorough and timely spraying will usually yield from 90 to 95 per cent and often more of worm-free fruit, except in some of the semiarid regions of the West where this insect is unusually abundant and destructive. In the absence of combative measures, the codling moth will frequently infest from 25 to 90 per cent or more of the fruit, depending upon the locality, seasonal and weather conditions, size of the crop, and other contributing factors. Apples infested with this insect are commonly called "wormy apples" (figs. 1, 2, and 3), but to avoid possible confusion it should be borne in mind that this fruit may be wormy through infestation by other pests, as the apple maggot (p. 13), lesser apple worm (p. 10), etc.

Shortly after hatching from the egg, the larva or worm eats its way into the flesh of the apple, usually feeding in the direction of the core, and on reaching it frequently attacks the seeds. A considerable but variable propor-

[1] *Carpocapsa pomonella* Linnaeus.

[a] Folger and Thompson, The Commercial Apple Industry of North America, p. 3. 1921.

tion of the first brood enters through the calyx or blossom end, while the later or summer brood worms apparently prefer to enter through the side of the apple. A favorite place of entrance is at the point where two apples are in contact. As the codling-moth larva tunnels through the fruit, it grows and makes a correspondingly larger feeding area, which becomes more or less packed with dark reddish brown to blackish pellets, which are gradually pushed out toward the entrance hole. Upon attaining their full growth, some larvæ leave the fruit by way of their entrance holes, while others make their exit at another point, thus producing in the same apple two holes, an entrance and an exit. Another type of injury frequently found in the semi-arid fruit regions of the West, and other fruit districts where the codling moth is abundant, is known as the "sting" and the affected apples are called "stung" fruit. The typical "sting" is caused by a worm eating a small hole (about the size of a pinhead) through the skin of the apple, after which it makes a shallow excavation in the flesh to the depth of about one-sixteenth to one-eighth of an inch and sufficiently large to accommodate the body of the young worm. These so-called "stings" are frequently made by larvæ that have been poisoned but which are able to complete the "sting" pocket before dying from the effects of the arsenical. Occasionally worms complete a "sting" pocket and then for some unknown reason leave it to enter the fruit at another point. It is also quite possible that some larvæ after having eaten through the skin are washed off by heavy rains or are blown or brushed off during windstorms. Although apples having a few "stings" usually are not damaged seriously except perhaps as to keeping qualities, they are nevertheless discriminated against by the buyers and placed in a lower grade, thus making this type of injury of commercial importance.

FIG. 1.—Wormy apple caused by codling moth larva entering calyx end of fruit.

Some codling-moth larvæ feed to a certain extent upon the foliage of the apple previous to their attack upon the fruit. They usually eat into the lower surface of the leaf, either along the midrib or at the juncture of a vein with the

FIG. 2.—A worm-injured apple, showing codling moth worm in fruit (left half).

midrib. This leaf-feeding habit is of negligible importance as to foliage injury, but it is of some consequence from the control standpoint in that some larvæ may be killed or weakened by eating the poison before they reach the fruit.

The codling moth passes the winter in the larva stage, inclosed in a silken cocoon (fig. 4), which is about three-fourths of an inch in length. The over-wintering larva is about the same length as the cocoon and is usually of a dirty white color with a brown head. The larvæ normally make their cocoons beneath the bark scales of the trunk and larger limbs, in tree crotches, and in decayed stubs resulting from improperly pruned limbs; they also spin up in trash about the orchards, in cracks of the soil adjacent to the tree, in field harvest boxes, in packing houses, etc. In the spring the larva transforms successively into the pupa (fig. 4) and moth stage (fig. 5). The pupa is about half an inch in length and varies in color from dark yellow to brown. The abdominal segments are movable and each is provided with a double row of spines, except the terminal segments, which have but one each. The moth is somewhat variable in size, but the wing expanse averages about three-fourths of an inch. The front wings are crossed by irregular dark and light bands except the tips, each of which bears a dark metallic brown spot or ocellus. The moth, which is seldom seen by the orchardist, usually conceals itself in or about the tree during the day, but becomes more active about twilight, when it deposits a majority of its eggs. These are laid on both the leaves and fruit, the first-brood eggs being usually found on the foliage, while those of the summer brood are as a rule deposited on both the fruit and foliage. The egg is about the size of a pinhead, flat, round to oval in shape, the surface being covered with a network of ridges, and when freshly laid is pearly white in color. The young larva which hatches from the egg feeds chiefly upon the fruit, and after attaining its full growth leaves the apple and spins its cocoon on the tree trunk or in other places, as elsewhere noted. In districts having two or more generations, part of the first-brood larvæ soon transform to pupæ, while the others remain in the larva stage until the following spring. Those that transform the same season as hatched produce a new generation. In the more northern fruit-growing districts of the United States, as in New England, there is a small second generation, whereas in some of our extreme southern regions, as in the Pecos Valley of New Mexico, as many as three generations and a partial fourth may develop. In any locality the relative abundance of worms, especially those developing late in the season, varies from year to year, largely in accordance with the weather conditions. If the season is early, dry, and hot, a larger number of worms than usual will be produced, whereas during late, cool, and wet seasons the reverse is true. The orchardist should therefore study the seasonal weather conditions, and if these are favorable to the codling moth supplemental spray treatments should be applied.

FIG. 3.—Apple infested with the codling moth. Note frass pushed out of larval burrow.

The length of the different stages of the codling moth varies with the climatic conditions. In the spring the pupa stage averages about 3 weeks, with an approximate range from 2 to 6, while later in the season this stage is shortened to an average of about 2 weeks. The incubation period of the egg during the relatively cool spring weather will frequently extend over 2 weeks, although the average period is usually about 8 or 9 days. Later in the season this average is reduced to 6 or 7 days, and there are records in the Bureau of Entomology of an incubation period as low as 4 days. The feeding period of the larva is also prolonged in the spring, sometimes almost to 2 months, with an average of about 3 to 4 weeks, while during the summer the larvæ usually complete their feeding within about 3 weeks.

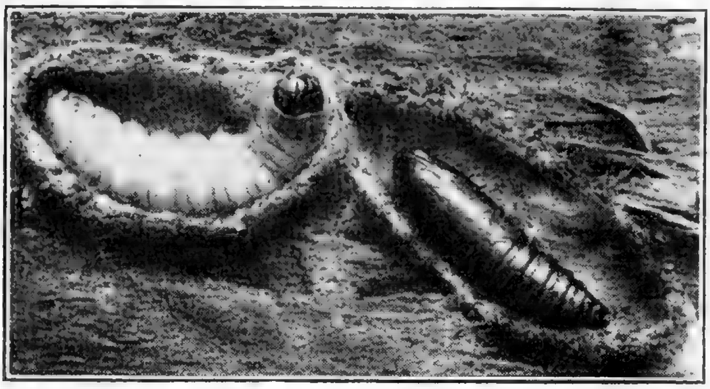


Fig. 4.—Codling moth larva and pupa within cocoons beneath bark of apple tree. Enlarged.

The control of the codling moth is largely effected by spraying with a poison, such as arsenate of lead, described on page 83. The number of spray applications required to secure satisfactory results will vary with the locality, the number of generations, and the relative abundance of the insect. In the northern latitudes good control is frequently obtained with from one to three applications, whereas in districts having longer seasons, or wherever the moth is naturally abundant, as in the semiarid valleys of the West, it is often necessary to spray from five to seven times.

The time of the application is very important, and although no definite schedule that will meet satisfactorily the conditions obtaining in all parts of the country can be given here, the following suggestions will be of value. The first application should be made in every orchard just after the blossoms have dropped (fig. 180) and this application should be completed before the calyx lobes close (fig. 181). In order to cover large orchards in time it is often necessary to commence spraying when only 85 to 90 per cent of the blossoms have fallen, but care should be taken not to spray when the trees are in bloom and attractive to bees. The object of this application is to deposit in the calyx cup a quantity of poison sufficient to kill all the larvæ that endeavor later to enter the apple through the calyx end. The calyx cup is open at the time the blossoms drop, but is closed about a week later, after which it will be too late to force the poison into the cavity. No subsequent spray can be of much value in preventing calyx worms, hence the great importance of this application.

Fig. 5.—Codling moth resting on apple leaf. Enlarged.

The first larvæ or worms begin to hatch in most sections about 3 to 4 weeks after the blossoms have fallen, although in some districts, and particularly if the weather is warm, a few worms will commence to hatch in from 2 to 3 weeks following the fall of the bloom. The second spray should therefore be applied in from 2 to 4 weeks after the first in order to coat the leaves and young fruit with poison just previous to the hatching of the early worms. In fruit districts where the insect is difficult to control, one or two additional applications against the first brood should be made so as to provide a fresh covering of poison during the period when these worms are attacking the fruit in large numbers. It is highly important to spray thoroughly against the first-brood worms so as to reduce their number to a minimum, since this brood is the sole progenitor of the later generations.

The second-brood worms begin to hatch about 8 to 10 weeks after the petals have dropped. In some of the Northern States there may be so few of these as to render it unnecessary to make a special application for them. In most fruit districts, however, it is essential to spray at this time, and in heavily infested regions an additional application for the second brood should be made in time to have the fruit covered with poison when the worms are hatching in maximum numbers. Additional spray applications will usually be necessary where there are three and four generations, but care should be taken that spraying is not done too close to the harvest season, so as to avoid the presence of spray residue on the marketed fruit.

Arsenate of lead at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide is recommended for the control of the codling moth. The powdered form is preferable to the paste, since it is more convenient to use and can be kept more easily from one season to another without deterioration. It is usually desirable in commercial practice to combine arsenate of lead with a fungicide such as dilute lime-sulphur or Bordeaux mixture, and often with a contact insecticide, like nicotine sulphate, for the simultaneous treatment of chewing and sucking insects and the prevention of the common fungous diseases. (See spray schedules, pp. 86 and 90.)

A power sprayer having sufficient capacity and pressure is essential for commercial orchards. This should be equipped with well-made hose and couplings, and if the trees are large should be provided preferably with a spray tower (fig. 178), so that the higher parts of the trees may be treated thoroughly.

In badly infested regions spraying is sometimes supplemented with the so-called "banding method," which consists in placing around the tree trunk a burlap band under which many of the worms will collect after they leave the fruit. These bands should be examined at regular intervals and the insects found beneath destroyed. The orchardist should bear in mind that many of the worms beneath the bands soon become moths and that unless they are destroyed before they reach this stage the moths will escape and deposit more eggs.

During the harvest, many worms leave the fruit while it is being handled in the packing house. These worms spin up for the winter in field boxes and other containers and in cracks and crevices of the packing house. By early summer they will have become moths which, if not confined, will fly to the orchard and deposit eggs. If feasible, the escape of the moths should be prevented by screening the windows and closing up any other possible exit.

PLUM CURCULIO.[2]

The plum curculio probably ranks in importance next to the codling moth as an apple pest and is responsible for much of the misshapen and gnarly fruit (fig. 6) that is commonly found in orchards. It is a native species and feeds upon plums, haws, etc. While the plum curculio attacks the apple and other pome fruits, it is especially injurious to the stone fruits, and in addition to these is also reported from other hosts. It is widely distributed in the States east of the Rocky Mountains, but is not known to occur farther west.

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[2] *Conotrachelus nenuphar* Herbst.

The injury to the apple is chiefly confined to the egg punctures (fig. 7), made by the females in the spring, and the feeding punctures, made by both sexes in the spring and fall. The egg puncture (fig. 8) is made by the snout of the female and is very distinctive, consisting of a small cavity or hole in the flesh of the fruit just below the skin. The female then cuts with her snout a small crescent-shaped incision just in front of the place where the egg was deposited. The feeding puncture is a small circular opening about the size of a pinhead, extending into the flesh of the apple for a distance of about one-sixteenth of an inch and is produced by the snout of the beetle in the course of its feeding.

Fruit that is badly punctured early in the season is likely to drop and many of the larvæ that hatch therein develop to maturity, since the fallen fruits furnish conditions favorable to the growth of the grubs. The punctured fruit remaining on the tree is usually dwarfed and gnarly in appearance, but the curculio larvæ seldom if ever develop to maturity in it. Late varieties of apples sometimes outgrow the egg punctures more or less, though many of them are conspicuous at harvest as irregular, yellowish brown, corky areas, often somewhat elevated above the surface of the apple. The fall feeding puncture (fig. 9) of the curculio differs from the spring feeding puncture and is fairly characteristic. The beetles prefer the calyx or stem ends, where small holes are eaten through the skin, under which, with the hole as a center, the flesh is eaten out as far as the length of the beetle's snout will permit. This results in a discolored ring of skin around the opening, which may later become enlarged into a shallow pit, as it becomes invaded with decay-producing organisms. These pits may be further excavated by the beetles, and the latter can often be found feeding or resting in them. The beetles also feed on the foliage in the spring and fall, eating out small, circular holes.

The plum curculio spends the winter in the adult or beetle stage, usually hibernating in protected places, as beneath trash in orchards or in near-by woods. The adult (fig. 10) is a small, brownish snout-beetle and varies somewhat in length, averaging about one-fourth of an inch. Early in the spring the beetles emerge from their hibernating quarters, some of them reaching the apple trees before the blossoming period. As soon as the young fruit is set, the beetles attack it, as previously described. The curculio egg is elliptical in shape, whitish in color, with a smooth, shiny surface, and measures about one-fortieth of an inch in length by one-sixtieth of an inch in width. A full-grown larva is about five-sixteenths of an inch in length, footless, yellowish white in color, with a brownish head. Upon completing its feeding period, the larva leaves the fruit and enters the soil, forming a pupal cell, in which it transforms successively to the pupa and adult stages. The pupa is whitish in color and about three-sixteenths of an inch in length. The adults emerge in 2 or 3 weeks, and in the far South some individuals deposit eggs giving rise to a second generation. The beetles feed upon the fruit and foliage until the approach of cold weather, when they seek hibernating quarters.

The most practical means of control are spraying with arsenate of lead and the cleaning up of trash from the orchards and vicinity, as well as thorough cultivation during the summer. Destruction of trash removes favorable hibernating quarters, while cultivation at the proper time will kill the delicate pupæ within the soil. The prompt collection and destruction of the infested, fallen fruit will also aid in reducing this pest. The first spray application to poison the beetles should be applied in the pink cluster-bud stage, and the second as soon as the blossom petals have dropped, using arsenate of lead at the

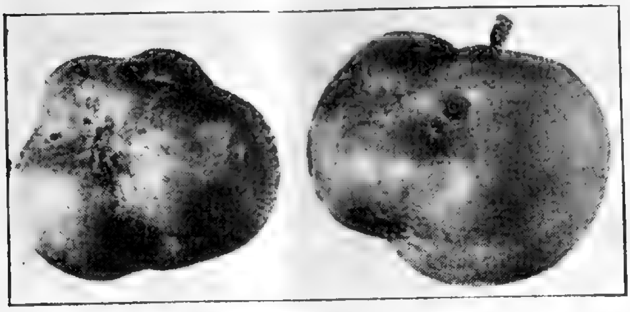

Fig. 6.—Apples deformed by the plum curculio.

Fig. 7.—Egg punctures made by the plum curculio.

Fig. 9.—Fall feeding punctures of the plum curculio.

Fig. 8.—Egg punctures made by the plum curculio.

Fig. 10.—The plum curculio on peach. Enlarged.

rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide. Supplemental treatments are desirable in orchards where the curculio is more than ordinarily destructive.

LESSER APPLE WORM.[3]

The lesser apple worm as a rule is not noticeably injurious, except periodically in the Ozark Mountain regions and more occasionally in the New England and Middle Atlantic States. When abundant, however, the later generations in particular will frequently cause as much damage to the fruit as the codling moth.

This insect is closely related to the codling moth and, like it, feeds upon the flesh of the apple. The type of injury, however, is somewhat different, since the larvæ of the present species usually feed near the surface of the fruit, frequently excavating just beneath the skin (figs. 11 and 12.) In some instances, however, the larvæ penetrate deeper into the flesh, causing injury quite similar to that of the codling moth. The larvæ will attack any portion of the fruit but seem to prefer the calyx basin cavity, although entrance through the side is

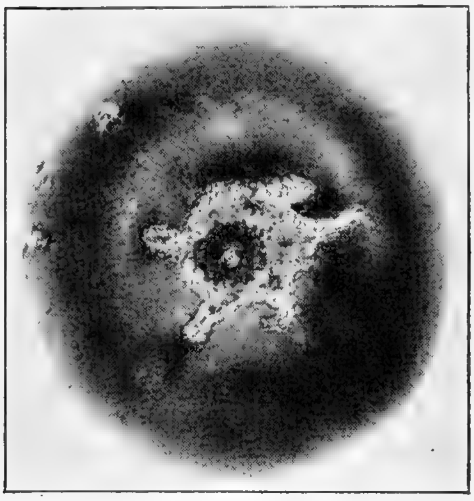

FIG. 11.—Work of lesser apple worm in calyx end of apple.

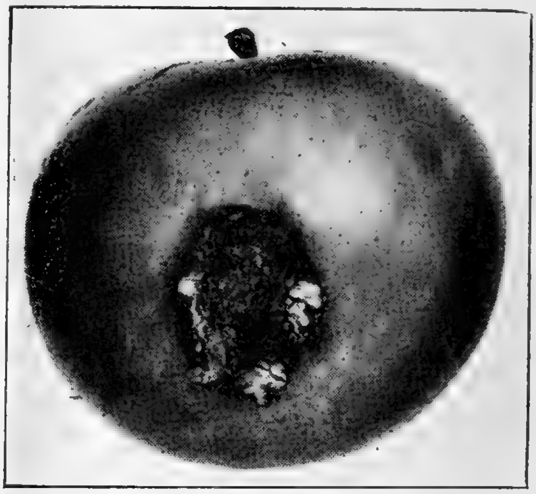

FIG. 12.—Injury to apple by lesser apple worm.

very common. The typical injury results in a blotch mine which is very conspicuous and unsightly. The lesser apple worm usually does not complete its feeding as early as does the codling moth, and, as a result, it is not infrequently found at work after the fruit has been barreled. The lesser apple worm is doubtless a native insect and has long been known to feed upon species of thorn apple, crab apple, and wild plum. It is primarily of economic importance as an apple pest, but has been reported on many of our common deciduous-tree fruits, as well as on black-knot of plum and galls of the oak and elm.

The life history and habits of the lesser apple worm are quite similar to those of the codling moth (see p. 3). The winter is passed in the larva stage within silken cocoons beneath the loose bark of fruit trees, in barrels or boxes which have contained infested fruit, in packing houses, or in almost any place accessible to the larvæ at the time they leave the fruit. When full grown the larva is about five-sixteenths of an inch in length, fusiform in shape, uniformly reddish or flesh colored above and lighter below, the head being brown to dark brown. The moths emerge in the spring about the same time as the codling moth and deposit their eggs upon the foliage. The moth is small, having dark colored front wings, with the basal one-fourth irregularly covered with rust red. The eggs are usually of an oval shape, slightly convex, covered with a network of ridges,

[3] *Laspeyresia prunivora* Walsh.

and have a diameter of about one-fortieth of an inch. When freshly laid the egg is of a pearly white color, resembling somewhat, except for its smaller size, that of the codling moth. The number of generations varies with the locality, there being a partial second generation in the North and as many as three and a partial fourth generation in the southern apple districts.

Since the life history and habits of the lesser apple worm are quite similar to those of the codling moth, thorough treatments as indicated for the latter (p. 6) will obviate the necessity of special control measures for this pest.

APPLE RED BUGS.[4]

Most orchardists are familiar with the manner in which the plum curculio (p. 7) and the rosy apple aphis (p. 22) dwarf and distort apples, but comparatively few fruit growers are well acquainted with the somewhat similar injuries caused by the so-called apple red bugs, which have attracted considerable attention in certain localities within the last decade. It is usually not difficult to distinguish the work of the red bug on the fruit from that of the plum curculio, but red-bug injury may sometimes be more readily confused with the work of the rosy apple aphis, although, upon a careful examination of the trees, the aphid-curled leaves surrounding the fruit would soon reveal whether the latter insect was responsible. Fruit injured by red bugs shows distinct depressions or dimples, while that attacked by the rosy apple aphis is more or less constricted and puckered about the calyx or blossom end. In many instances all three insects may be present in the same orchard, the combined attack causing the fruit to become very gnarled in appearance.

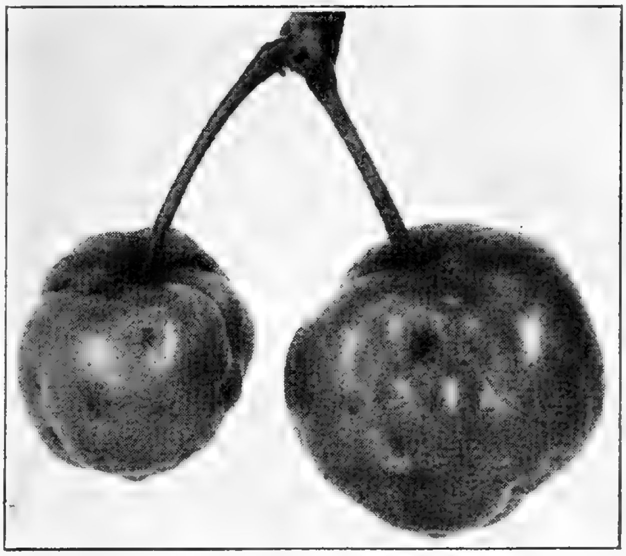

FIG. 13.—Apples deformed by apple red bugs. Note the dimpled appearance.

Shortly after hatching in the spring, the young red bugs or nymphs commence sucking out the juices of the new foliage, the injury causing the foliage to become somewhat distorted and covered with small reddish spots. Later, as the fruit develops, the insects turn their attention to it, stunting the growth as well as disfiguring it by the red-bug dimples (fig. 13). Severely attacked fruit will frequently fall to the ground, while that which is the least injured will remain on the tree until harvest. Late in the season the injured leaves have a very ragged and crinkled appearance similar to that shown in the illustration (fig. 14).

When abundant the apple red bugs become first-class orchard pests and frequently ruin the fruit for market purposes as quickly and thoroughly as any insect with which the fruit grower has to contend. Red bugs, it is believed, are native to this country and have been reported as occurring in the New England States and certain of the Middle Atlantic States, as well as in Michigan and Canada, and are undoubtedly present in many eastern States. While these insects are primarily apple pests, they are known to attack the pear and thorn apple.

[4] There are two species, the darker one, *Heterocordylus malinus* Reuter, known as the apple red bug, and *Lygidea mendax* Reuter, which is lighter in color and is called the false apple red bug.

Both species of the red bugs pass the winter in the egg stage, but the eggs are deposited in somewhat different places and hatch at slightly different periods. The eggs of the apple red bug are inserted in the bark of the smaller branches and are difficult to locate. They are about one-sixteenth of an inch long, curved, whitish in color, and they begin to hatch shortly after the leaves commence to unfold. The eggs of the false apple red bug are about the same size as those of the other species and are usually inserted in the lenticels of the small branches and commence to hatch about a week later than those of the other species. The young nymphs of each species are red, but those of the red bug become darker with age, approaching black when full grown, whereas those of the false red bug are relatively lighter in color throughout their nymphal period. The nymph of the red bug is about one-twentieth of an inch long when first hatched and approximately one-sixth of an inch long in the last nymphal stage, while that of the false red bug is slightly smaller in all of its nymphal stages. The feeding of the nymphs is confined to sucking of the juices from the foliage and fruit. During the latter part of the summer the insects reach maturity and deposit their eggs for the next generation, which do not hatch until the following spring. The adult apple red bug is about one-fourth of an inch in length, dark red to black in general color, with reddish wings which are usually black along the wing tips and have a black spot close to the outer edge. The false red bug (fig. 15) is about the same size as the other species, but is somewhat lighter in general color and has an orange red head and prothorax. The adults of both species are active in depositing eggs and when disturbed are very agile and endeavor to hide from view.

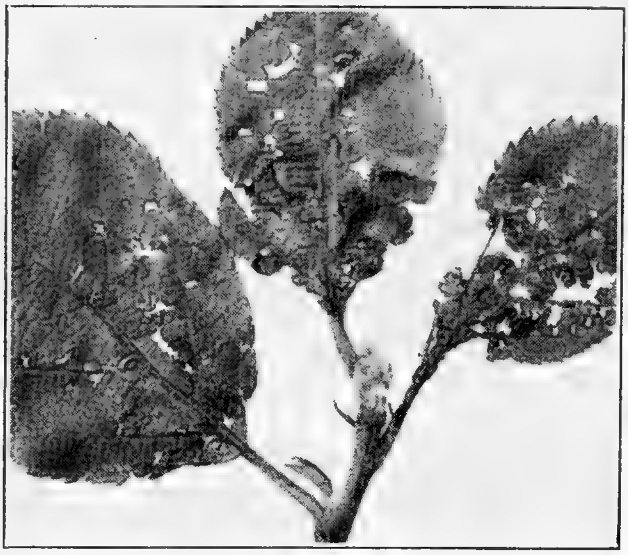

FIG. 14.—Appearance of apple leaves as a result of red bug injury.

Since the red bugs are sucking insects, they can best be killed by means of contact insecticides. Forty per cent nicotine sulphate is commonly used at the rate of one-half pint to 50 gallons of soapy water made by dissolving therein about 2 pounds of soap. If it is desired to use a combination spray for the control of sucking and chewing insects and fungous diseases, the same amount of nicotine sulphate (omitting the soap) may be combined with arsenate of lead and summer-strength lime-sulphur solution or Bordeaux mixture. The first application should be made during the pink cluster-bud stage and the second just after the petals have dropped, at which times commercial orchards are usually sprayed for other insect pests and fungous diseases. Attention should be called to the fact that the spraying should be done preferably on warm days when the nymphs are actively at work. It is also desirable to use a high-pressure driving spray and quickly wet the entire tree, and if feasible have two operators spray simultaneously from opposite sides of the trees, so that none of the insects will have a chance to escape by dodging the spray solution.

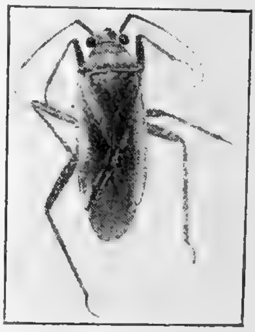

FIG. 15.—Adult of false apple red bug. Enlarged.

APPLE MAGGOT OR "RAILROAD WORM."[5]

The apple maggot, a native insect, is commonly found in the New England States and Canada and also occurs in Michigan and other Northern States. When abundant, it presents a very serious problem and is likely to cause considerable injury, particularly to the varieties most susceptible to attack. The work of this insect in its earlier larval stages is often very deceptive, and apples that appear sound externally are frequently infested with one or more maggots. As soon as the infested apples become mellow, however, the maggots develop rapidly and can be readily detected by the brownish tunnels which are often visible through the skin, especially with varieties having light or yellowish colored skins (fig. 16). The larvæ or maggots make winding burrows or tracks throughout the flesh of the fruit and often reduce it to a brown pomace-like consistency, rendering it absolutely worthless for market purposes (fig. 17).

The original food plant of this insect was the haw, but at present the cultivated apple is its principal economic host. Although there is a wide range of susceptibility among the several varieties of apples, usually the summer and fall sweet to subacid varieties are preferred, but in their absence the more acid, as well as the winter apples, are attacked as soon as they reach the proper state of maturity. In addition to the apple, this insect has been reported on pear, plum, cherry, huckleberry, blueberry, cranberry, mountain cranberry, and snowberry.

The apple maggot passes the winter in the pupa stage beneath the surface of the soil, the true pupa being developed within the puparium a few days after the latter is formed. The puparium (fig. 18) is at first light brown, later becomes darker, and is about three-sixteenths to one-fourth of an inch in length. The adults or flies first begin to issue during midsummer, usually in July, and deposit their eggs in the early varieties of apples, just beneath the skin of the fruit. The adult fly (fig. 19) is slightly smaller than the common house fly but is naturally somewhat sluggish unless disturbed, when it can dart quickly out of reach. The adult is shiny black in general color, the abdomen having four transverse white bands in the case of the female and three in the male, and the wings are marked with four irregular dark bands. The flies do not usually oviposit until a few weeks after emergence. The eggs are more or less yellowish white and average about one-thirtieth of an inch in length. They hatch in a few days and the resulting larvæ immediately begin to feed on the flesh of the fruit. After falling from the tree, the infested apples quickly mellow and shortly thereafter the full-grown larvæ leave the fruit and enter the ground. The larva (fig. 17) is whitish to yellowish white and when full grown measures about three-eighths of an inch in length.

In southern New England there is a small partial second generation, but the majority of the first brood do not transform to the adult stage until the following summer, and a small percentage remain in the ground until the second summer, thus making for the latter a two-year life cycle. The flies of the first brood emerge during midsummer, while those of the second brood issue during the fall and deposit their eggs in the different varieties of fruit when it reaches the proper stage of maturity.

The most practical method of reducing injury, though not as effective and dependable as desirable, is to spray the trees, beginning in early July, with arsenate of lead powder, using 1 pound, or 2 pounds of the paste, to each 50 gallons of water. From two to three applications made at intervals of about two to three weeks will be required. The flies are killed by lapping the poison from the foliage and fruit. The prompt picking up and destruction of the

[5] *Rhagoletis pomonella* Walsh.

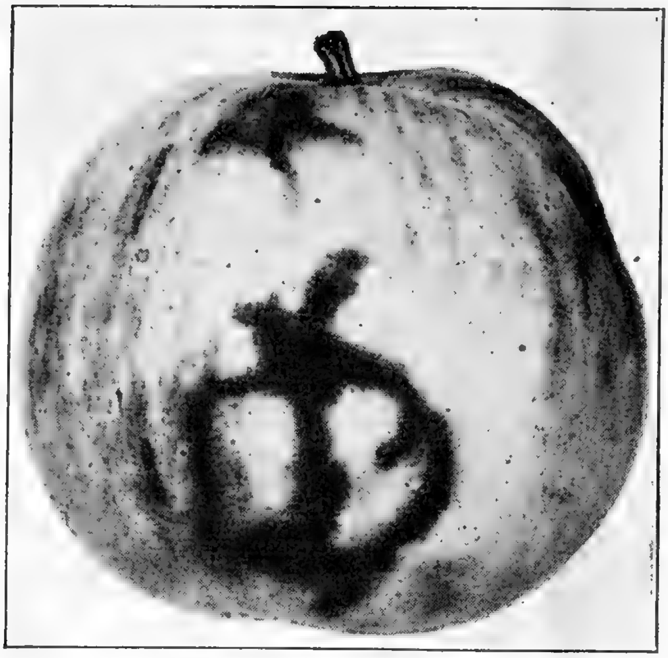

FIG. 16.—Characteristic appearance of apple maggot tunnel as seen through skin of fruit.

FIG. 18.—Puparium of apple maggot. Enlarged.

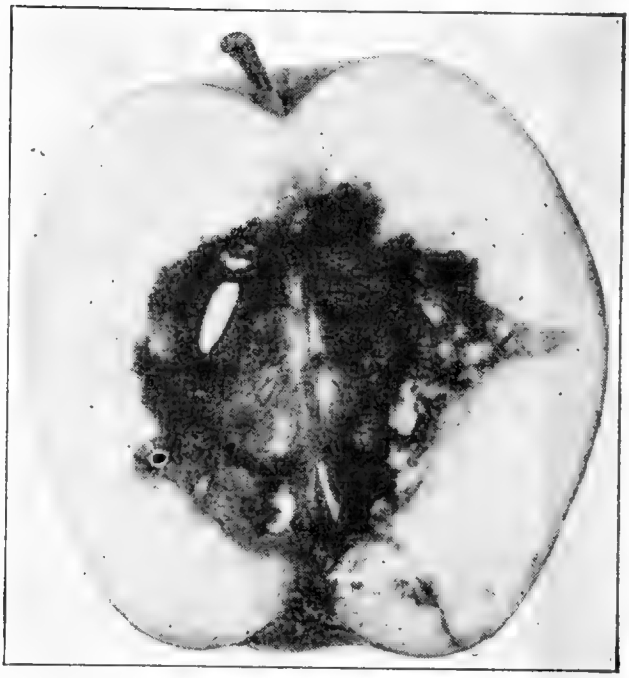

FIG. 17.—Injured apple showing whitish apple maggot larva within.

FIG. 19.—Apple maggot flies resting on fruit. Slightly enlarged.

dropped fruit shortly after it falls, or pasturing hogs in the orchard, will serve to destroy the maggots before they have an opportunity to enter the ground. Another means of reducing the insect is to cultivate the orchard thoroughly during the early summer so as to kill the puparia before the flies begin to issue.

APPLE LEAF-ROLLER.[6]

About the time the apple buds are beginning to open in the spring the caterpillars of the apple leaf-roller begin to hatch and crawl to the buds, where they eat minute holes in the unexpanded leaves. They continue to feed upon the unfolding leaves, which they web together by means of silken strands. Later the larvæ roll up a single leaf or several leaves (fig. 20) and also web together and feed upon the blossom buds, often causing in this way considerable injury during the pre-blooming period. The caterpillars sometimes spin very heavy webs, as shown in figure 21. After the apples have set, the caterpillars frequently neglect the foliage for the fruit, upon which they feed, protected more or less by surrounding webbed-up leaves. They eat the apples voraciously, consuming irregular patches of the pulp (figs. 22 and 23) and have been known in instances of excessive abundance practically to destroy entire crops. They are especially destructive in portions of Colorado and New Mexico, where serious outbreaks have occurred, and more occasionally in New York State. At this time they are attracting considerable attention in the Pacific Northwest.

Fig. 20.—Leaf-roller injury to apple foliage.

The apple leaf-roller is a native species, widely distributed throughout the United States, feeding upon a large variety of plants, as apple, pear, quince, plum, cherry, apricot, currant, raspberry, gooseberry, and a large number of trees and shrubs, as well as many other agricultural crops.

The winter is passed in the egg stage (fig. 24), the eggs being laid in grayish masses of over 100 on the trunk, limbs, and branches of the trees. The full-grown caterpillar is about three-fourths of an inch in length, light green in color, with dark brown to black head. Upon reaching maturity the larva transforms to a brownish pupa, usually within a rolled-up leaf (fig. 25), and emerges in about 10 days as a moth (fig. 25), which deposits the overwintering eggs. The moth is small, with a wing expanse of about three-fourths of an inch, the forewings being cinnamon brown in color, with lighter markings.

[6] *Archips argyrospila* Walker.

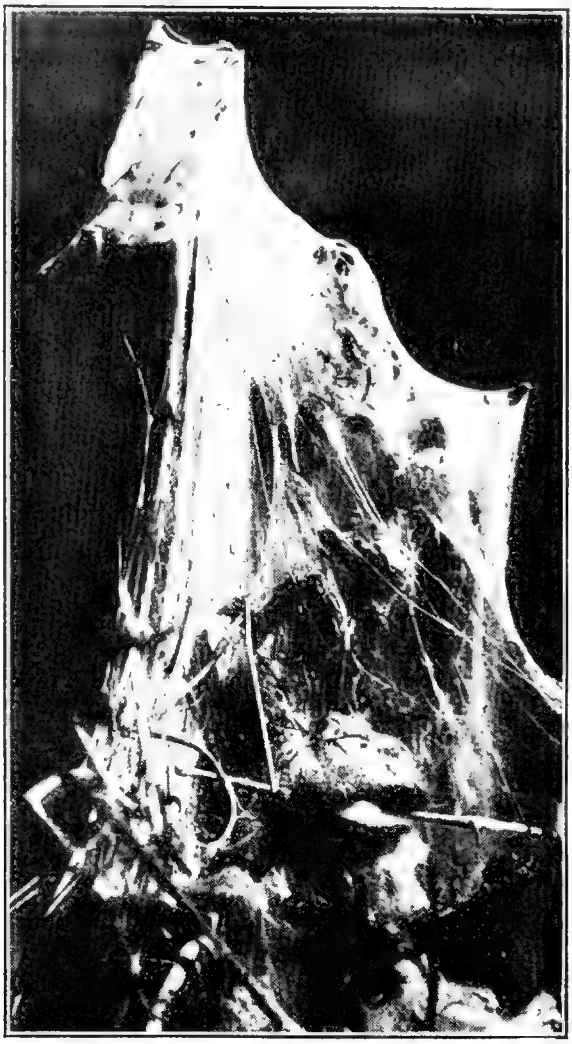

FIG. 21.—Heavy silken web spun by apple leaf-roller larva on grapevine and arbor.

FIG. 23.—Leaf-roller injuries to apples often callus over as corky depressions.

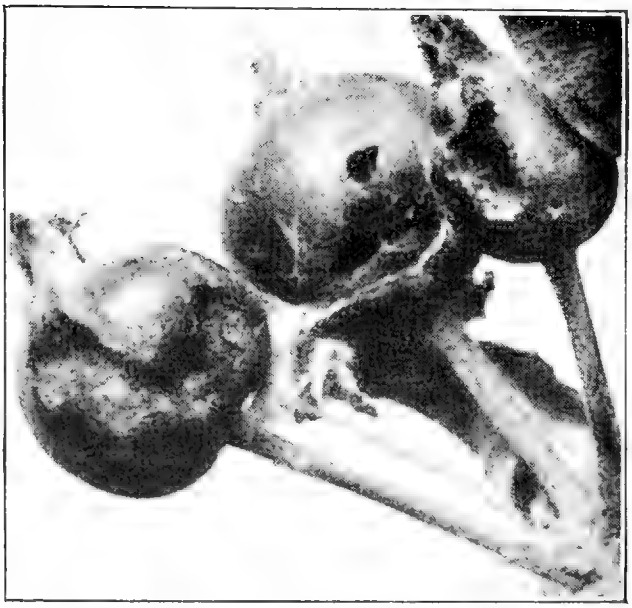

FIG. 22.—Fruit eaten by apple leaf-roller larvæ.

FIG. 24.—Egg mass of apple leaf-roller.

As the result of considerable experimentation it has been found that the apple leaf-roller is best controlled by destroying the eggs with a good miscible oil, used at the rate of 1 gallon to 15 gallons of water, applied during the dormant season, preferably just before the buds swell in the spring. The spraying should be done on bright days to insure as rapid evaporation of the oil as possible. In instances of severe infestations, an application of lead arsenate at the rate of 1½ pounds of the powder or 3 pounds of the paste to 50 gallons of water or fungicide should be made as soon as the larvæ begin hatching. There is also evidence that the addition of one-half pint of 40 per cent nicotine sulphate to each 50 gallons of spray is effective in destroying many of the newly hatched larvæ.

ROSE-CHAFER.[7]

Fruit growers are frequently alarmed by the discovery in their apple orchards during late May or early June of an invading horde of the rose-chafer, or "rose-bug," as it is sometimes called. These awkward, long-legged, yellowish brown beetles often skeletonize the foliage (figs. 26 and 27) and are particularly destructive to the fruit by eating out irregular holes, thus rendering it practically worthless (fig. 28). This insect appears every now and then in large numbers, especially in poorly cared for, untilled orchards, or in orchards adjacent to sandy, uncultivated land. Well-kept orchards, however, are sometimes seriously damaged, particularly in regions of light sandy soils, where the rose-chafer is more or less a chronic pest.

FIG. 25.—Apple leaf-roller cocoon, pupal skin, and moth. Enlarged.

It is found chiefly in the eastern part of the United States and as far west as Oklahoma and Colorado. The beetles are partial to the rose and grape, but will attack practically all kinds of vegetation, including fruit and shade trees, shrubs, vegetables, etc.

This insect passes the winter in the larva stage in an earthen cell beneath the surface of the soil. The full-grown larva is about three-fourths of an inch in length, yellowish white in color, with a light brown head, and transforms in the spring to a light brown pupa (figs. 29 and 30). The beetles (fig. 31), which are light yellowish brown and about one-third of an inch in length, with long, ungainly, spiny legs, appear early in the summer and feed upon the foliage and fruit, as described. The females deposit very small, white, oval eggs singly in the soil a few inches below the surface. The larvæ hatch in a couple of weeks and feed on decaying vegetation and on succulent roots, preferring those of the grasses. They reach maturity in the fall and then construct their small, earthen cells in which they hibernate.

It is very difficult to combat this pest successfully, particularly when it arrives in swarms, as is frequently the case. While no spray materials that have given entire satisfaction have been discovered, some measure of protection is afforded by one to two applications of arsenate of lead at the rate of 2 or 3 pounds of the powder, or 4 to 6 pounds of the paste, to 50 gallons of

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[7] *Macrodactylus subspinosus* Fabricius.

FIG. 26.—Injury to apple foliage caused by rose-chafer. Leaves have dried and curled as a result of the attack.

FIG. 27.—Work of rose-chafer on apple leaf.

FIG. 29.—Pupa of rose-chafer, side view. Enlarged.

FIG. 30.—Pupa of rose-chafer, ventral view. Enlarged.

FIG. 28.—Apple eaten by rose-chafer.

FIG. 31.—Rose-chafer beetles feeding on chestnut blossoms. Enlarged.

Bordeaux mixture (4–4–50), the first application being made as soon as the earliest beetles appear. Some success has also been reported from the use of arsenate of lead at the foregoing strength combined with 1 gallon of cheap-grade molasses to each 50 gallons of water. Self-boiled lime-sulphur mixture has been found quite effective against this insect in New Jersey and in addition would have some value as a fungicide.

In regions where this species is prevalent, the orchardist during the late spring should practice thorough cultivation, especially of sandy land, in which the insect thrives, so as to destroy the pupæ previous to their transformation to the beetle stage. The maintenance of meadows on sandy soils, in the neighborhood of orchards and vineyards, is bad practice from the standpoint of rose-chafer control.

APPLE CURCULIO.[8]

The apple curculio is a snout-beetle and attacks the apple usually in association with the plum curculio (p. 7). It is not nearly as abundant as the latter, but may occur in injurious numbers under conditions that are propitious to the plum curculio, as in weedy, uncultivated, unpruned orchards and in orchards adjacent to woodlands. It covers the same general territory as the plum curculio, being found in the States east of the Rocky Mountains. It has attracted most attention as an apple pest in the North-Central States. Among the more important food plants of the apple curculio are apple, pear, quince, crab apple, haws, etc.

Apples attacked by this beetle become dwarfed and gnarled (fig. 32) as they grow, and when severely punctured during their early development many drop to the ground, where some become sufficiently mellow to permit the larvæ to reach maturity. The egg-laying punctures of this insect differ from those of the plum curculio in that the female does not cut a crescent-shaped slit adjacent to the egg cavity. The apple curculio inserts its beak into the flesh of the fruit and, after enlarging the opening at the base, deposits an egg. It then plugs the hole with excrement (fig. 33).

In general the life history and habits of this insect are similar to those of its near relative, the plum curculio, except that the pupæ of the apple curculio (fig. 34) develop within the fallen fruit, whereas the pupæ of the plum curculio are formed in the soil. The full-grown larva (fig. 35) is a dirty white, curved, wrinkled, footless grub, having a light brown head. The small, reddish brown adult or beetle (fig. 36), measuring about one-fourth of an inch in length and having four conspicuous humps on its wing covers, eats very sparingly of the skin of the fruit while making its feeding and egg laying punctures, and hence poisoned sprays are of comparatively slight value in its control. The very minute, oval egg (fig. 37) is at first pearly white, but changes later to dull yellowish.

As stated, poison sprays are of little avail, though they may perhaps have some slight value as a deterrent. It is therefore necessary to rely chiefly upon orchard sanitation, such as pruning to admit sunlight and the removal of favorable hibernating quarters, such as trash and litter, from within or near the orchard. If the fallen fruit infested with larvæ or pupæ is exposed to strong sunlight, the insects will die, and it is mainly for this reason that the apple curculio is better held in check in well-pruned and cared for orchards. Where feasible, the prompt destruction of the fallen fruit or raking it out into the sunlight will help to keep this pest in check.

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[8] *Tachypterus quadrigibbus* Say.

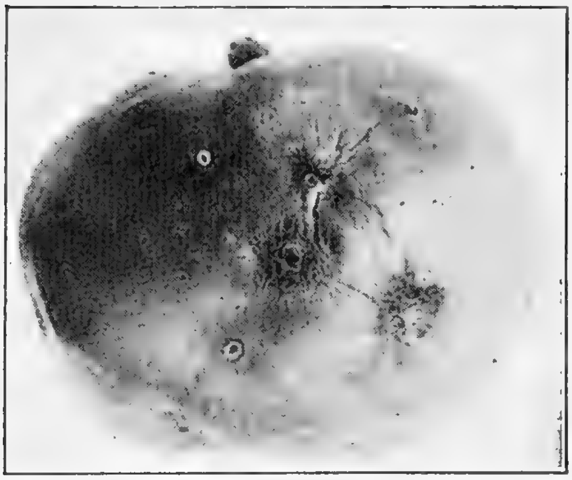

FIG. 32.—Apple showing punctures made by apple curculio.

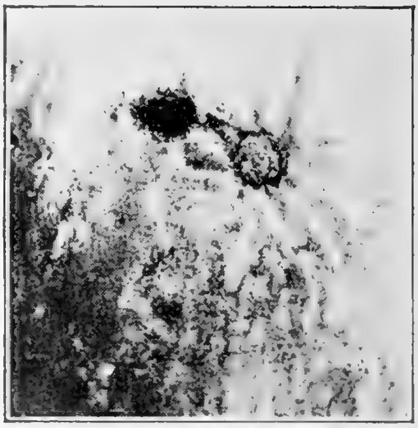

FIG. 33.—Feeding puncture (left) and plugged egg cavity (right) of the apple curculio. Enlarged.

FIG. 34.—Live pupa of the apple curculio in natural position in apple. Enlarged.

FIG. 35.—Larvæ of the apple curculio. Enlarged.

FIG. 36.—Apple curculio beetle resting on apple. Slightly enlarged.

FIG. 37.—Egg puncture and egg of apple curculio in wild crab apple. Enlarged.

GREEN FRUITWORMS.[9]

Every now and then orchardists discover that some pest has eaten large holes in their young apples (fig. 38), but upon careful search are unable to find any trace of the destructive agent. In many instances injury of this character is due to one or more of the species of green fruitworms. It is fortunate that these caterpillars are not generally as abundant as some other fruit insects, since during their more or less sporadic outbreaks they often cause important injury. They not only attack the fruit, but previous to its formation the young larvæ eat the buds and foliage. These insects, of which there are numerous species, are widely disseminated in the United States and feed upon the apple, pear, and other common deciduous fruits, as well as many forest trees.

The life histories of the several species are somewhat similar, differing chiefly in that certain of them pass the winter in the moth stage, whereas the others hibernate as pupæ in the soil, either inclosed in thin, silken cocoons or as naked pupæ. The moths are about three-fourths of an inch long when at rest and resemble one another closely, having in general an ash gray color. They deposit circular-shaped pinkish eggs with a diameter of about one-fiftieth of an inch, in the scars of branches, particularly in leaf scars, the eggs usually being laid previous to the appearance of the leaves. The young larvæ hatch from these eggs and commence feeding upon the buds and expanding foliage and later attack the fruit as soon as it develops. Upon reaching maturity, certain species of larvæ are about 1½ inches long, yellowish green, with a slender, light-colored stripe down the middle of the back and a wider stripe along each side. At the conclusion of their feeding period they enter the soil and there construct the pupal cells, in which they transform successively to pupæ and moths. The pupæ are dark brown, a trifle over a half inch in length, and are to be found from 1 to 3 inches below the surface of the soil.

Fig. 38.—Two species of green fruitworms feeding on foliage and young apples.

An early application of arsenate of lead while the larvæ are small is the most practical method of control. This application may be made during the pink cluster-bud stage, with 2 pounds of the powder or 4 pounds of the paste to 50 gallons of water or fungicide. If no spray is applied until the fruit has set, the worms will have developed to such a size that only very strong doses of the arsenical will be of value, and in any event much of the fruit will be damaged before the poison will take effect.

RED-BANDED LEAF-ROLLER.[10]

During the harvest orchardists sometimes note apples injured by an insect that has eaten out small, shallow, somewhat irregular patches just through the skin (fig. 39), particularly where a leaf has been in contact with the fruit. Injury of this nature may be due to the small, active caterpillar of the red-banded leaf-roller, which is known to be quite widely distributed in the United

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[9] *Xylina* spp.

[10] *Eulia velutinana* Walker.

States, occurring rather generally over the East and having also been reported from California and Texas. It is a very general feeder, attacking deciduous fruits, truck crops, flowers, shrubs, trees, etc., but only occasionally are its injuries to the apple very important, as during seasons of unusual abundance, or in orchards insufficiently sprayed.

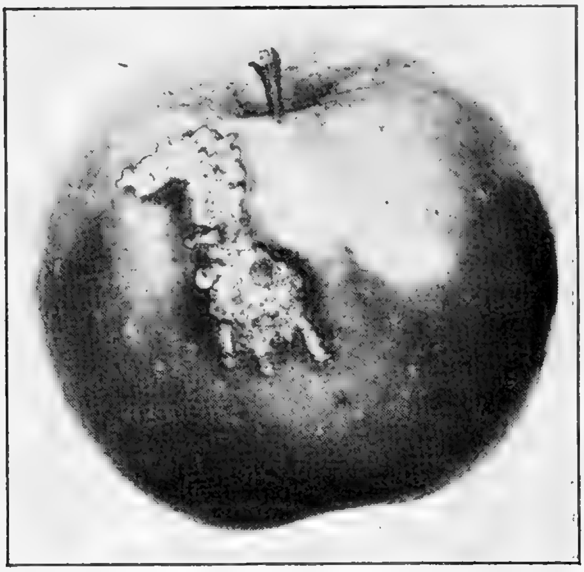

FIG. 39.—Injury to apple by red-banded leaf-roller.

The insect hibernates in the pupa stage, the pupa being less than half an inch in length and brownish in color. The moth emerges early in the spring and deposits its yellowish eggs in flat masses (fig. 40) on the twigs of the apple and other food plants. The moth is brownish with a wing expanse slightly over half an inch. Across the forewing of the female there is a relatively large dark red band. The full-grown larvæ are greenish and about three-fourths of an inch long. Two or three generations are thought to occur each year in the vicinity of Washington and probably only two farther north.

The usual orchard spraying schedule as recommended for the codling moth (p. 6) should hold this insect well in check.

SERPENTINE FRUIT-MINER.[11]

The larvæ of this minute moth make long, narrow, winding mines or trails just under the skin of the apple (fig. 41), greatly disfiguring it and lessening its keeping qualities. Thus far this insect, which has been called the serpentine fruit-miner, has not been sufficiently abundant to be the cause of much injury, though it is the subject of some inquiry, because of the unusual appearance of the injured fruit. Only recently has the adult been obtained and the exact identity of the miner determined. It is doubtless a native species and has been reported from Delaware, New York, Illinois, Oregon, and the Ozark Mountain regions. It apparently feeds only on the apple, though related species are miners on the twigs and branches of various plants. Little is known concerning its life history and habits, though it is supposed to winter in the larva stage. No experiments have been reported on methods of control of this species, as it has not been sufficiently important to necessitate careful study.

FIG. 40.—Egg mass of red-banded leaf-roller.

ROSY APHIS.[12]

The rosy aphis, a small, sucking insect, is unquestionably at the present time the most injurious of the plant-lice attacking the foliage and fruit of the apple. It causes annually an important loss. This aphis curls the foliage, especially that surrounding the fruit (fig. 42), and also attacks the fruit stems and the fruit. The latter often becomes dwarfed and distorted, resulting in the so-

[11] *Marmara pomonella* Busck.

[12] *Anuraphis roseus* Baker.

called "aphis apples" (fig. 43). On young trees the aphids often feed upon the tender shoots, which frequently become twisted, sometimes making a complete loop. The rosy aphis is believed to have been introduced from Europe and is now commonly found in practically all of the apple districts of the United States. The only known food plants are the apple and its alternate summer hosts, the plantains.

FIG. 41.—Work of the serpentine fruit-miner.

The winter is passed in the egg stage on the tree, and the so-called stem mothers begin to hatch about the time the buds burst and immediately settle upon the unfolding leaves. Several generations of the rosy aphis are produced on the apple and these feed upon the foliage and fruit as soon as it is formed, causing the leaves to become curled and deformed. Both winged and wingless individuals are produced, the former migrating when mature to the plantains. The wingless viviparous[a] female is rosy brown, becoming purplish with age, and is covered with a powdery bloom. The spring migrant is brownish green with black head and thorax and transparent wings. The abdomen has a large black patch on the center of the back and the appendages are partly black and partly yellowish brown. In the fall, migrants develop on the plantains and these return to the apple and produce sexual females, which deposit the overwintering eggs, usually on the twigs or in the axil of the buds and occasionally on the larger limbs or in the bark crevices. When first deposited the eggs are pale green, changing later to a glossy black.

FIG. 42.—Work of rosy apple aphis on fruit and foliage of the apple.

On account of its leaf-curling habits the rosy aphis is difficult to control. Best results can be obtained if a spray application is made in the spring period when the aphids are clustered on the green tips of the swelling buds. Where this aphid is usually troublesome the trees should be very thoroughly sprayed at this time with a contact insecticide, preferably 40 per cent nicotine sulphate at the rate of three-eighths of a pint to 50 gallons of water, to which should be added about 2 pounds of soap previously dissolved in hot water. If the San Jose or other scale insects requiring a dormant treatment are present, the orchardist may delay spraying for them until the proper time to treat the apple

[a] Viviparous females are those that bring forth young alive, the eggs developing and hatching within the body of the parent.

aphids and, if the nicotine sulphate is added to the lime-sulphur spray, there will be no necessity for making separate applications against scale insects and apple aphids. This combination treatment, popularly known as the "delayed dormant," consists of three-eighths of a pint of 40 per cent nicotine sulphate and about 6½ gallons of concentrated lime-sulphur (32° Baumé), with sufficient water to make a total of 50 gallons. *Soap should not be added to any solution containing lime-sulphur solution.* This spray should be applied when the bud tips show green and completed by the time the leaf tips have begun to separate. Orchardists with considerable acreage to treat, and planning to make the

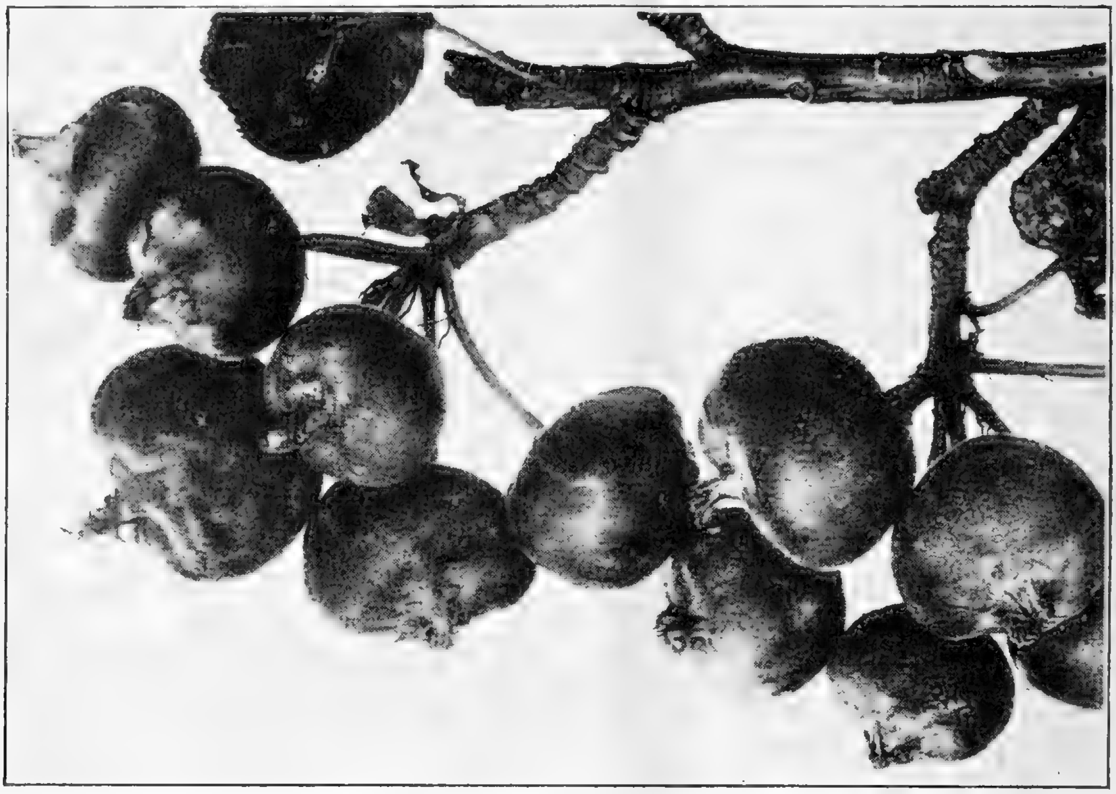

FIG. 43.—Apples injured and stunted by rosy apple aphis. Commonly called "aphis apples."

"delayed dormant" application, should be sure to have adequate equipment to accomplish the work before the foliage expands to any appreciable extent.

GREEN APPLE APHIS.[13]

The green apple aphis hatches from overwintering eggs in the spring about the same time as the rosy aphis, but unlike the latter feeds during the entire season upon the apple. It is often injurious to bearing orchards, but is much more serious as a nursery pest and in young orchards, sucking sap from the tender shoots and leaves (fig. 44), the latter becoming much curled, the attack materially checking the growth, especially during periods of drought. This insect secretes a large amount of honeydew on which ants feed; these often are quite abundant and are mistaken for the real depredator. A black fungus grows on the honeydew, giving the foliage and shoots a sootlike appearance. The green apple aphis is widely disseminated throughout the United States, feeding principally on the apple, but it has also been recorded upon the pear, wild crab, and white thorn.

[13] *Aphis pomi* DeGeer.

The insect passes the winter in the egg stage, the eggs being laid on twigs and water sprouts. They are yellowish green when freshly laid, later changing to a glossy black. The so-called stem-mothers hatch from these eggs about the time the buds begin to burst. From 9 to 17 generations are produced during the season, following which the sexual individuals appear and deposit the overwintering eggs. The wingless viviparous female is of a uniform green color, darkening with age, frequently having a yellowish head. The winged viviparous female is of a pea-green color, with head and thorax shiny black, wings transparent, and appendages more or less completely black.

FIG. 44.—Green apple aphis on apple foliage.

Thorough spraying of trees as the buds are bursting in the spring (delayed dormant treatment) as described for the rosy aphis (pp. 23–24) will be of much value in controlling this species. By midsummer, however, the aphids may become abundant again and in the case of young orchards do considerable damage in checking tree growth. It is a question of judgment on the part of the orchardist whether or not to spray, in view of the only partial effectiveness of treatments due to the curled and rolled-up leaves. If the injury is pronounced, spraying with the 40 per cent nicotine sulphate and soapy water spray is probably advisable, care being taken to apply the liquid thoroughly and with force.

FIG. 45. — Individuals of apple-grain aphis clustered on swollen apple bud. Enlarged.

APPLE-GRAIN APHIS.[14]

Fruit growers are often unnecessarily alarmed early in the spring upon finding the swollen apple buds covered with small, light-greenish aphids (fig. 45) awaiting an opportunity to feed upon the first succulent leaf tissue that appears. Later when the tree is in bloom, the same aphids may appear in hordes in the blossoms, often 15 or 20 individuals to a single flower. This is usually the apple-grain aphis, which, even when abundant, is believed to cause no important injury, since it leaves the apple shortly after the blooming period, migrating to grains and grasses, on which it passes the summer.

FIG. 46.—Eggs of apple-grain aphis on twig. Enlarged.

The apple-grain aphis, or "apple bud aphis," as it is sometimes called, is quite widely distributed throughout the United States. It passes the winter in the egg stage. The eggs (fig. 46), which are laid in crevices of the bark or on the twigs, are pale green when first deposited, later changing to a glossy black. Some of the eggs hatch prematurely during warm days in winter and are destroyed, but the majority do not hatch until the buds commence to swell. Several generations are produced by the time the apple blooms have fallen, at which time the aphids migrate

[14] *Rhopalosiphum prunifoliae* Fitch.

to grains and grasses, as described. The wingless viviparous female is pale green in color, darkening with age, and on its back are commonly found three longitudinal stripes of darker green. The appendages are marked with black near the tips. The winged viviparous female is greenish, with a glossy black head and thorax and with each side of the abdomen marked with a row of black dots and a small black patch near the base of each cornicle. The wings are transparent and the appendages are more or less completely black. In the fall migrants develop on the grains, and these return to the apple and produce the egg-laying females. After mating with the winged males the sexual females deposit their overwintering eggs.

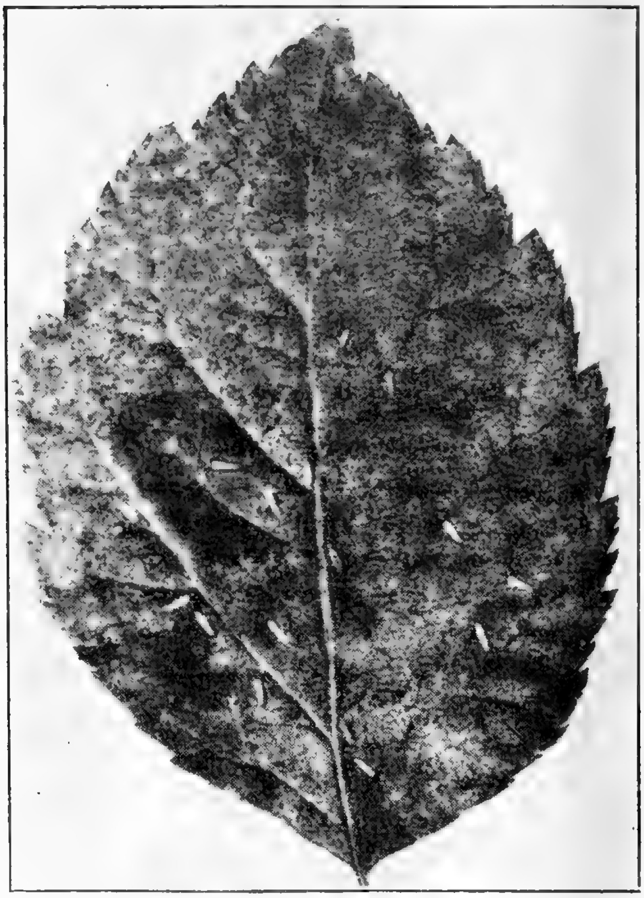

FIG. 47.—Apple leaf showing mottled appearance due to rose leafhopper.

If the apple-grain aphis is the only species present, it will cause but slight injury to the apple, and special control measures will not be required. In many instances, however, some of the other common and more injurious apple aphids are at work, in which event spraying with nicotine sulphate, as recommended for the rosy aphis (p. 23), will be desirable and will kill the plant-lice present, regardless of the species.

ROSE LEAFHOPPER.[15]

During midsummer and early fall the lower apple foliage is often more or less stippled or mottled with white (fig. 47). An examination of such leaves will usually reveal on the lower surface many small, active insects, the so-called rose leafhopper (fig. 48). During recent years injuries by this pest have attracted increasing attention in certain commercial orchards. Leaves seriously infested by this hopper are unable to function properly and in extreme cases fall to the ground, interfering with the proper development of fruit buds and fruit. The leaves are not curled by this species, such injury being caused by the apple leafhopper (p. 27).

The rose leafhopper is believed to have been introduced from Europe, perhaps on nursery stock, and is now widely distributed throughout the United States. Among its food plants, in addition to the rose and apple, are our common deciduous fruits; the grape, raspberry, currant, gooseberry, and blackberry; the elm, oak, etc. Rosaceous plants, however, are preferred.

The rose leafhopper passes the winter in the egg stage. The winter eggs are deposited beneath the bark of the apple and other plants, especially the rose where available, producing small, blister-like spots, slightly crescentic in outline. The egg is elongate, about one-fortieth of an inch in length, and at the time of deposition is transparent, changing toward the close of its incubation to yel-

[15] *Empoa rosae* Linnaeus.

lowish white. The young or nymphs hatch in the spring, usually from three to four weeks earlier than the apple leafhopper, and immediately begin their attack upon the foliage. They are full grown during early summer, at which time they are yellowish green and about one-eighth of an inch in length. After feeding on the foliage for several weeks the adults deposit eggs in the veins of the leaves. The second generation hatches from these eggs and the nymphs continue to feed upon the foliage. It is the work of this brood which as a rule is most conspicuous during late summer. The second brood of adults deposits the overwintering eggs in the bark of the apple, rose, etc., as previously mentioned.

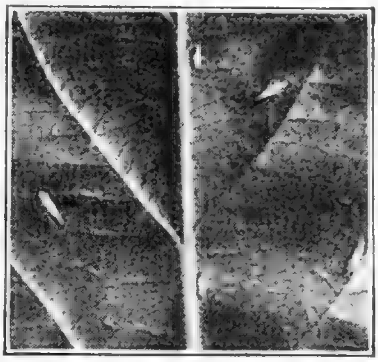

FIG. 48.—Rose leafhoppers on apple leaf.

For the control of the rose leafhopper 40 per cent nicotine sulphate should be used at the rate of 1 part to 1,200 or 1,500 parts of water. If other grades of nicotine compounds are employed, care should be taken that the diluted spray has an equivalent strength, namely, about 0.03 per cent of actual nicotine. Fish-oil or laundry soap should be added at the rate of 2 to 3 pounds to each 50 gallons of water. The spraying should be directed against the first-brood nymphs on the under surface of the lower leaves, which will require careful and thorough spraying. One application should so reduce the "hoppers" that further spraying will not be necessary. The treatment should be made when the first-brood nymphs are present in maximum numbers, and preferably in the first to third stages, which as a rule will be 3 to 4 weeks earlier than the first spray for the apple leafhopper. If spraying for the first brood has been neglected and the second brood requires treatment, use 40 per cent nicotine sulphate as described above, timing the application when the nymphs are present in maximum numbers.

FIG. 49.—Apple leaves curled by apple leafhopper.

APPLE LEAFHOPPER.[16]

The apple leafhopper much resembles in size and general appearance the rose leafhopper (p. 26), though its injuries are quite different. This form attacks principally the tender terminal leaves, causing them to become reduced in size, curled, and misshapen (fig. 49). The effect of feeding by the insects eventually causes the tips of the leaves to dry up and turn brown. This injury is often important on young orchard trees and on nursery stock. The

[16] *Empoasca mali* LeBaron.

apple leafhopper is widely disseminated throughout the United States, attacking numerous plants, including most deciduous fruits, as well as shade trees, grasses, cereals, truck crops, and the like.

The insect hibernates in the adult stage (fig. 50) beneath fallen leaves or other convenient shelter in the orchard or near by. It is pale green, about one-eighth of an inch in length, and on the thorax are two pearly white, longitudinal lines, connected by a transverse line forming the letter H. As the weather becomes warm in the spring the adults leave their hibernating quarters and make their way to the underside of the terminal leaves, where they commence feeding. Later the eggs are inserted beneath the lower epidermis of the leaf and in due time give rise to the nymphs. The latter are principally responsible for the curled and deformed condition of the foliage.

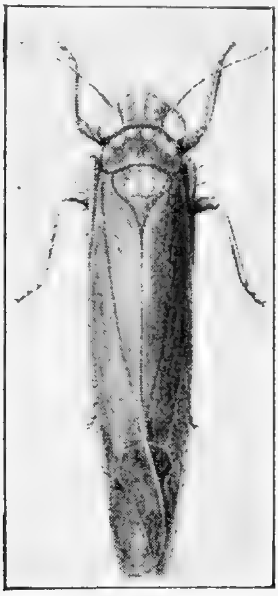

Fig. 50.—Adult apple leafhopper. Enlarged.

Three generations are produced each year in the Middle Atlantic States, the adults of the last one hibernating as described. The eggs are very minute, cylindrical, about one-thirtieth of an inch in length, transparent when first deposited, changing later to a pale yellow. In size the nymphs vary according to age and in general have a yellowish-green color. The adults are very active and when disturbed can readily dart from one limb to another or fly to near-by trees.

The apple leafhopper, like the rose leafhopper, can best be controlled by a nicotine spray, as 40 per cent nicotine sulphate, at the rate of 1 part to 1,200 or 1,500 parts of soapy water. The spraying should be done against the first-brood nymphs, special attention being given to covering the lower surface of the leaves, and the application made when the insects are mostly in the third nymphal stage. This can be determined by frequent examinations of the insects on the leaves. Since lime-sulphur is frequently used as a summer spray, the nicotine sulphate may be combined with it, *omitting, however, the soap.* Arsenate of lead, if desired, may be added to this combination and thus at the same time effect the control of chewing insects as well as of fungous diseases.

BUD MOTH.[17]

The little, brownish, overwintering caterpillars of this species are about half-grown when the apple buds begin to swell in the spring and are ready to gnaw into the buds when these open. Later they feed upon the expanding foliage (fig. 51, B), but the injury is usually greatest to fruit buds, which are frequently devoured to such an extent as to destroy the prospects of a crop. As mentioned later, injury of a different nature is caused during the summer and early fall by the new generation of larvæ, but this damage is not so serious as that produced by the overwintering caterpillars. Nursery stock is sometimes seriously injured and the pest often is accidentally distributed through the sale of the infested trees.

The bud moth was introduced into this country from Europe and easily ranks as the most important of the apple bud-infesting insects. It is essentially a

[17] *Tmetocera ocellana* Schiffermüller.

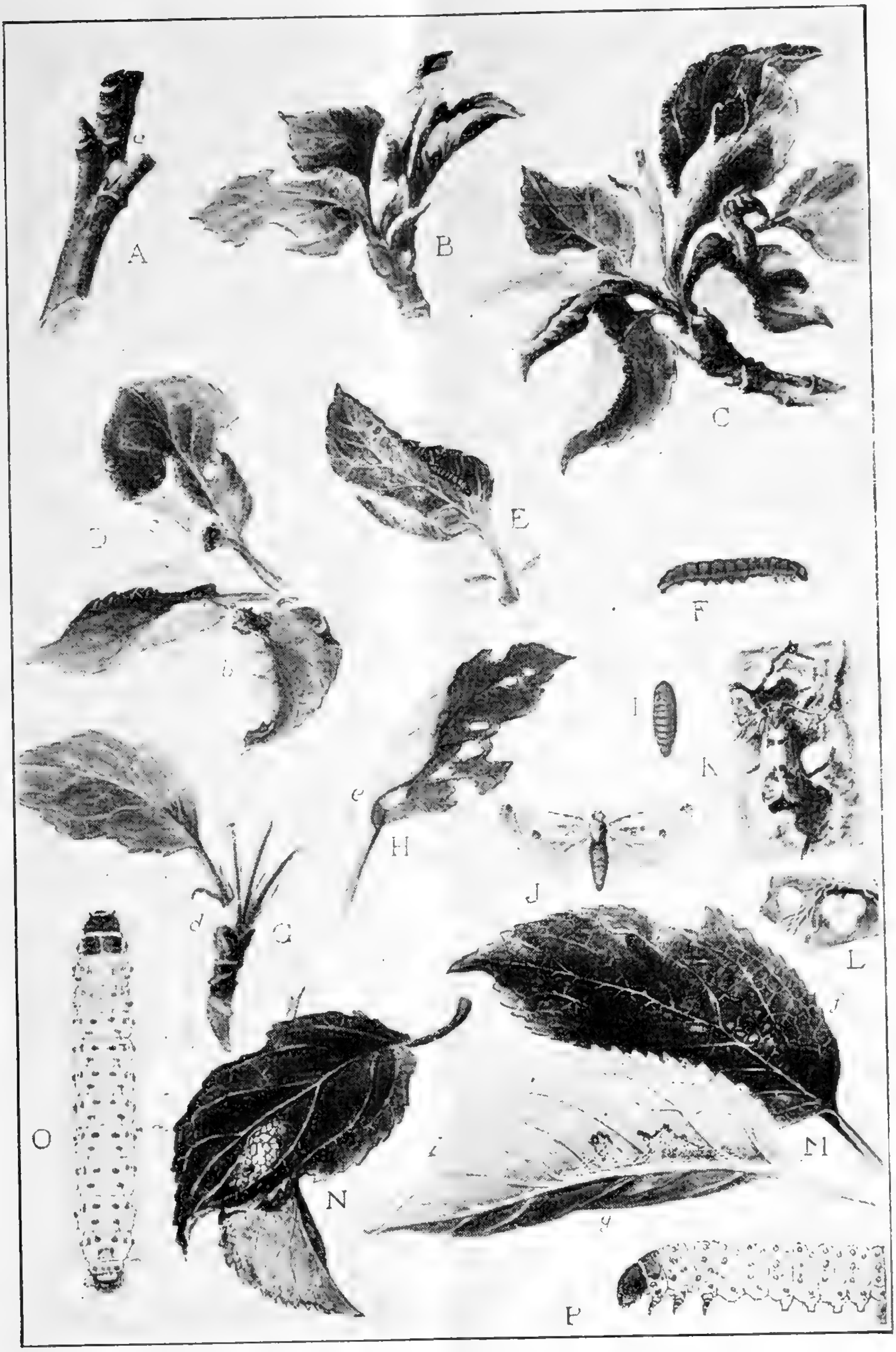

FIG. 51.—Bud moth: *A*, Twig with winter cocoon or hibernaculum in crotch at *a*; *B*, spring feeding of larva in expanding leaves; *C*, later stage of infested leaves, showing dead, rolled leaves; *D*, larval nests in rolled leaves, a deserted one at *b* and a new one at *c*; *E*, feeding areas and larva on a leaf; *F*, mature larva; *G*, *H*, pupal cocoons at *d* and *e*; *I*, pupa; *J*, *K*, bud moth adults; *L*, eggs on underside of leaf, enlarged; *M*, two leaves showing summer feeding of larva; *f*, appearance on upper surface; *g*, web-covered feeding area on under surface in which is partly concealed a tube of silk and frass; *N*, a common condition where two leaves are webbed together, one leaf being dead and detached from its base; *O*, *P*, diagrams of larva showing arrangement of tubercles and hairs, enlarged.

northern species, being found chiefly in the upper tier of States from coast to coast, but is perhaps most numerous in the New England States, where it frequently causes a considerable loss, particularly in unsprayed or poorly cared for orchards. The apple is its principal host, but it will also attack pear, quince, peach, cherry, plum, prune, blackberry, laurel, oak, and other plants.

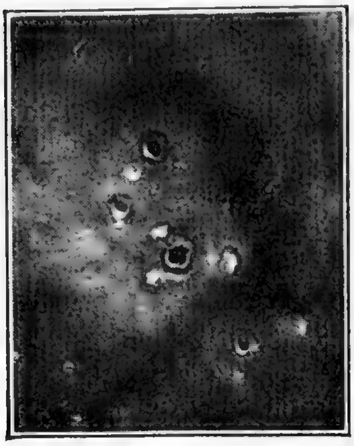

FIG. 52.—Holes in apple made by bud moth larvæ during summer.

The bud moth, as above mentioned, passes the winter as a half-grown, dark-brown, black-headed larva, within a small silken case, known as a hibernaculum (fig. 51, A). This is composed of silk, reinforced by small bits of bark or leaves, and is attached to an apple twig. As soon as the bud scales commence to separate in the spring the larvæ begin feeding and continue to work on the expanding foliage and flower parts, usually webbing these more or less together by means of silken strands so as to form a protective covering. Some of the caterpillars continue their burrows through the buds into the tender twig growth. In early summer the caterpillars reach maturity, when they are reddish brown, with a black head, and are about half an inch in length. Subsequently they transform to pupæ within a curled leaf or several leaves sewed together. The pupa (fig. 51, I) is brownish and about five-sixteenths of an inch in length. The small ash-gray moths (fig. 51, J and K), having whitish bands across the forewings and a wing expanse of slightly more than half an inch, appear shortly afterwards and deposit very small, oval, practically transparent eggs (fig. 51, L), which hatch in a week or so following their deposition. The new generation of larvæ protect themselves with a covering of silk as they feed upon the foliage and often eat out shallow excavations through the skin of the fruit (fig. 52), particularly where it comes in contact with a leaf. These small holes may sometimes be confused with the so-called "stings" (p. 4) made by the late broods of the codling moth. As fall approaches the larva builds a hibernaculum, in which it spends the winter.

FIG. 53.—Apple bud infested with lesser bud moth larvæ. Enlarged.

Although it is somewhat difficult to effect immediate control in orchards where this pest is numerous, thorough spraying, regularly practiced, will soon bring satisfactory results. The first application should be made as soon as the flower buds appear, and this should be followed by another application when the buds are in the pink cluster-bud stage, using in each instance 2 pounds of arsenate of lead powder or 4 pounds of the paste to 50 gallons of water or fungicide. After the pest has been well reduced in numbers, the regular orchard sprays, as applied for apple scab, the plum curculio, and the codling moth, will ordinarily hold it in check. Where spraying is not so generally practiced, as in nurseries or young orchards, it will often be feasible to examine the trees and remove the infested leaves or else crush with the hands the insects within the nests.

LESSER BUD MOTH.[18]

Although the lesser bud moth is reported as an apple pest of minor importance, it is quite possible that its depredations are more extensive than generally recognized, since it may be responsible for a part of the injury usually attributed to the bud moth (p. 28). The overwintering larvæ bore into the buds as they begin to swell in the spring (fig. 53) and often, like the bud moth, destroy the flowering parts, thereby reducing the size of the fruit crop. As the leaves begin to expand, the larvæ tie them together with silken strands and feed within the inclosure thus formed. Another type of injury of much less importance is caused by the newly hatched larvæ mining in the leaves during midsummer (fig. 54).

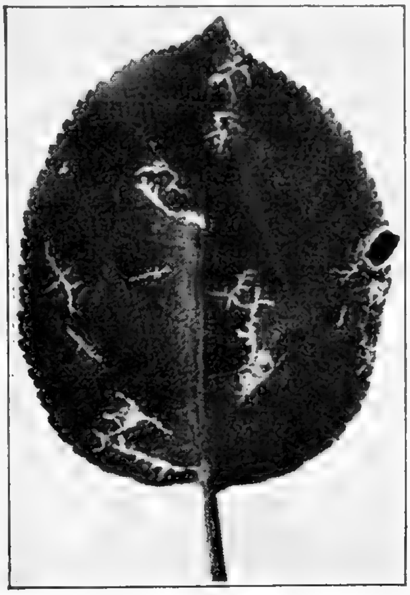
FIG. 54.—Work of lesser bud moth larvæ on apple leaf.

The lesser bud moth is of European origin and was probably accidentally introduced into this country on nursery stock. Its present distribution covers the Northeastern and North-Central States. The pear is reported as its favorite food plant, but it has also been found on the apple, peach, plum, cherry, wild plum, and hawthorn.

At the conclusion of the spring feeding period, the full-grown larvæ, which are about three-eighths of an inch in length and of a brown to light green color, crawl to the tree trunk, where they spin cocoons beneath the bark scales or in crevices. The larvæ soon transform to pupæ which measure about three-sixteenths of an inch in length and vary in color at first from green to greenish brown, later changing to brown. The small moths (fig. 55), which have a wing expanse of about half an inch, are streaked in appearance and have conspicuous black and white banded legs. They deposit their small, yellowish colored eggs on the underside of the foliage, and the larvæ, upon hatching, eat through the lower epidermis of the leaf and mine therein until the approach of cold weather, when they desert their mines and spin their winter hibernacula.

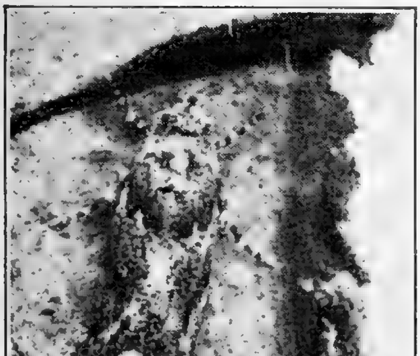
FIG. 55.—Adult of the lesser bud moth resting on bark of pear tree. Enlarged.

The lesser bud moth can be well controlled by spraying the dormant trees with concentrated lime-sulphur solution, testing 32° Baumé, at the rate of 6 to 6½ gallons, diluted with sufficient water to make a total of 50 gallons—a strength also effective against the San Jose scale, blister mite, etc. If the orchardist does not wish to make the foregoing dormant treatment, two applications of arsenate of lead at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide may be substituted. The first of these applications should be made when the buds are swelling and the second as soon as the cluster buds have separated, commonly known as the pink cluster-bud stage.

[18] *Recurvaria nanella* Hübner.

NEW YORK WEEVIL.[19]

The large snout-beetle known as the New York weevil is more formidable in appearance than the plum and apple curculios, but is of less importance. It seldom attracts much attention, except locally during seasons of unusual abundance. While known to occur in many fruit districts, its injuries have been confined mainly to parts of the South and the Mississippi Valley. The New York weevil feeds upon a wide variety of host plants, the more important including our common deciduous tree fruits, white and burr oak, hickory, etc.

This weevil attacks the buds early in the spring and frequently eats into the twigs and tender shoots and cuts off the leaves. Occasionally young trees and nursery stock are quite seriously injured.

Although the life history of this beetle has not been carefully investigated, it is known that the adults are active early in the spring and attack the buds as soon as they start to push out. The adult is a large snout-beetle, about five-eighths of an inch in length and of an ash gray color, with small, light dots on the wing covers (fig. 56). The eggs are deposited on burr oak and certain other trees and the resulting larvæ live in the twigs. The larva is footless and light yellow, with yellowish brown head.

Fig. 56.—The New York weevil. Enlarged.

As a means of combating this insect, jarring similar to that done against the plum curculio is sometimes practiced. On small trees hand picking is advantageous if the number of trees is not too great. Probably a thorough application of Bordeaux mixture and arsenate of lead made as soon as the beetles appear would serve to repel or kill them before they seriously injure the buds.

RED-LEGGED FLEA-BEETLE.[20]

The red-legged flea-beetle every now and then appears suddenly in such numbers as to cause much alarm among orchardists who have set out young fruit trees on newly cleared locust land or in the vicinity of recently cut-over locust timber. While these sporadic attacks are often of a serious nature locally, they are fortunately of quite irregular occurrence. The beetles attack the buds early in the spring, resulting at times in the death of the trees. They also feed later upon the foliage and blossoms. The red-legged flea-beetle is found in Europe and the United States and is known to have a large number of host plants, the more important of which include the apple and other deciduous tree fruits, many small fruits, and such trees as locust, hazel, dogwood, etc.

The life history of this insect has not been fully investigated, but it is known that it hibernates in the adult stage. The beetles are about one-tenth of an inch in length, oblong-oval, with wing covers usually of a polished bright blue and bright red legs. The larvæ are supposed to live on the roots of locust.

The buds of fruit trees should be sprayed with arsenate of lead at the rate of 1½ to 2 pounds of the powder or 3 to 4 pounds of the paste to 50 gallons of water or fungicide, and the application repeated if the beetles continue their attack. Bordeaux mixture (4–4–50) serves more or less as a repellent, and this, combined with arsenate of lead, is as satisfactory a spray as anything known at the present time. As a supplementary control measure, the beetles should be jarred from the trees on sheets, as is sometimes done in the case of the plum curculio.

[19] *Ithycerus noveboracensis* Förster. [20] *Crepidodera rufipes* Linnaeus.

APPLE FLEA-BEETLES.[21]

The so-called apple flea-beetles, in common with other flea-beetles, have strongly developed hind legs with which they are able to jump somewhat after the manner of fleas. Generally speaking, the two species here treated are not particularly destructive to bearing apple orchards, but young orchards and nurseries may sometimes be attacked so severely that special remedial measures are desirable. The overwintering beetles begin their attack upon the foliage in late spring to early summer, and when abundant eat many small holes through the leaves, giving them a perforated appearance. The larvæ appear during midsummer and feed upon the soft leaf tissue, skeletonizing the foliage.

The life histories of these insects have not been studied in detail. They pass the winter as bright, metallic green beetles, about one-sixteenth of an inch long. The eggs are yellowish, more or less elongate in outline; and are about one-twenty-fifth of an inch in length. The full-grown larvæ are generally black in color, about one-fourth of an inch long, and when grown pupate in fragile earthen cells just below the surface of the ground. Later the beetles issue and hibernate, there being but one generation annually.

Since flea-beetles are chewing insects, they may be controlled by an application of arsenate of lead of the usual strength in water or fungicide, as lime-sulphur solution or Bordeaux mixture. The application should be made as soon as the beetles are discovered. Orchards and nurseries properly sprayed for other chewing insects will seldom require special treatment for this pest.

SPRING CANKERWORM.[22]

Cankerworms, also known as measuring worms, loopers, or spanworms, have long been known as defoliators of apple and certain shade trees, and during cankerworm years may cause very important injury, especially in orchards not usually plowed or sprayed. In common with many other insects, cankerworms have their periods of abundance, usually lasting 4 or 5 years, after which they practically disappear, due to the combined effects of parasites, climate, etc. The damage is done by the larvæ feeding upon the foliage, which they consume, except the midribs and larger veins (fig. 57). By the close of the feeding period, orchards may be so defoliated that from a distance they appear brown and scorched as if swept by fire (fig. 58). Cankerworms are most often troublesome in neglected orchards and on unsprayed trees growing in sod around the home, and when once established under such conditions may defoliate the trees several years in succession.

The spring cankerworm is native to North America, occurring in Canada and the northern United States, ranging southward through the Mississippi Valley and westward to Kansas and Texas. It is present also in California. Its principal host plants are the apple and elm, although it also feeds on cherry, plum, prune, apricot, linden, etc. The winter is passed in the pupa stage (fig. 59) just below the surface of the ground. If the weather conditions are warm the moths will sometimes emerge as early as February, but, as a rule, emergence does not take place until early spring. The wings of the female moths are very much dwarfed and are useless for flying, and this necessitates their crawling up the trees in order to deposit their eggs. These are laid in patches along the trunk or larger limbs or in any convenient crevice. The females (fig. 60) are grayish, with a dark stripe upon the back, and measure about five-sixteenths of

[21] *Altica foliacea* LeConte; *Altica punctipennis* LeConte. [22] *Paleacrita vernata* Peck.

Fig. 57.—Work of the spring cankerworm.

Fig. 59.—Two views of pupa of spring cankerworm. Enlarged.

Fig. 61.—Eggs of spring cankerworm on bark. Enlarged.

Fig. 58.—Apple tree defoliated by spring cankerworm.

Fig. 60.—Female moths of the spring cankerworm. Enlarged.

an inch in length. The male moth has dark gray forewings, which are crossed with three dark bands. On the back of the abdomen of both the male and female are several rows of reddish spines by which this species may be distinguished from the fall cankerworm. The eggs (fig. 61) are considerably less than one thirty-second of an inch in length, oval in shape, and yellowish green, sometimes showing a purplish iridescence. The young larvæ hatch about the time the foliage of the apple commences to appear and immediately start feeding. The growth is completed by late spring, when the larvæ usually lower themselves to the ground by means of a silken thread. The full-grown larva (fig. 62) is slender, about an inch long, varying in color from yellowish brown to black. There are often three broken yellow stripes above the spiracles, a narrow yellow stripe below the spiracles, and a broad greenish-yellow stripe along the lower surface, bordered on each side with black. There are only two pairs of prolegs, which necessitates the larvæ looping as they crawl, after the manner of measuring worms.

As already stated, orchards properly sprayed for the codling moth and leaf-eating insects are rarely if ever injured by cankerworms. Both the spring and fall cankerworms are controlled by thorough spraying of the trees with arsenate of lead at the usual strength, though if the caterpillars are half-grown or larger when the application is made, the quantity of arsenate of lead should be increased. Trees may also be protected by means of bands of sticky material or bands of cotton batting (see pp. 84–85) placed around the trunk a month or two previous to the time the buds usually begin to swell. These barriers will keep the females from crawling up the trees to deposit eggs and will, if properly applied, prevent the young larvæ that may hatch below the bands from ascending the trees. Thorough plowing and cultivation of the soil after the larvæ have pupated in late spring will be effective in destroying many of the insects while in this helpless stage.

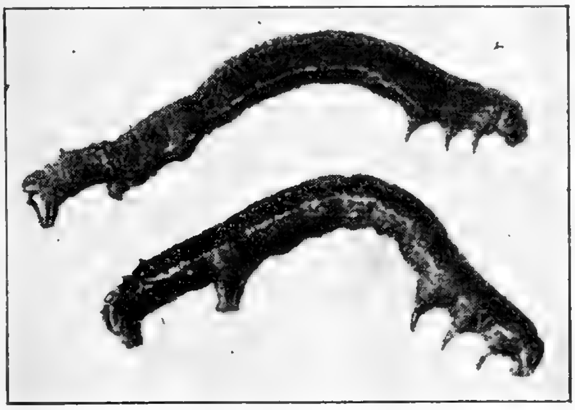

FIG. 62.—Larvæ of the spring cankerworm. Enlarged.

FALL CANKERWORM.[23]

The caterpillars of the fall cankerworm, known also as loopers, measuring-worms, or spanworms, attack the foliage of the apple in the manner described for the spring cankerworm, and the two species, along with certain other loopers, may often be present on the trees at the same time. The fall cankerworm is a more general feeder than the spring form, attacking, in addition to the principal pome and stone fruits (fig. 63), the hackberry, common hickory, linden, walnut, butternut, etc. It occurs generally over the northeastern United States and in Canada, extending westward to the Central States. It is also present in California, attacking various deciduous fruits.

The life history of the present species differs somewhat from that of the spring cankerworm in that the winter is passed chiefly in the egg stage, the eggs being deposited usually in the fall, though some eggs are laid in the spring by moths that emerge at this time. The dark gray eggs, which are arranged neatly side

[23] *Alsophila pometaria* Harris.

FIG. 63.—Injury to cherry by fall cankerworm.

FIG. 66.—Female moth of the fall cankerworm depositing eggs. Enlarged.

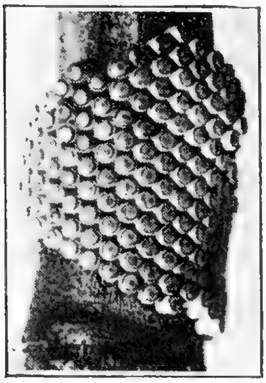

FIG. 64.—Egg mass of the fall cankerworm. Enlarged.

FIG. 67.—Female moths of the fall cankerworm. Enlarged.

FIG. 68.—Male moth of the fall cankerworm. Enlarged.

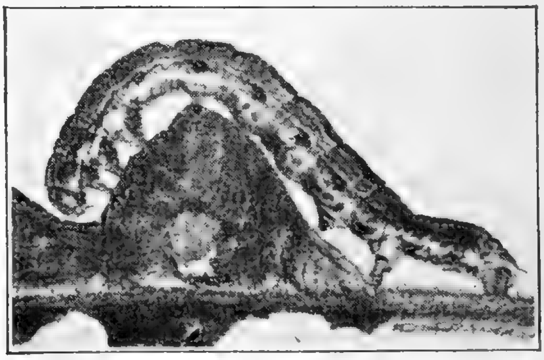

FIG. 65.—Fall cankerworm larva. Enlarged.

by side in clusters of 100 to 400 upon apple twigs, as shown in figure 64, resemble tiny flowerpots. When full grown the larva is about 1 inch in length, slender, with three pairs of prolegs, which serve readily to distinguish it from the spring cankerworm, which has only two pairs. The larvæ (fig. 65) are usually dark greenish or blackish in color, the majority showing on each side a prominent, longitudinal stripe of light lemon yellow. Like the moth of the spring form, females of this species are wingless and must crawl up the trees in order to deposit eggs on the twigs (fig. 66). The female moths (fig. 67) are dark gray and about half an inch long. The males (fig. 68) resemble in size those of the spring cankerworm and have about the same wing expanse. Neither sex, however, has the two rows of spines on the back of the abdomen, as has the preceding species.

The remedial measures indicated for the control of the spring cankerworm will be effective in combating the fall form. If bands of sticky material or cotton (see pp. 84–85) are used, they should be applied in October and kept in good order by frequent examination until the danger of injury is over in the spring.

APPLE-TREE TENT CATERPILLAR.[24]

The apple-tree tent caterpillar constructs the unsightly tents or webs, familiar objects in the spring in neglected orchards and in trees along fences, roadways, streams, etc. During caterpillar years considerable damage frequently results from defoliation to young orchards and trees not regularly sprayed. It is a native insect and occurs westward to the Rocky Mountains. On the Pacific slope it is replaced by other closely related forms. The favorite host plant of the tent caterpillar appears to be wild cherry, though it feeds freely upon apple, peach, plum, and other deciduous fruits, and upon various shade and forest trees.

The tent caterpillar passes the winter in the egg stage. The eggs are laid on twigs in clusters of 300 to 400 (fig. 69), each egg mass being covered with a waterproof material. An individual egg is somewhat thimble-shaped and is about one twenty-fifth of an inch in length. The eggs hatch as the apple buds begin to open or somewhat earlier and the larvæ are ready to attack the new leaves as soon as they appear. Almost immediately after hatching the colony begins to form its silken nest or tent, usually in the crotch of the tree limbs, sometimes at or near the trunk of the tree. As the larvæ grow, the tent is enlarged from time to time to accommodate the needs of the colony (fig. 70). When full grown, the caterpillars make their way to sheltered places for spinning their cocoons, in which the pupa stage is passed. The full-grown larva (fig. 71) is about 2 inches long, deep black with a white stripe along the back and blue and white spots on each side. The caterpillars are partially covered with yellowish hairs. The brownish pupa (fig. 72), which measures about three-fourths of an inch in length, is inclosed in a silken cocoon (fig. 72), loosely woven on the outside but tightly woven within, and, when freshly made, is more or less covered with a yellowish powder. The moths issue during midsummer and soon thereafter deposit their characteristic overwintering egg masses. The moths are reddish-brown, the forewings having two transverse, oblique, whitish stripes (fig. 73).

Apple orchards regularly sprayed for other insects will rarely be seriously troubled by this insect. The arsenate of lead used in the pink cluster-bud spray will destroy the caterpillars before they have occasioned much damage. Whenever it is desirable to spray for the tent caterpillars alone, arsenate of lead is advised in water or fungicide, using the poison at the rate of 1 pound of the

[24] *Malacosoma americana* Fabricius.

FIG. 69. — Two egg masses of the apple-tree tent caterpillar.

FIG. 70.—Larvæ and nest of apple-tree tent caterpillar in wild cherry tree.

FIG. 71.—Larva of apple-tree tent caterpillar. Enlarged.

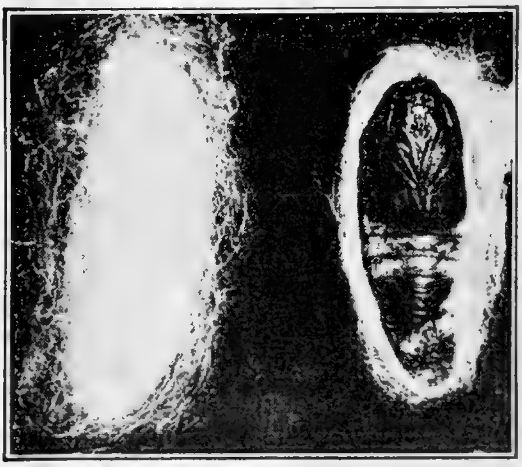

FIG. 72.—Cocoon (left) and pupa (right) of apple-tree tent caterpillar. Enlarged.

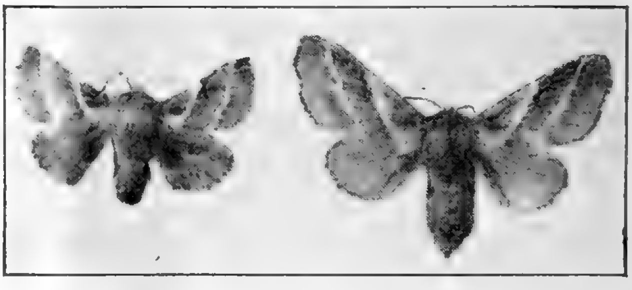

FIG. 73.—Apple-tree tent caterpillar moths: Male at left and female at right.

powder or 2 pounds of the paste to 50 gallons for the young caterpillars, but doubling the amount of poison in case the larvæ are one-third grown or over. It is quite practicable to destroy the nests and caterpillars by hand where these are not too numerous. During the work of pruning, lookout should be kept for the egg masses and these removed and destroyed. The destruction of wild-cherry trees in the vicinity of orchards will aid in keeping the pest reduced.

FALL WEBWORM.[25]

As the name indicates, the larvæ of this species web together a considerable number of leaves and twigs into an unsightly nest (fig. 74), much in evidence in the late summer and early fall. Within the nest the larvæ feed upon the leaves, as well as any fruit which may be inclosed. This insect is not ordinarily an important apple pest, except in epidemic years in neglected orchards or in young orchards to which arsenical sprays are not as a rule applied. It is a native species, widely distributed over the United States, and attacks a large variety of food plants, as the apple, pear, pecan, and various nut and shade trees. It is rather chronically injurious to shade trees.

The winter is passed in the pupa stage concealed beneath trash on the ground or just under the surface of the soil or sometimes in crevices of the bark. The dark-brown pupa (fig. 75) is inclosed in a flimsy silken cocoon, into which hairs from the caterpillar are woven. The first brood of moths issue irregularly, but some larval webs are to be found within a few weeks after the foliage has pushed out. In the Middle and Southern States a second brood appears in late summer or fall. The moths (fig. 76) have a wing expanse of about 1¼ inches and are variable in color, some being pure white, while others are white spotted with black and brown dots. The eggs (fig. 77), which are light yellow and globular, are deposited on both the upper and lower surfaces of the leaves in flat clusters, usually containing a few hundred eggs and are more or less covered with white hairs from the body of the female. Upon hatching, the caterpillars attack the terminal leaves of the branch and soon inclose a section within a silken web, enlarging it as more food is required. Feeding is continued within this web until the larvæ are nearly grown, when they frequently feed outside of the nest at night. A full-grown caterpillar (fig. 78) is about 1¼ inches long, with a broad, dark band along the back, the body being covered with long, whitish hairs, though there is a considerable variation in their color and appearance.

This species yields readily to arsenicals of the strength usually employed and will require no attention in apple orchards receiving the proper spray applications for other chewing insects.

RED-HUMPED APPLE CATERPILLAR.[26]

Ordinarily the red-humped apple caterpillar is one of the minor insect enemies of the apple, the injury consisting in the defoliation of individual branches or occasionally of young trees. The caterpillars feed in colonies at the ends of branches and are met with from midsummer until early fall, according to latitude. It is a native species, quite generally distributed throughout the United States, and, in addition to the apple, feeds upon the pear, cherry, plum, and prune, as well as certain other fruit, nut, and shade trees. As a rule it winters in the larva stage within a loosely constructed cocoon in some sheltered place on or near the ground (fig. 79, F). In the late spring or early

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[25] *Hyphantria cunea* Drury. [26] *Schizura concinna* Smith and Abbot.

FIG. 74.—Nest or web of the fall webworm.

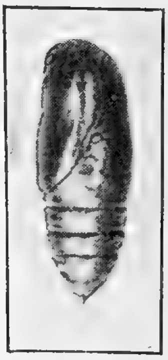

FIG. 75.—Fall webworm pupa. Enlarged.

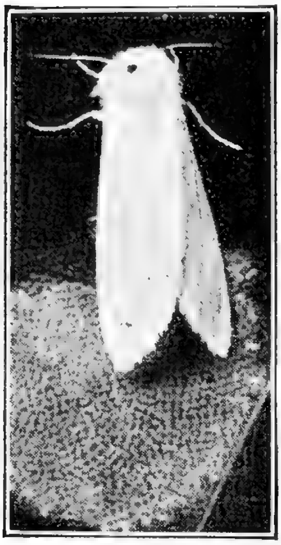

FIG. 76.—Moth of fall webworm depositing eggs. Enlarged.

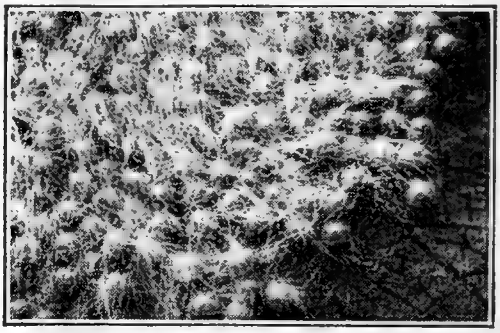

FIG. 77.—Eggs of fall webworm. Greatly enlarged.

FIG. 78.—Fall webworm caterpillars.

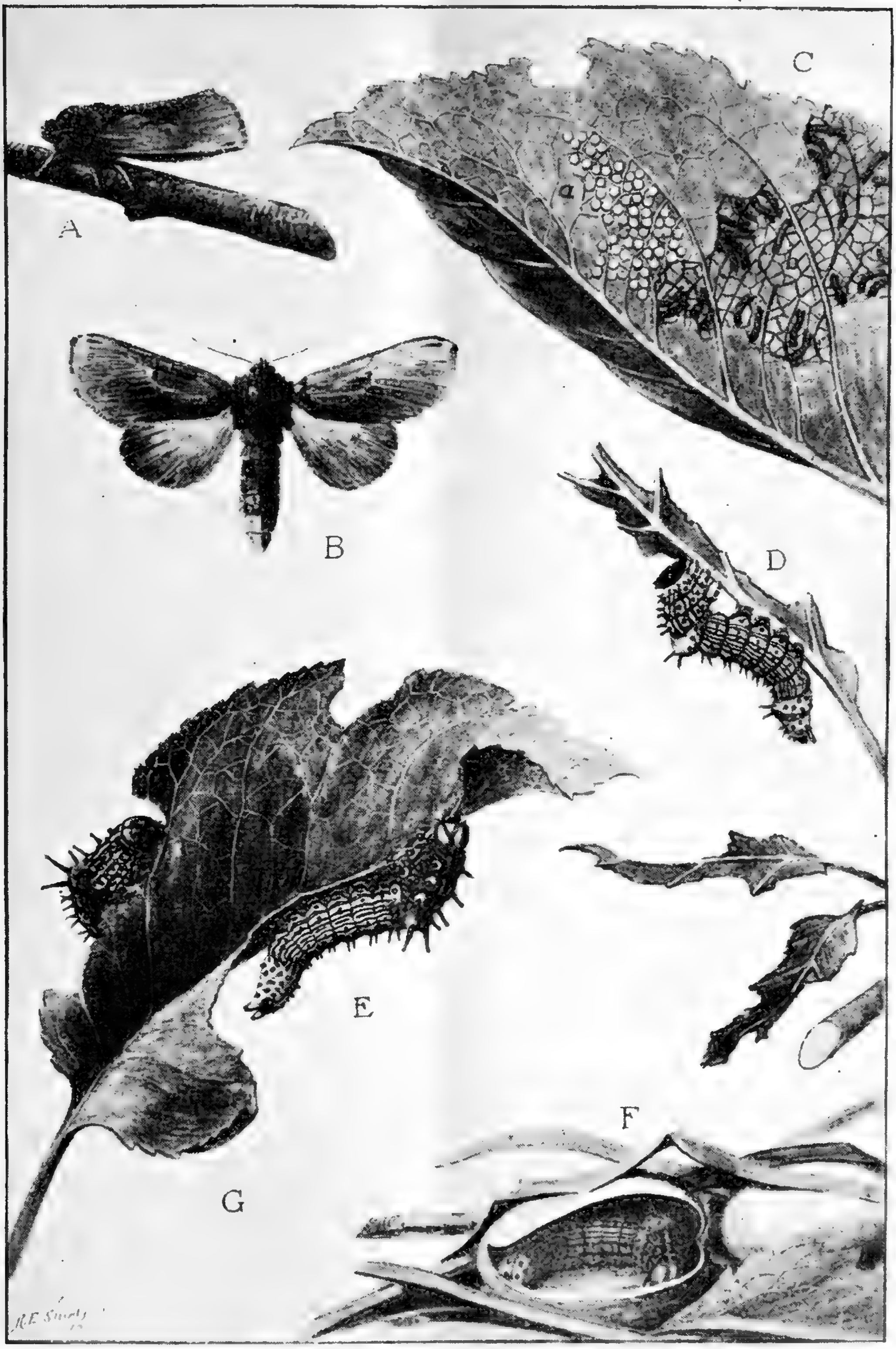

FIG. 79.—Red-humped apple caterpillar: *A*, Moth at rest on twig; *B*, moth with wings spread; *C*, apple leaf showing unhatched eggs at *a*, and young caterpillars feeding on lower epidermis at *b*; *D*, caterpillar nearly full grown; *E*, full-grown caterpillar; *F*, cocoons on ground amongst grass and dead leaves, one cocoon cut open to show caterpillar within.

summer the larvæ transform to pupæ, from which moths issue somewhat later. The parent moth is dark brown (fig. 79, B), with a wing expanse of about 1¼ inches. The forewings are grayish near the tips, merging into a dark brown near the body. The whitish, globular eggs (fig. 79, C) are deposited side by side in a cluster of 50 to 100 on the underside of the leaf. The young larvæ upon hatching are gregarious; they feed upon the lower leaf surface and eat out the soft parenchyma (fig. 79, C). As they become older they feed along the edges of the leaf (fig. 79, E), consuming the leaf more or less completely. Upon attaining their full growth the larvæ construct cocoons for the winter in the North, whereas in the South they spin very light cocoons in leaves or other convenient places, pupate, and finally transform to the adult stage, giving rise to a second generation. A full-grown larva (fig. 79, E) is about 1¼ inches in length, with the head coral red and a red hump on the fourth body segment. There are black and yellowish-white lines along the body, while on the back are two rows of blackish spines. When at rest the rear end of the body is elevated.

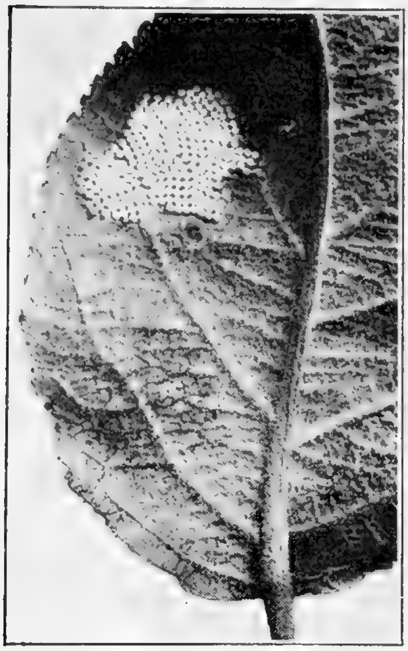

FIG. 80.—Egg mass of yellow-necked apple caterpillar.

The red-humped apple caterpillar will readily yield to arsenate of lead sprayed upon the infested trees. Where this insect has been more or less troublesome in past years, a lookout should be kept for its first appearance and the arsenical applied promptly. Scattering colonies, if not too numerous, can often be economically destroyed by hand.

YELLOW-NECKED APPLE CATERPILLAR.[27]

The yellow-necked apple caterpillar is very similar in its habits and method of feeding to the red-humped apple caterpillar, the injury as a rule being confined to individual limbs, although sometimes entire trees are defoliated, principally in young orchards. Ordinarily it does very little damage, except during occasional years. It is native to America and attracts attention principally in the Central and Northern States. It feeds upon the apple, pear, cherry, quince, and many nut and shade trees.

FIG. 81.—Yellow-necked apple caterpillars.

The insect passes the winter in the ground near the surface of the soil as a naked, brownish, pupa slightly less than an inch in length. The moths appear in midsummer and deposit some 25 to 100 eggs in flat masses (fig. 80) on the underside of the leaves. The adult, which has a wing expanse of about 2 inches, is reddish brown, with the forewings crossed by three or four dark lines. The larvæ feed in dense

[27] *Datana ministra* Drury.

colonies, at first on the lower surface of the foliage, but later on the edges of the leaves. If disturbed, they are likely to cease feeding and erect their heads and rear ends in a characteristic attitude, as shown in figure 81. Upon reaching their full growth the caterpillars leave the trees and enter the soil, where they pupate for the winter, there being but one brood each year. The mature larva measures about 2 inches in length. The head is black and the sides are striped with black and yellow lines; the body is more or less covered with whitish hairs.

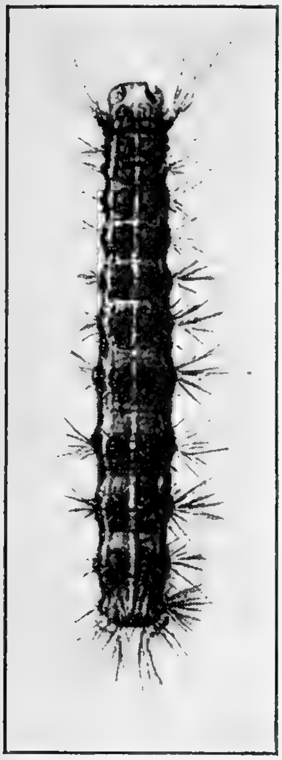

FIG. 82.—Gipsy moth caterpillar.

When this species becomes troublesome on apple, it may be readily controlled by spraying the trees with arsenate of lead at the usual strength. Occasional colonies of the caterpillars found in the orchard can be shaken or brushed from the trees and killed on the ground.

GIPSY MOTH.[28]

The gipsy moth in its area of distribution is often quite injurious to the apple. The larvæ when young eat small holes in the leaves, but later consume the entire leaf with the exception of the larger veins. This insect is notorious for its injuries to shade and forest trees in the New England States, where large sums of money have been spent in restricting its further spread. It was accidentally introduced from Europe into Massachusetts about 1869. It is still confined to the New England States, except for an outbreak recently found in New Jersey. The caterpillars attack a very large variety of plants, including various deciduous fruits, but, as above mentioned, are especially destructive to forest and shade trees.

During the winter season the gipsy moth is in the egg stage, the eggs being laid in more or less flat masses, containing from 400 to 500 eggs and covered by hairs from the body of the female. These masses are placed frequently at the base of trees, under stone walls, or on wooden fences, the moth apparently not being particular, except to find a somewhat protected location. The caterpillars are hatching in the spring by the time the apple buds begin to show green, and as the leaves expand these are fed upon until the caterpillars complete their growth. The mature larva is about 2 inches in length, with characteristic markings on the back which consist of five pairs of blue tubercles followed by six pairs that are reddish in color. Between these markings is a thin yellow stripe, and the body is well clothed with black hairs (fig. 82).

FIG. 83.—Male gipsy moth.

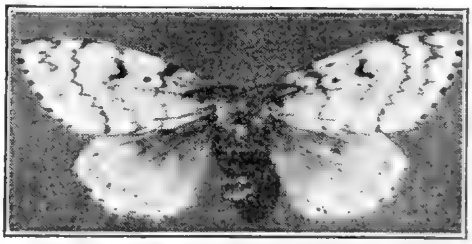

FIG. 84.—Female gipsy moth.

[28] *Porthetria dispar* Linnaeus.

The pupa measures about an inch in length and is of a dark brown color. The moths emerge during midsummer and deposit the overwintering eggs, there being but one brood of caterpillars each year. The extended wings of the male moth measure about 1½ inches from tip to tip, are light brown, and crossed with four irregular, dark lines (fig. 83). The female (fig. 84) is somewhat larger and is unable to fly. Its wings are whitish with dark lines on the forewings as in the male moth.

Orchardists can reduce the infestation to a considerable extent by examining their trees and surrounding fences for the egg masses during the winter and treating them with crude coal-tar creosote, to which should be added a small quantity of lampblack to serve as a marker. The trees should also be sprayed as soon as the leaves are large enough to take an application of poison. Since the gipsy-moth caterpillars are quite resistant to arsenical poisons, it is necessary to use 3 or 4 pounds of the arsenate of lead powder, or double this amount of the paste, to each 50 gallons of water or fungicide, and this strength is effective only during the very early season, when the larvæ are young.

BROWN-TAIL MOTH.[29]

Early in the spring, as the leaves are pushing out, the small larvæ of the brown-tail moth emerge from their winter nests and attack the foliage. Somewhat later in the spring they also feed upon the blossoms (fig. 85). When abundant they defoliate the trees more or less completely. The insect occurs rather generally over the New England States and extends into Canada. While not now especially destructive, it has in recent years been a pest of importance and may reappear in destructive numbers at any time. The brown-tail moth is a native of Europe and is thought to have gained entrance into this country about 1890 or a few years later. The apple is one of its favorite food plants, as is also the pear, but it is preeminently an enemy of shade and forest trees, except conifers.

The insects winter as very small caterpillars in tough silken nests composed of partly skeletonized leaves, securely webbed together (fig. 86). With the approach of warm weather the caterpillars emerge from their winter nests to attack the developing foliage. They continue feeding until early summer, when they become full grown, and spin very light cocoons, frequently in a leaf or amongst trash near the trees. The full-grown larva is about 1½ inches long and dark brown to black. The body is covered with reddish brown hairs and on each side is a row of white tufts, with two bright red tubercles near the posterior end of the body. The larvæ transform into dark brown pupæ about three-quarters of an inch in length and later the adults or moths appear. The adults (fig. 87) have white wings which expand about 1½ inches. The abdomen is tipped with a tuft of brown hairs, more noticeable in the female than in the male, which gives the insect its common name. The globular eggs are deposited on the underside of the terminal leaves, in clusters of from 100 to 300 eggs, the entire mass being covered with brownish hairs from the abdomen of the female. The eggs hatch in the latter part of summer and the young larvæ feed upon leaves for a time and later construct their winter nests on the terminal twigs, often quite conspicuous during winter (fig. 88). In figure 89 is shown a nest attached to apples.

There are two principal means of protecting trees from the ravages of the brown-tail moth. The first is to spray the trees, just as the larvæ are hatching, with arsenate of lead at the rate of 2 pounds of the powder or 4 pounds of the paste to each 50 gallons of water or fungicide. Particular attention should be given to applying the poison to the tips of all the branches, since the cater-

[29] *Euproctis chrysorrhoea* Linnaeus.

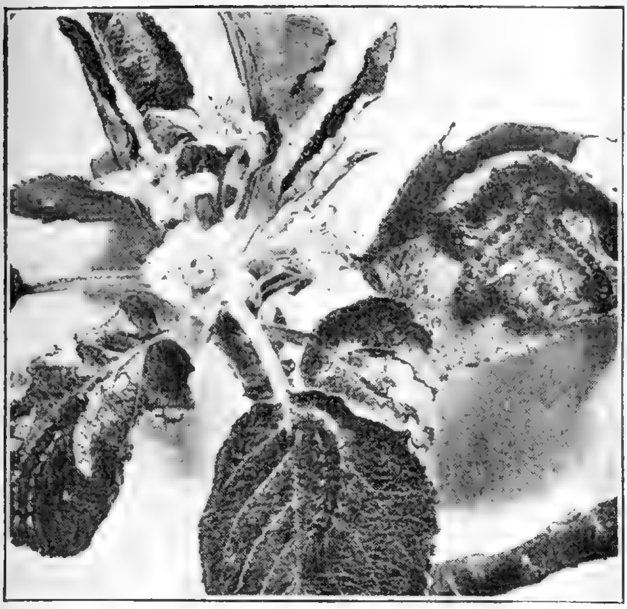

FIG. 85.—Brown-tail moth caterpillars devouring apple foliage and blossoms.

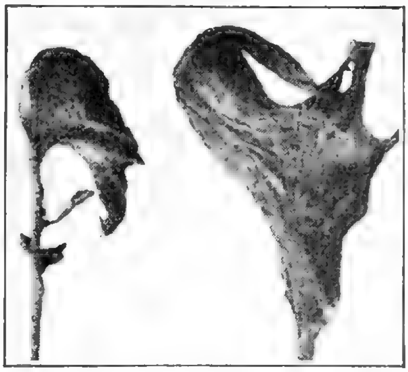

FIG. 86.—Two nests of the brown-tail moth.

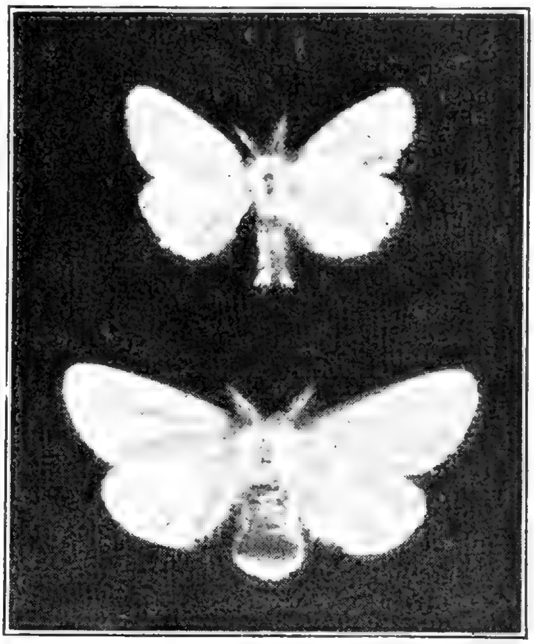

FIG. 87.—Brown-tail moth: Male above, female below.

FIG. 88.—Nests of the brown-tail moth on apple tree.

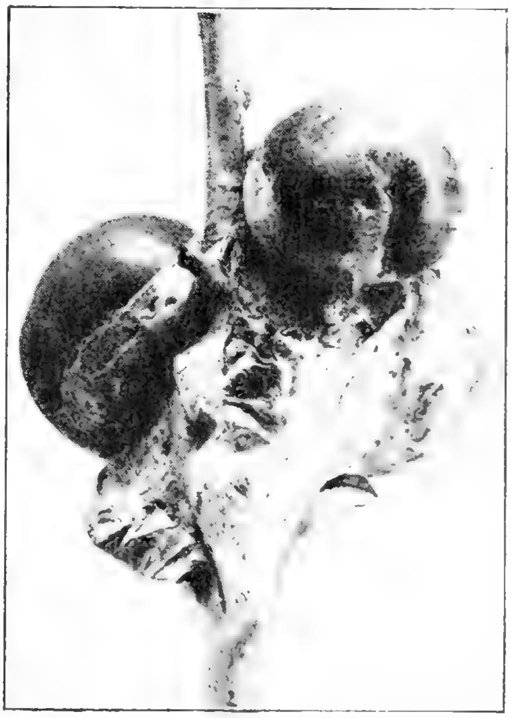

FIG. 89.—Nest of brown-tail moth attached to apples.

pillars feed on the terminal leaves. The second or supplementary means of control is to remove and burn during the winter all of the brown-tail nests found on the trees. If the caterpillars' nests have not been destroyed during the winter or by the time the new foliage appears, the arsenate of lead treatment should be made promptly as described.

WHITE-MARKED TUSSOCK MOTH.[30]

During some years the white-marked tussock moth is of considerable importance by reason of its injuries to the apple, and at these times it is usually abundant on shade trees in the same region. Its injury consists in eating the foliage, though it has been known to do material damage by eating holes in the green fruit (fig. 90). It is a native species occurring quite generally throughout the eastern portions of the United States and in Canada. The caterpillars feed upon a very large list of plants, including the apple, pear, and other deciduous fruits, as well as a large number of shade trees. They are likely to be met with any year in orchards, but only occasionally do they cause serious damage. The winter is passed as eggs, which are deposited in clusters containing from a few to several hundred and are protected by a white, frothlike substance (fig. 91). An individual egg is roundish and light cream-colored and the masses are placed upon the trunk, in crotches of limbs, and other places, usually upon the cocoon from which the female moth has emerged. The female moth (fig. 91) is light gray, with mere rudiments of wings, whereas the male has well-developed wings and is grayish, the forewings being crossed by irregular dark bands, with a white spot near the tip of the outer edge (fig. 92). The larvæ hatch in the spring after the foliage has appeared and with a few weeks of feeding attain full growth and seek a place upon the tree or on some near-by object to spin their cocoons preparatory to pupation. The larvæ are rather ornate, and when full grown measure about 1½ inches long (fig. 93). The head is coral red, and two protuberances of the same color occur on the rear end of the body. There are also two conspicuous black plumes extending from the fore end and one from the rear end of the body, on which are also found four pale yellowish tufts of hair. The pupæ are brownish and are inclosed in the cocoon made of silk and hairs. Toward the northern part of its distribution there is only one brood of larvæ each year, but in the central and more southern States, depending upon the latitude, there may be as many as three broods.

There are two other species of tussock moths likely to be found in orchards in certain regions. The antique tussock moth,[31] of European origin, is present in the New England States and adjacent Canada, its general range of distribution, however, extending westward to the Pacific. The California tussock moth [32] occurs only in California apparently, where it has done important injury to apples, cherries, and certain forest or shade trees. Both species can be controlled by the means recommended for the white-marked tussock moth.

The caterpillar of the tussock moth is quite resistant to arsenicals, but can be controlled while young with a spray of arsenate of lead, using the powder at the rate of 2 pounds or the paste at the rate of 4 pounds to 50 gallons of water or fungicide. When the caterpillars are very abundant, much relief can be secured by searching out and creosoting the egg masses as for the gipsy moth (p. 44), or these can be removed and destroyed by burning.

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[30] *Hemerocampa leucostigma* Smith and Abbot.
[31] *Notolophus antiqua* Linnaeus.
[32] *Hemerocampa vetusta* Boisduval.

Fig. 90.—Caterpillars of the white-marked tussock moth feeding upon the foliage and fruit of the apple.

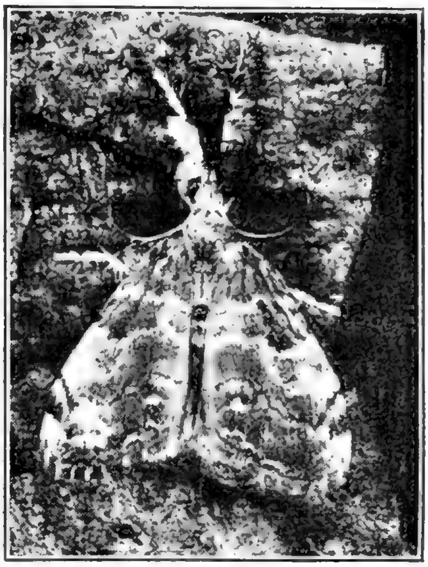

Fig. 92.—Male white-marked tussock moth. Enlarged.

Fig. 91.—Female white-marked tussock moth depositing egg mass on silken cocoon. Enlarged.

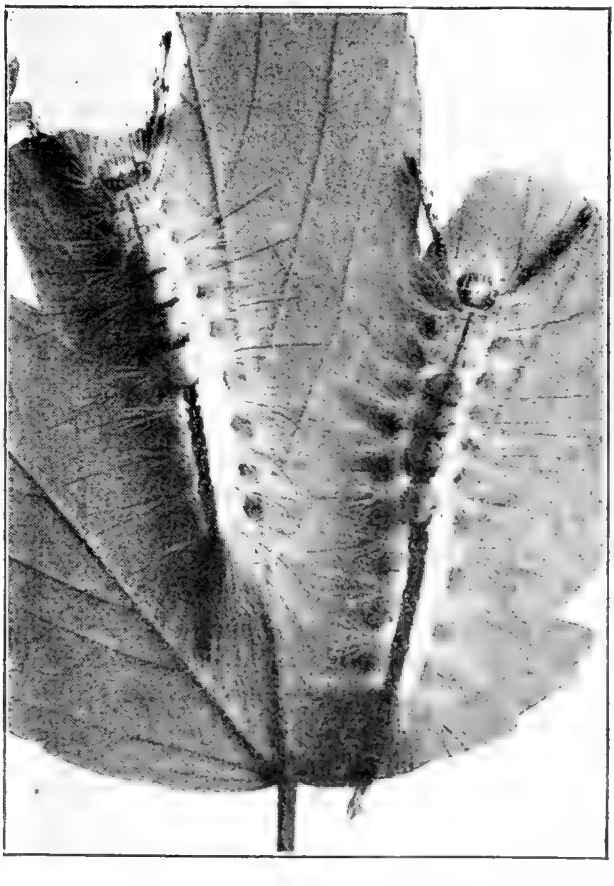

Fig. 93.—White-marked tussock moth caterpillars. Enlarged.

HICKORY TIGER MOTH.[33]

This is another insect which sometimes attracts attention in neglected orchards and young orchards not regularly sprayed with arsenicals. The caterpillars are gregarious (fig. 94) and, if not checked in the course of their feeding, may cause considerable defoliation of the trees. This insect, the hickory tiger moth, is well known in the New England States and is often found as far

FIG. 94.—Young caterpillars of hickory tiger moth.

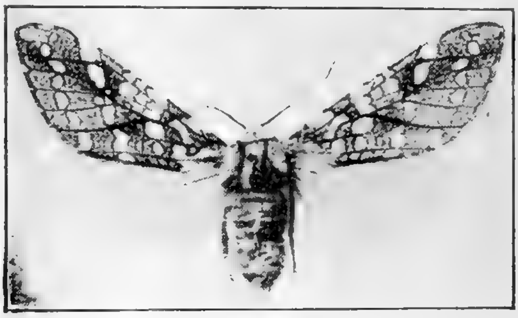

FIG. 95.—The hickory tiger moth.

FIG. 97.—Cocoon of hickory tiger moth.

FIG. 96.—Full-grown larva of the hickory tiger moth.

West as Montana and Missouri, attacking the apple, pear, quince, cherry, hickory, walnut, and many other trees.

The hickory tiger moth hibernates in the pupa stage, usually in trash on the ground. Early in the summer the moths emerge and soon deposit their eggs on the foliage in clusters containing from less than 100 to about 400. The roundish eggs are about one-thirty-fifth of an inch in diameter, bluish white when fresh, but later becoming darker. The moths (fig. 95) have rather conspicuous markings, the forewings being mottled with small brownish dots, with three more or less distinct rows of white dots, and having an expanse of approximately 2 inches. Upon hatching, the larvæ feed at first upon the surface of the foliage and later consume the entire leaf except the larger veins. The full-grown larva (fig. 96) is about 1½ inches long and is covered with black and white hairs.

[33] *Halisidota caryae* Harris.

The cocoons (fig. 97) are made among the leaves or trash on the ground and the pupa stage is entered for the winter. There is only one generation of the caterpillars each year, and they are not likely to be troublesome, except during occasional years, and more or less locally.

Orchards thoroughly sprayed with arsenicals will rarely require special treatment for the hickory tiger moth. When found in young orchards it may readily be controlled by the use of arsenate of lead at the usual strength, the spray application being made as soon as the insects are detected. If the caterpillars when discovered are one-third grown or over, an increased amount of poison should be used.

FIG. 98.—Case in which apple leaf-crumpler caterpillar passes the winter. Enlarged.

APPLE LEAF-CRUMPLER.[34]

In the course of the winter pruning, fruit growers often notice a mass of leaves (fig. 98), sometimes in considerable abundance, rather tightly tied to twigs. Upon tearing open such leaf masses, there will be found a considerable number of tough horn-shaped cases, made by the apple leaf-crumpler, in which the larva spends the winter. Although of minor importance, this insect has occasionally become injurious, particularly in nurseries and young orchards. It is a native species, more or less common in the Northern and Central States, and feeds upon the apple, crab apple, quince, cherry, wild cherry, plum, wild plum, peach, pear, and perhaps other host plants.

The winter is passed within the winter case as a half-grown caterpillar (fig. 99), which becomes active in the spring as the buds begin to open. Later bunches of leaves are tied together, among which the caterpillars feed, occasionally attacking the fruit after it is set and sometimes the bark of the new wood. By late spring to early summer the caterpillars are full-grown and attach their cases, in which the pupa stage is passed, to the bark of the tree. A full-grown larva is about three-fifths of an inch long, greenish brown, with a dark brown head. In due time the moths emerge and deposit their very minute eggs over the foliage of the host plant. The forewings of the moth are light brown with silver markings and the wing expanse is about three-fourths of an inch. The larvæ of the new brood feed upon the foliage until late fall, when they attach their cases to the trees as described.

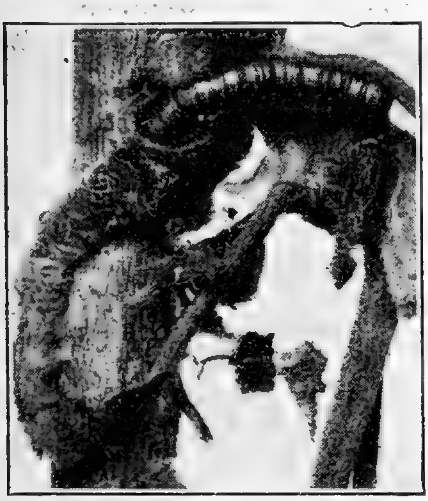

FIG. 99.—Winter case and caterpillar of the apple leaf-crumpler. Enlarged.

Spraying with arsenate of lead at the rate of 1 pound of the powder or 2 pounds of the paste to 50 gallons of water or fungicide is an effective remedy for this insect. The application should be given in the spring shortly after the leaves have begun to push out. In commercial orchards which have received regular sprayings, the leaf-crumpler will rarely, if ever, require special treatment.

[34] *Mineola indigenella* Zeller.

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APPLE LEAF SKELETONIZER.[35]

In the Mississippi Valley States the apple leaf skeletonizer is at times the cause of important injury to young orchards (fig. 100) and to nursery trees. The caterpillars feed on the upper side of the leaves, protected by a web of silken threads. They skeletonize the leaves, eating out the soft leaf tissue, the injury giving the foliage a brown, dry appearance. This insect is undoubtedly native and occurs rather generally over the United States east of the Rocky Mountains. Its principal food plant is the apple, but occasionally it attacks the quince and plum.

It passes the winter in the pupa stage in cocoons among the fallen leaves, the moth appearing during the following May and June. This is a small, purplish brown insect, with two silvery gray bands across each forewing. The forewings have an expanse of nearly half an inch. The larva (fig. 101) is pale brownish or greenish, about half an inch long, with four shiny tubercles on the back behind the head. There are two broods of larvæ each year, the first during midsummer and the second in the fall, the last brood changing to pupæ with the coming of cold weather.

This insect will readily yield to thorough spraying of the foliage with arsenate of lead at the usual strengths.

APPLE LEAF-SEWER.[36]

The presence in orchards of the apple leaf-sewer, sometimes called the apple leaf-folder, is indicated by the occurrence of leaves folded, as in figure 102, often exhibiting a somewhat scorched appearance and with the upper parenchyma of the leaves more or less consumed. This insect only occasionally attracts attention, usually in unsprayed or neglected orchards or on young apple or nursery trees that do not receive arsenical sprays. It is a native insect and is confined principally to the eastern half of the United States and to certain districts of Canada. The apple appears to be the only plant upon which it subsists, though it is probable that it feeds upon wild crabs and other plants related to the apple.

The insect hibernates as a larva (fig. 103) within the folded leaves that have fallen to the ground. At this time it is about half an inch in length and light gray; the head is yellow with a somewhat darker thoracic shield, bearing a black spot on each side. In the spring the larvæ change to brownish pupæ, from which the moths issue. The adult, or moth (fig. 104), is white, with markings of brown, and the wing expanse is about three-fourths of an inch. The small, flat, oval, yellow eggs are placed on the foliage and are usually securely glued to the under surface of the leaf. Upon hatching, the larva spins a silken web on the lower leaf surface, where it begins eating the parenchyma, gradually folding over as it grows a portion of the lower side of the leaf. After feeding awhile in this somewhat restricted area, it eats its way through the upper tissues and migrates to a near-by leaf, where it begins another web on the lower leaf surface and fastens together the opposite halves of the leaf. The leaves are folded in this way until the larva completes its growth, and thus a single caterpillar will often injure several leaves. The larva remains through the winter within the last leaf attacked, in the fallen leaves on the ground.

In orchards regularly sprayed for the codling moth this species will require no specific treatment. Where for any reason special applications are necessary, arsenate of lead should be used at the usual strength for caterpillars of this character. The raking together and burning in early spring of fallen, infested leaves may also be advisable, if the insect is particularly abundant.

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[35] *Canarsia hammondi* Riley.

[36] *Ancylis nubeculana* Clemens.

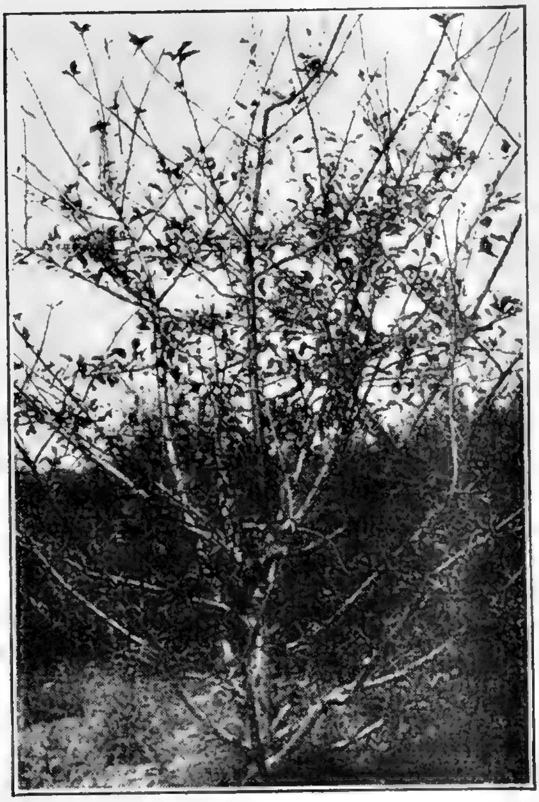

FIG. 100.—Apple tree defoliated by apple leaf skeletonizer.

FIG. 102.—Work of the apple leaf-sewer.

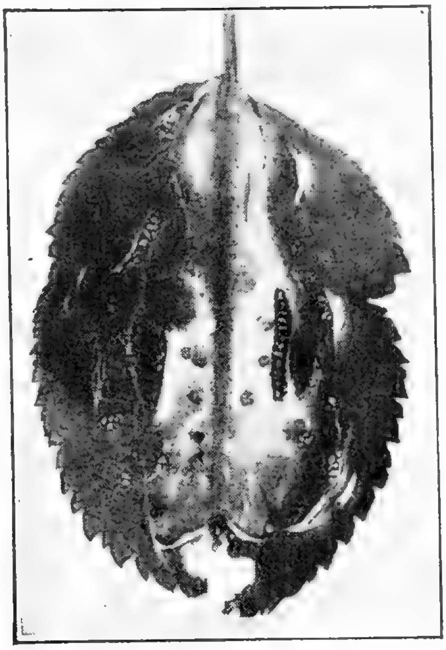

FIG. 103.—Larva of apple leaf-sewer.

FIG. 101.—Larva of apple leaf skeletonizer and its work on apple leaf. Enlarged.

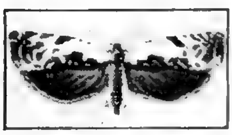

FIG. 104.—Adult of the apple leaf-sewer.

CIGAR CASE-BEARER.[37]

The cigar case-bearer is another species of minor importance, although it has occasionally been reported as doing considerable damage to foliage (fig. 105) in orchards that have been more or less neglected. It is primarily an apple and pear pest, but also attacks the quince, plum, cherry, and haw. It is thought to be a native species, feeding originally upon wild haws. Although reported principally from the North, it occurs in New Mexico and is likely to be found in most apple sections, since it is readily distributed on nursery stock.

FIG. 105.—Apple leaves injured by cigar case-bearer.

The cigar case-bearer hibernates as a half-grown larva within its case, which is attached to a branch of the tree. The caterpillars become active on the approach of spring and migrate to the opening buds, where they feed upon the expanding foliage and later eat the flower and fruit stems, as well as small holes into the young fruit itself. The black-headed, golden brown larvæ (figs. 106 and 107) quickly develop in size, which necessitates the enlarging of their winter cases, and later in the spring they construct new cigar-shaped cases in which they continue to feed until early summer (fig. 108). Upon completing their growth they migrate to the branches, where they transform successively to light brown pupæ and small, gray moths (fig. 109), with heavily fringed wings, measuring about three-eighths of an inch from tip to tip. The eggs are very minute, yellow, and are usually located along the midrib of the lower surface of the leaves. Upon hatching the larvæ mine within the soft tissue of the leaves, and toward the approach of fall construct their winter cases, migrating in due time to the twigs, where the winter is passed.

Well-cared-for orchards will rarely, if ever, suffer important injury from the cigar case-bearer, and even though it may become abundant it can be easily controlled by spraying with arsenate of lead at the usual strength. A contact spray, as 10 per cent kerosene emulsion, or 40 per cent nicotine sulphate at the rate of one-half pint to 50 gallons of soapy water, may be employed instead of an arsenical.

PISTOL CASE-BEARER.[38]

Another curious little insect closely related to the cigar case-bearer and which occasionally attracts the attention of the orchardist is known as the pistol case-bearer. This insect is usually of minor importance, except in more or less neglected orchards or during seasons of local outbreak, when it may

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[37] *Coleophora fletcherella* Fernald. [38] *Coleophora malivorella* Riley.

FIG. 106.—Larva of cigar case-bearer. Enlarged.

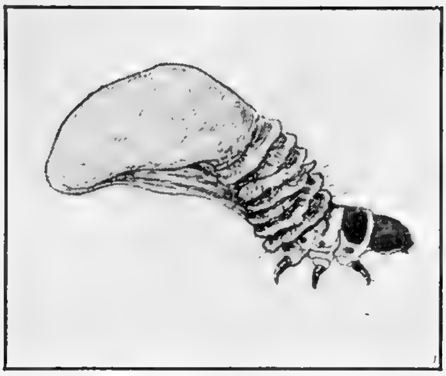

FIG. 107.—Larva of cigar case-bearer protruding from its case. Enlarged.

FIG. 108.—Larvæ of the cigar case-bearer and their work on apple foliage. Enlarged.

FIG. 109.—Moths of cigar case-bearer emerging from pupal cases.

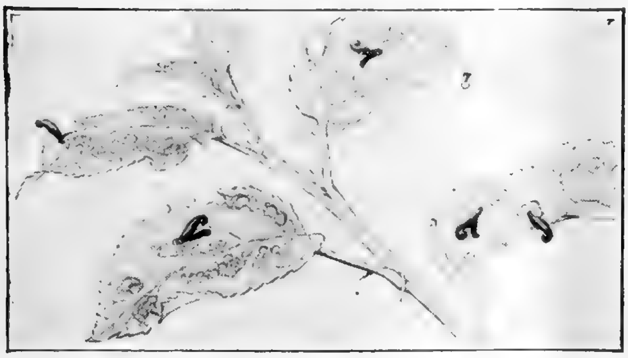

FIG. 110.—Pistol case-bearer and its work on apple foliage.

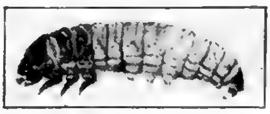

FIG. 111.—Larva of pistol case-bearer. Enlarged.

become prominent. It has about the same distribution as the cigar case-bearer and attacks essentially the same host plants. Although the larvæ usually attack the fruit, the chief damage is done to the flowering parts and foliage. This injury, however, to apple foliage is somewhat different from that caused by the cigar case-bearer, since the larvæ of this species do not mine the foliage, but, instead, eat out irregular patches, thus often skeletonizing the leaves (fig. 110).

FIG. 112.—Mines of trumpet leaf-miner.

The life history of the pistol case-bearer resembles in a general way that of the cigar case-bearer, the principal points of difference being that the orange-colored larva (fig. 111) does not spend a part of its life as a miner; nor does it construct an entirely new case in place of its hibernaculum. Instead, the larva, as it grows, builds additions to its winter case so as to accommodate its body. The adult is a small, light brown moth, with orange wings which measure about half an inch from tip to tip. The eggs, which are deposited on the foliage, are very minute, reddish brown, strongly ribbed, and suggest a miniature inverted teacup.

The same suggestions given for the control of the cigar case-bearer are appropriate for this species.

TRUMPET LEAF-MINER.[39]

The trumpet leaf-miner is another species of minor importance although the subject of occasional inquiry. Its injuries on different occasions have been of importance, and it has been perhaps more destructive than other related leaf-miners. As the name suggests, the completed mines have somewhat the shape of a trumpet (fig. 112). When abundant, the injury may result in some defoliation of the trees, with consequent injury to fruit buds and fruit. It is thought to be native and doubtless fed originally upon crab-apple trees and wild haws, as it does at the present time. It occurs rather generally throughout the eastern half of the United States and Canada.

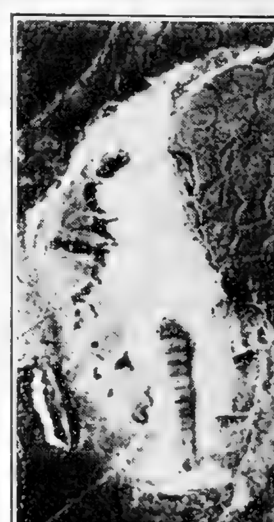

FIG. 113.—Larva of trumpet leaf-miner. (Upper epidermis of mine removed.) Enlarged.

The winter is passed in the larva stage within the mines in the fallen leaves (fig. 113), the mines being well lined with silk. The mature larva is about one-fifth of an inch in length, flat, legless, with a pale green body and yellowish brown head. It enters the pupa stage in the spring, and the moths are on the wing by the time the foliage is well out. The tiny moths have a wing expanse of about one-fourth inch, the forewings being brown with a somewhat purplish luster.

[39] *Tischeria malifoliella* Clemens.

The elliptical eggs are exceedingly minute, iridescent, of a greenish yellow tint, and are placed on the foliage. Upon hatching, the larvæ immediately burrow into the upper surface of the leaf, eventually eating out the characteristic trumpet-shaped mines. There are from two to four generations each year, depending upon the locality.

This insect can be destroyed in its mine by the use of contact sprays, such as 12 to 15 per cent kerosene emulsion or 40 per cent nicotine sulphate at the rate of one-half pint to 50 gallons of water, to which should be added 2 pounds of soap which has previously been dissolved with water. Plowing under leaves prior to the blooming period of the apple should aid in its control by burying the overwintering insects, thus preventing the escape of the moths.

SPOTTED TENTIFORM LEAF-MINER.[40]

The spotted tentiform leaf-miner also is of comparatively little importance, but is occasionally the subject of inquiry from observing orchardists. As a larva it makes a small mine on the lower surface of the leaf, but since it does not devour all of the soft tissue, the mine appears spotted when viewed from above. Owing to the crumpling of the leaf, the mine bears some resemblance to a tent, and hence the rather fanciful common name. This insect, of European origin, is now distributed over most of the eastern part of the United States, and has been reported as feeding upon the apple, quince, plum, wild cherry, wild haws, and sweet-scented crab.

It passes the winter in the pupa stage within the mine on fallen leaves. The moths emerge in the spring and deposit their minute eggs on the foliage. The resulting caterpillars are about one-fifth of an inch in length and yellowish. The moths are very small, with brownish forewings on which are white lines and spots, with a black spot at the tip of the wing.

The suggestions given above for the control of the trumpet leaf-miner are applicable to the present species.

UNSPOTTED TENTIFORM LEAF-MINER.[41]

The larva of the unspotted tentiform leaf-miner makes a tent-like mine (fig. 114) on the underside of the leaf somewhat larger than that of the spotted tentiform leaf-miner and, unlike the latter, consumes all of the leaf tissue except the veinlets. It attacks, in addition to the apple, pear, crab apple, haw, plum, and wild cherry. Although sometimes abundant in orchards, it is of very minor importance. It is probably a native species, and is more common in the Northern and Middle States than elsewhere.

The winter is passed in the pupa stage within a cocoon made in the folded edge of a leaf (fig. 115). The pupa is about one-sixth of an inch long and yellowish brown. The small grayish moths issue in the spring and deposit on the foliage, usually on the lower surface, their very minute eggs, which are invisible to the naked eye. The footless larvæ soon hatch and eat their way into the inner leaf tissue, where they start their characteristic mines. The full-grown larva is about one-fourth of an inch long and greenish gray. Several generations are produced yearly, the last brood pupating during the late fall and passing the winter in this condition.

Special remedial measures will seldom be necessary, but if such is the case the most practical means of control is, perhaps, to destroy the overwintering pupæ in the fallen leaves by plowing and disking the orchard in the early spring previous to the issuance of the adults.

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[40] *Lithocolletes blancardella* Fabricius. [41] *Ornix geminatella* Packard.

FIG. 114.—Appearance of apple leaves infested with unspotted tentiform leaf-miner.

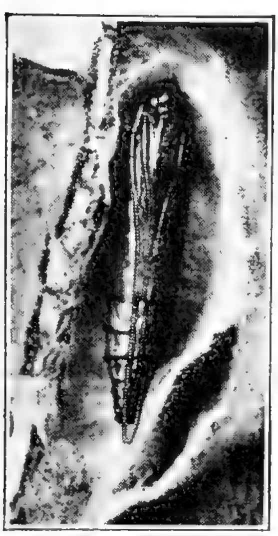

FIG. 115.—Pupa of unspotted tentiform leaf-miner. Enlarged.

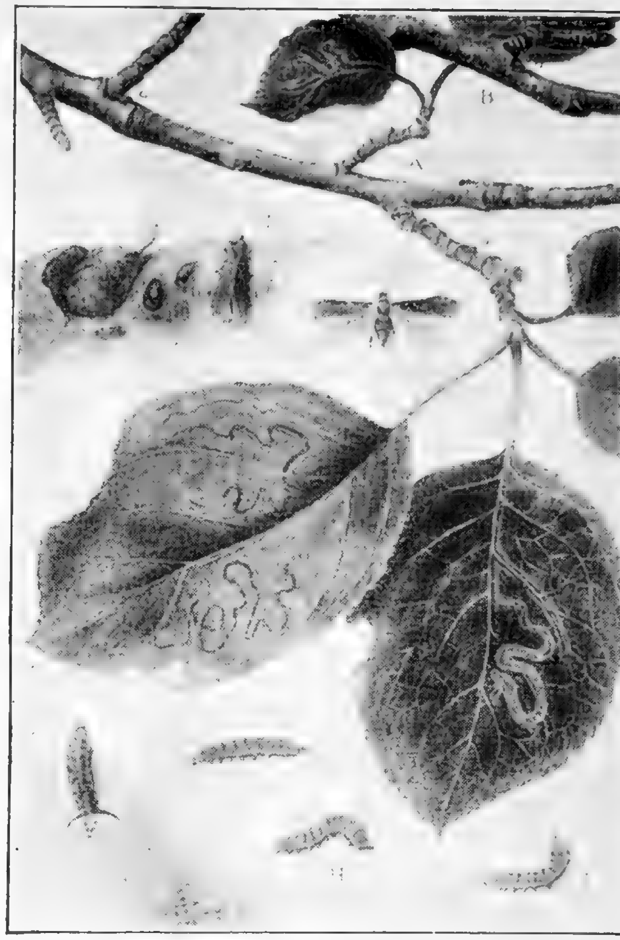

FIG. 116.—Serpentine leaf-miner: *A*, Apple twig in fall, showing serpentine mines on leaves and new cocoons at *a* and *a*; *B*, winter twig, showing discolored cocoon at *b*; *C*, cocoon in spring with empty pupal skin projecting, enlarged; *D*, emerged moth resting on side of twig, enlarged; *E*, moth with wings spread, enlarged; *F*, mature caterpillar emerging from slit at end of its mine, enlarged; *G*, *H*, *I*, attitudes of the caterpillar when crawling, enlarged.

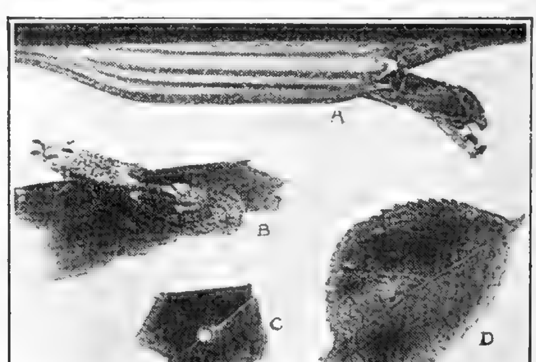

FIG. 117.—Apple bucculatrix: *A*, Cocoon and empty pupal case, enlarged; *B*, moth, enlarged; *C*, egg, enlarged; *D*, work of the apple bucculatrix on foliage.

SERPENTINE LEAF-MINER.[42]

Fruit growers, particularly in the New England States, have frequently had their attention attracted to long serpentine mines on the upper surface of the leaves. These mines (fig. 116, A) are constructed by the so-called serpentine leaf-miner, which is more an object of curiosity than of economic importance.

The insect winters in the larva stage within a small brownish cocoon (fig. 116, C), which is usually attached to a twig or in the crotch of limbs. In the spring the full-grown dark-green larvæ (fig. 116, G, H, I), measuring nearly one-eighth inch in length, transform to greenish pupæ, from which develop the small, dark purplish moths, with crimson, yellow-tufted heads (fig. 116, D, E). The eggs are very minute and are deposited on the foliage, giving rise to larvæ which mine in the leaves in characteristic serpentine fashion.

The insect is controlled by the same measures effective against the trumpet leaf-miner (p. 54).

APPLE BUCCULATRIX.[43]

In the course of the winter pruning the attention of the fruit grower is sometimes attracted to the small, whitish, ribbed cocoons (fig. 117, A) of the apple bucculatrix. These measure about one-fourth of an inch in length and are often built side by side, usually on the lower side of small branches and twigs. Although widely distributed from the Atlantic coast to the Rocky Mountains, it is seldom that this insect causes important injury, except perhaps in instances where the trees have been long neglected. The apple bucculatrix, or ribbed cocoon-maker of the apple, as it is sometimes called, is essentially an apple pest, but has also been recorded as feeding on docks, alfalfa, and certain grasses.

The winter is passed as a pupa within the cocoon. Early in the spring, about the time the foliage begins to expand, the very small, delicate moths (fig. 117, B) commence to issue and deposit their minute, pale greenish eggs (fig. 117, C) on the lower side of the leaves. The moths are light brown, with heavily fringed wings, which have an expanse of about one-tenth of an inch. Upon hatching the young larvæ eat into the leaves and make small mines (fig. 117, D), somewhat less than an inch in length. They then desert the mines and construct on the surface of the leaves small flimsy cocoons in which they molt. After feeding upon the leaf surface for a few days they make a second cocoon for molting purposes, after which they continue their surface feeding for a period of about a week. When the foliage is attacked by large numbers of the caterpillars it will become more or less brown and shriveled. The full-grown larvæ seek a place to build their cocoons, which may be constructed on the foliage, fruit, or twigs. In northern New England there is only one generation, but farther south two generations occur annually, the second brood of moths issuing during the latter part of the summer. The life history and habits of the second brood are similar to those described for the first brood.

Orchards regularly sprayed for the more important apple insects will seldom require special treatment for this pest. The dormant spray treatment with lime-sulphur solution will aid in destroying the overwintering pupæ, and the summer applications of lead arsenate will kill the larvæ that feed on the leaf surface. After pruning the trees the wood should be burned before spring, thus destroying the overwintering pupæ.

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[42] *Nepticula pomivorella* Packard. [43] *Bucculatrix pomifoliella* Clemens.

PALMERWORM.[44]

If history repeats itself in the case of the palmerworm, fruit growers are not likely to encounter this insect in injurious numbers more than once in a lifetime, since in the past outbreaks have occurred only at intervals of about 60 years. The injury is caused by the small worms feeding on the foliage in the open or within a few leaves or sometimes beneath the protection of a folded leaf edge. They sometimes skeletonize the foliage when abundant and often eat holes in the young fruit, resulting in a type of injury which may be more or less confused with that caused by the green fruitworms (p. 21). In addition to attacking the fruit and foliage of the apple, the palmerworm has been reported as feeding principally upon the foliage of pear, plum, cherry, and oak. It has been reported chiefly from New York, the New England States, and Canada.

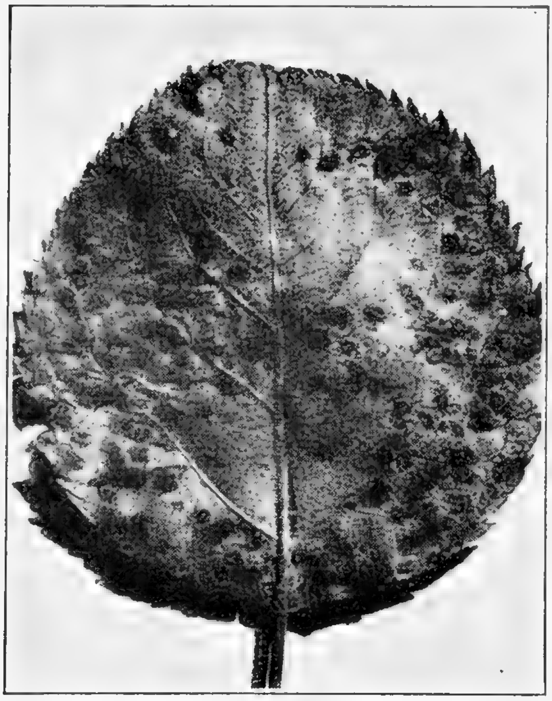

FIG. 118.—Apple leaf infested with pear-leaf blister mite.

The palmerworm supposedly hibernates in the adult or moth stage. The moths are of a variable gray to brown color and measure about half an inch across the expanded wings. Early in the spring, upon the appearance of the foliage, the moths deposit their very small whitish eggs on the underside of the leaves, and from these hatch the destructive worms or larvæ. When full-grown the larvæ are about half an inch in length and are usually of a dark green color traversed by four whitish stripes, the outer of which are broader than the inner. After feeding for a period of about a month, the larvæ transform to small brownish pupæ, which are secured to the leaves by means of silken threads or in some instances are to be found on the ground. Through further transformation the moths issue during midsummer, but do not oviposit, so far as is known, until the following spring. There is thus only one generation annually.

In common with many other leaf-feeding caterpillars, the palmerworm may be controlled by means of a spray consisting of arsenate of lead powder 1 pound, or paste 2 pounds, to 50 gallons of water or fungicide, applied at the time of hatching. If the worms are not discovered until partly grown, it may be necessary to use a stronger dosage, depending on their size.

PEAR-LEAF BLISTER-MITE.[45]

The pear-leaf blister-mite attacks the foliage of the apple and pear, producing minute greenish or reddish galls or blisters, which after a time turn brown, spotting the leaves with dead areas like certain forms of fungous attack (fig. 118). When the galls are abundant, there results considerable dead and injured tissue, giving the leaves a brownish and shriveled appearance. Badly infested orchards have a distinctly yellowish cast, and later become brownish as the injured patches discolor. Injury to the foliage causes much of it to

[44] *Ypsolophus ligulellus* Hübner. [45] *Eriophyes pyri* Pagenstecher.

fall, with consequent damage to the tree and fruit crop. The fruit itself is sometimes injured, as shown in figure 119. The pear is more generally infested by this species than the apple, and the service-berry and other host plants are also attacked. While not a pest of first-class importance to apple growers generally, nevertheless its injuries in some localities must be provided against. Damage to the apple has been especially pronounced in New England, in portions of New York, and more recently in certain apple-growing districts in Washington. Recently apple leaves infested by this mite have come from Mississippi. The pear-leaf blister-mite is of European origin and was probably introduced into this country many years ago on nursery stock. It is now widely distributed in the United States wherever pears are grown.

The winter is passed in the adult stage beneath the bud scales. The adults (fig. 120) are very small, elongate, whitish, and measure about one one hundred and twenty-fifth of an inch in length. In the spring, when the leaves are unfolding, the mites enter through the lower epidermis, and their activities soon bring about the blisterlike galls in which they live and multiply. After reaching maturity, the mites desert the old galls, make new ones, and produce a new generation. A succession of generations is thus developed each season up to the approach of cold weather, when the mites migrate to the bud scales, beneath which they hibernate.

FIG. 119.—Injury to fruit by pear-leaf blister mite.

If it is necessary to spray the orchard for the San Jose scale, no special treatment for the pear-leaf blister-mite will be required. It is readily controlled by the use of commercial lime-sulphur (32° Baumé) $6\frac{1}{2}$ gallons with water sufficient to make a total of 50 gallons, as employed in the control of the San Jose scale. If the application is for the mite only, a somewhat weaker spray will answer, using $5\frac{1}{2}$ gallons of the concentrate and sufficient water to make 50 gallons. The application may be made after the leaves have dropped in the fall or in the spring before the buds have swollen to any extent. Miscible oils and kerosene emulsion of standard dormant tree strengths may also be used effectively.

RED SPIDER.[46]

The injury to the apple by the red spider results from the sucking out of plant juices, giving the foliage an unhealthy, mottled appearance. If the attack is severe, the injury may be quite important, resulting in defoliation of the trees and interference with the proper development of the fruit and fruit buds. This mite is likely to be most troublesome during dry seasons, and in arid or semiarid regions it is a pest of importance. Its injuries, however, are often confused with those of the clover mite (p. 60). The red spider is widely disseminated throughout the United States and attacks the apple and many other deciduous fruits, cultivated flowers, vines, truck crops, etc. It is preeminently a pest in greenhouses and requires constant vigilance on the part of growers to keep it in check.

FIG. 120.—Adults of pear-leaf blister mite. Greatly enlarged.

[46] *Tetranychus telarius* Linnaeus.

The winter is passed in the adult stage beneath fallen leaves, weeds, and trash. The adult female (fig. 121) is about one-sixtieth of an inch long, varies in color from a russet green to almost black, but is usually dark red, and is generally marked with two large, dark spots on each side of the body. The male is smaller and is russet salmon, with the lateral spots less conspicuous than in the other sex. The eggs are globular and when freshly laid are clear, gradually turning opaque and later a dark straw color. The newly hatched mite is round, colorless, with six legs, and is about the same size as the minute egg, which is about one two hundred and fiftieth of an inch in diameter. The mites spin a very fine web over the leaf and feed under this protection. There are several generations during the season.

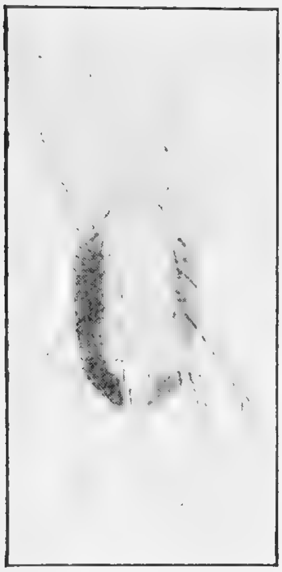

Fig. 121.—Female red spider. Greatly enlarged.

Dusting the trees with a mixture of 50 per cent sulphur and 50 per cent hydrated lime is recommended for controlling the red spider, as is also spraying with summer-strength lime-sulphur wash.

CLOVER MITE.[47]

The clover mite, known also as the brown mite, is very small, scarcely as large as a pinhead, reddish or brownish, and readily recognized under a hand lens by its unusually long front legs (fig. 122). In the Middle West and the Eastern States this mite is of importance principally on account of its damage to clover and various grasses, its injuries to fruit trees not, as a rule, attracting attention except during periods of drought. It is, however, sometimes complained of by householders, since during the fall the mites may enter dwellings, often in large numbers, and become a decided nuisance. In the more arid sections of the country, particularly west of the Rocky Mountains, the clover mite becomes one of the important orchard pests attacking most stone and pome fruits. Badly infested foliage assumes a yellowish, sickly appearance due to the injuries of the mites, and by midsummer or early fall much of it may drop to the ground. In the East such injury is not uncommon to trees in sheltered locations and, in fact, in orchards where conditions are favorable for the development of the mites. In warmer climates the clover mite

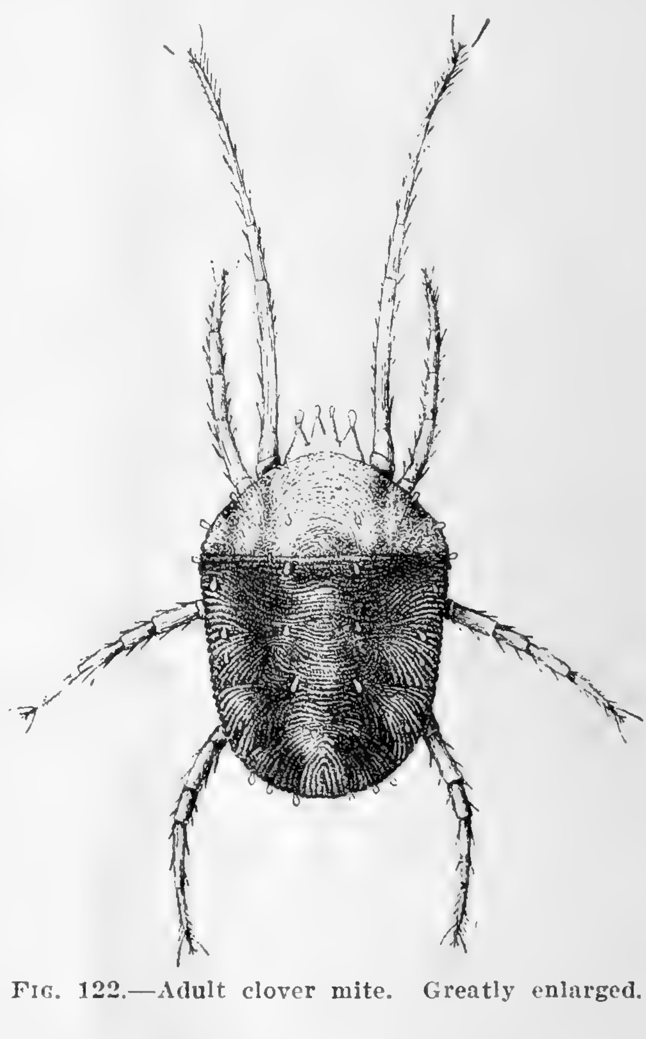

Fig. 122.—Adult clover mite. Greatly enlarged.

[47] *Bryobia pratensis* Garman.

may hibernate on the trees either in the adult or egg stage. In northern localities, where the temperature is more severe, eggs are deposited by the mites in the fall on twigs around bud scales, crotches of limbs, etc., and thus the winter is passed. The eggs are small, globular, and reddish, often occurring in large numbers and attracting the attention of orchardists during pruning operations. With the pushing out of the foliage in the spring, the eggs hatch and the mites attack the leaves, producing several generations during the season.

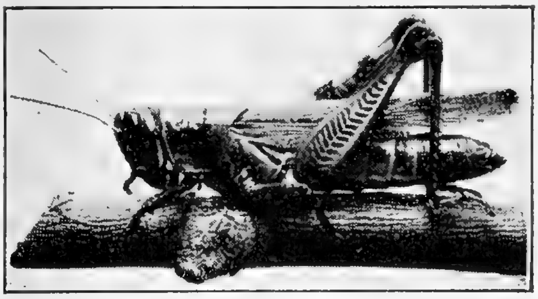

FIG. 123.—The differential grasshopper.

The eggs and hibernating adults of the clover mite on trees, as a rule, will be destroyed by a thorough spraying with lime-sulphur solution, using the concentrate 32° Baumé during the dormant period at the rate of 6½ gallons diluted with water to make 50 gallons, a strength which is also effective against the San Jose scale. For the control of the insect on trees in foliage, use freely a dust of finely divided sulphur and hydrated lime, half and half. If desired, the sulphur may be mixed with soapy water and sprayed on the plants, using sulphur at the rate of 10 pounds to 50 gallons of water. Kerosene emulsion, 10 per cent strength, or fish-oil soap, 1 pound in 10 gallons of water, are also effective as summer sprays.

FIG. 124.—Apple tree defoliated by grasshoppers.

GRASSHOPPERS.[48]

Several species of grasshoppers, one of which is shown in figure 123, at times occasion injury to apple trees by feeding upon leaves (fig. 124) or chewing the bark. During periods of serious outbreak this injury may be very important, and prompt and energetic measures are necessary to prevent destruction of the trees. Grasshopper injury is rarely of importance in the Eastern States, except in orchards adjacent to meadows which have recently been cut. In the West, however, injury in connection with grasshopper outbreaks may be much more important.

Most grasshoppers of importance to apple growers winter in the egg stage, the eggs being placed in podlike masses below the surface of the soil. The nymphs, or young insects, hatch in the spring and begin feeding on various kinds of plant growth. They mature during the summer and lay their eggs in the fall along roadways, headlands, meadows, etc.

In controlling grasshoppers the soil where the eggs are laid should be plowed or disked at any convenient time prior to the hatching period. A favorite means of combating grasshoppers at this time is to distribute here and there

[48] Red-legged locust, *Melanoplus femur-rubrum* DeGeer. Lesser migratory locust, *Melanoplus atlanis* Riley. Rocky Mountain or migratory locust, *Melanoplus spretus* Thomas. Differential locust, *Melanoplus differentialis* Thomas. Carolina locust, *Dissosteira carolina* Linnaeus. Two-striped locust, *Melanoplus bivittatus* Scudder.

in the orchard bran-mash poisoned bait made according to the following formula:

Part 1.		
Paris green (or white arsenic)	pounds	$2\frac{1}{2}$
Bran	do	50
Part 2.		
Lemons (pulp and rind finely chopped)	fruits	6
Molasses (low grade preferred)	gallon	1
Water	gallons	5

Mix thoroughly the ingredients of part 1; next mix together the materials of part 2, first adding to the water the lemon juice and the pulp and rind finely chopped, and finally the molasses. When ready to use, mix thoroughly the ingredients of parts 1 and 2 and add sufficient water to make a wet mash. The mash should be thoroughly scattered broadcast early in the morning, preferably when the soil is damp, at the rate of from 3 to 5 pounds to the acre. In arid regions the mash should be scattered along damp irrigation laterals, since it quickly hardens and when dry is not readily eaten by the insects.

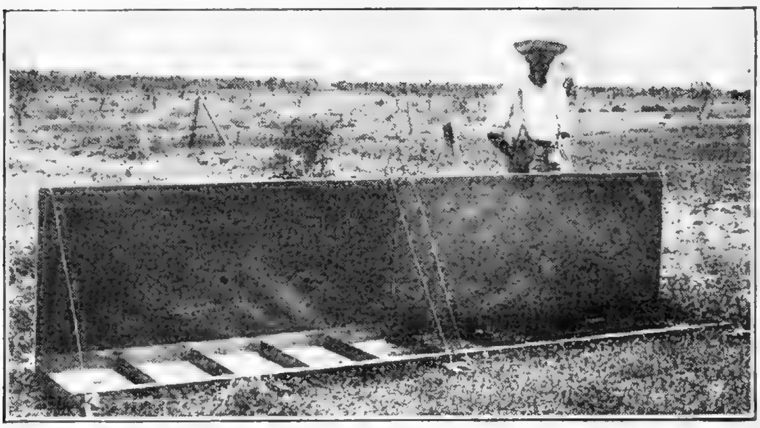

FIG. 125.—Hopperdozer for catching grasshoppers.

A further protection may be afforded fruit trees by spraying with arsenate of lead at the rate of 2 pounds of the powder or 4 pounds of the paste to each 50 gallons of water or fungicide.

A type of apparatus known as the hopperdozer, having shallow compartments to hold kerosene, as shown in figure 125, is frequently used. This is drawn through the orchard by a team, and the grasshoppers are killed when they leap into the pans containing the oil.

SAN JOSE SCALE.[49]

The San Jose scale, while a comparatively small and insignificant appearing insect, is, owing to its great powers of reproduction, a pest of first-class importance. Two or three decades ago it was the center of attention by orchardists and others, and was the cause of losses amounting to many millions of dollars. It is thought to have been introduced from China, and was first found in this country in San Jose, Calif., about 1870. Since its introduction it has been distributed by means of nursery stock and other agencies to practically all of the principal fruit districts of the United States. The development of effective and economical sprays, especially lime-sulphur wash, has enabled fruit growers satisfactorily to control the pest, and they now have full confidence in their ability to keep it reduced below injurious numbers.

At the present time the insect throughout much of the fruit-growing regions of the Central and Northern States is of much less importance as an orchard pest than formerly, due apparently to several factors. Probably one of the most important of these is the general use by orchardists of dilute lime-sulphur

[49] *Aspidiotus perniciosus* Comstock.

as a summer spray, which, observations and experiments have shown, is effective in destroying many of the newly hatched insects, so that the trees are kept fairly well freed of the pest as an incident to the use of the wash for other purposes. The effectiveness of parasitic and predatory insect enemies in reducing the scale has also apparently been gradually increasing. In fact, the scale in certain orchards has become so reduced in numbers that it has been found feasible occasionally to omit the dormant treatment without undue increase of the insect. Such omission, however, if made, should be based on very careful examination of the orchard to ascertain whether such practice is warranted. Under favorable seasonal conditions the scale is able to increase rapidly and may do serious damage to the twigs and in spotting the fruit, although present on the trees during the dormant period in apparently negligible numbers.

FIG. 126.—Apples spotted by San Jose scale.

In common with other scale pests, the San Jose scale is a sucking insect, and lives upon plant juices which it extracts from the twigs, limbs, trunk, foliage, and fruit. Small reddish discolorations will frequently be found at the point of feeding, and on the fruit itself these dots are conspicuous, unsightly, and lower its market value (fig. 126). When abundant this insect is capable of killing young trees within a few years, and older trees may ultimately be destroyed, although the process is a slower one (fig. 127). Infested trees are dwarfed and unthrifty in appearance, and the incrusted twigs have an ash gray color (fig. 128). Some years ago it was not uncommon to find entire orchards destroyed, but in recent years the trees have been well protected from its ravages by means of spray solutions. It should not be inferred, however, that the San Jose scale is no longer a dangerous pest, since in the absence of adequate treatment it could readily reestablish itself in numbers that would again result in enormous losses to the fruit industry. It has been estimated that from the progeny of a single female there may result over $1\frac{1}{2}$ billion females in the course of one season. From this the fruit grower will appreciate how readily this insect can reinfest and destroy an orchard. The apple, pear, and peach are its favorite food plants. Other deciduous fruit trees are subject to attack, as are also many bush fruits, shade and forest trees, and shrubs.

FIG. 127.—Apple tree practically killed by San Jose scale.

At the approach of winter the San Jose scale is found in practically all stages, from the very young to the mature, but nearly all of the individuals die except those that are about half developed—the stage in which the scale seems best to resist winter conditions. In the spring the scales that have successfully survived the winter continue their development until they reach maturity, after which the females produce their living young. There are several generations during the course of the growing season, depending upon the locality. The waxy scale which protects the yellowish, sac-like body of the female is circular, about the size of a pinhead, grayish, with a central nipple (fig. 129), while that of the male is oval, dark gray, with the nipple, or exuvium, toward the small end of the scale (fig. 129). The adult male is orange colored and has two delicate wings. The young scales, or nymphs, are smaller and have a blackish scale-covering with a central nipple.

FIG. 128.—Twig incrusted with the San Jose scale.

The best and safest spray is concentrated lime-sulphur solution, testing 32° Baumé, diluted at the rate of 1 gallon to 7 of water or approximately 6½ gallons to each spray tank of 50 gallons capacity. This wash may be applied any time after the leaves have dropped in the fall, provided the temperature is not freezing, and before the buds open in the spring. The dormant spraying, however, is usually deferred until after the winter pruning has removed much of the infested wood, thereby securing better results and saving spray material. If it is desired to spray for apple aphids, the dormant application may be delayed until the bud tips show green, when the same lime-sulphur solution combined with three-eighths of a pint of 40 per cent nicotine sulphate to each 50 gallons may be employed to combat both scale and aphids. Owing, however, to the limited time available for this work before the foliage has advanced too far, adequate equipment is necessary to accomplish the work in an effective manner. Miscible oils may also be used in cases of severe infestation, and are effective in the control of the scale, but injury to the trees sometimes results from their use. During the summer season the young scale insects are killed by the summer strength of lime-sulphur concentrate (1½ gallons to 50 gallons of water), and spotting of the fruit is thereby considerably reduced.

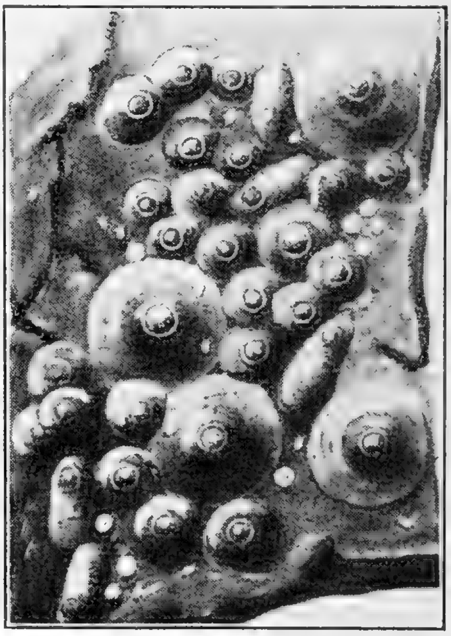

FIG. 129.—San Jose scale: Males and females. Greatly enlarged.

OYSTER-SHELL SCALE.[50]

The oyster-shell scale is of common occurrence, and because of its characteristic appearance (fig. 130) is readily identified by orchardists and others who may discover its presence on their trees. It is apparently not very fastidious, being found on a great variety of fruit and shade trees, bushes, and shrubs. Poplar was long supposed to have been a favorite food plant, but it is now believed that the insect most commonly found on poplar is not the same as the apple form. Frequently the oyster-shell scale is found in apple orchards, and although it usually ranks as a scale pest next to the San Jose, it is seldom very destructive. It sucks out the plant juices from the trees, limbs, trunks, foliage, and fruit, the principal injury occurring on the woody portions of the tree. Young trees heavily incrusted are sometimes killed, while older trees may occasionally be seriously injured, resulting in the death of twigs and limbs. On the fruit the scale causes small reddish dots, somewhat similar to those produced by the San Jose scale, thereby disfiguring the fruit and rendering it objectionable from the marketing standpoint.

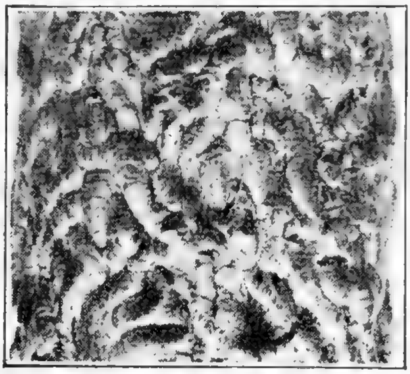

FIG. 130.—Twig incrusted with oyster-shell scale. Enlarged.

The winter is passed in the egg stage beneath the scale covering. The eggs (fig. 131), which are yellowish white, hatch in from 2 to 3 weeks after the apple blooms and shortly thereafter the young yellowish white scale insects settle on some part of the host plant. The male insects are winged, and upon reaching maturity during the summer mate with the females. The female scale covering is about one-eighth of an inch long, dark brownish gray, and resembles in general shape the oyster shell. The male scale covering is much smaller and is oval. In the North, where there is only one generation annually, egg laying takes place during late summer to early fall. In the more southern districts, including the southern parts of New Jersey and Pennsylvania, there are two generations yearly.

FIG. 131. — Appearance of eggs of oyster-shell scale. Enlarged.

While dormant treatment with winter-strength lime-sulphur solution is not generally as effective against the oyster-shell scale as against the San Jose scale, orchards regularly sprayed for the latter will not usually be troubled with the oyster-shell scale. In cases of severe infestation the dormant spraying may be supplemented with a contact spray of 10 per cent kerosene emulsion applied when the young are hatching.

SCURFY SCALE.[51]

Apple and pear trees, as well as other common deciduous tree and bush fruits, are frequently attacked by the scurfy scale, which retards the growth and vitality of its host. In severe infestations this scale has been known to kill young trees, but usually injury is confined to a few twigs or limbs. Occasionally it settles and feeds upon the fruit, resulting in reddish dots somewhat larger than those caused by the San Jose scale. The scurfy scale (fig. 132) is native to the United States, and

[50] *Lepidosaphes ulmi* Linnaeus.

[51] *Chionaspis furfura* Fitch.

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while it is widely disseminated, it attracts most attention in the New England and Middle Atlantic States. It is readily recognized by the characteristic dirty white, pear-shaped scale, somewhat less than one-eighth of an inch in length, which covers the yellowish female insect (fig. 133). The male scale-covering is snowy white, elongate, and only one twenty-fifth of an inch long (fig. 133). The eggs and the young are purplish, tinted with red.

FIG. 132.—The scurfy scale. Enlarged.

As in the case of the oyster-shell scale, this insect winters as eggs, which begin hatching shortly after the young apples have set. In the Northern States there is only one brood, while in the extreme South there are probably as many as three.

The remedial measures suggested for the control of the San Jose and oyster-shell scales are appropriate for the present species.

PINHOLE BORERS.

The three species of beetles here treated are known to attack the limbs and branches of the apple, boring small pinholes directly through the bark and into the wood. The pinhole borers which penetrate into the wood of the trees are also known as ambrosia beetles, because they feed upon ambrosia fungi which grow along the walls of their burrows. In addition to stone and pome fruits, many kinds of trees are subject to injury, usually after they have been weakened by other causes. One of the forms, the so-called pear-blight beetle,[52] bores into the branches of apple, pear, etc., and may cause a dying-back of the wood, the injury resembling that due to a disease known as pear blight. Another species, the apple wood-stainer,[53] as the name suggests, is associated with a staining of the wood along the burrows of the beetle, due to the growth of one of the ambrosia fungi. A frequent companion of this beetle is another form similar in appearance and habits.[54]

When remedial measures for the Ambrosia beetles are necessary, the recommendations given for preventing injury by the fruit-tree barkbeetle should be employed.

FIG. 133.—Female and male scurfy scales. Greatly enlarged.

FRUIT-TREE BARKBEETLE.[55]

The fruit-tree barkbeetle, also called the shot-hole borer, though closely related to the pinhole borers, differs materially in the character of its attack. Its injuries are confined principally to sickly or diseased trees, or to diseased limbs, and are not as a rule the primary cause of death of trees, though usually so regarded by fruit growers.

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[52] *Anisandrus pyri* Peck.
[53] *Monarthrum mali* Fitch.
[54] *Monarthrum fasciatum* Say.
[55] *Scolytus rugulosus* Ratzeburg.

Both the beetles and grubs or larvæ burrow into the bark and slightly into the wood, rapidly extending their burrows and destroying the vital part of the tree. On a tree that has been infested for some weeks the entrance and exit holes of the beetles may be so abundant as to suggest that the tree has been peppered with shot (fig. 134). This insect is of European origin and is now widely distributed over the United States east of the Mississippi, and in numerous localities farther west. It attacks most pome and stone fruits, as well as mountain ash, chokecherry, June berry, wild plum, service berry, and perhaps other plants.

During the winter season the fruit-tree barkbeetle is in the larva or grub stage within the larval galleries. The mature larvæ are whitish and are about three-sixteenths of an inch long. They pupate early in the spring and the beetles, which are about one-tenth of an inch in length and dark brown, emerge in late spring to early summer, according to the latitude. The females proceed to the trees and burrow through the bark until the sapwood is reached, where they make a round hole about the size of a pinhead. They then gnaw out a somewhat larger tunnel for a distance of about 2 inches parallel with the grain of the wood. Along the sides of this brood chamber small cavities are made, into each of which an egg is placed. These eggs hatch in a few days and the larvæ as they grow tunnel between the bark and sapwood in a direction at right angles to the brood chambers to a distance of about 3 to 4 inches. Upon attaining their full growth the larvæ pupate in cells just under the outer part of the sapwood. Shortly, through further transformation, the adults appear and cut their way out through the bark, making exit holes similar to those made by the females in entering the tree. In the North there are two generations a year, while in the South at least three and possibly four generations develop annually.

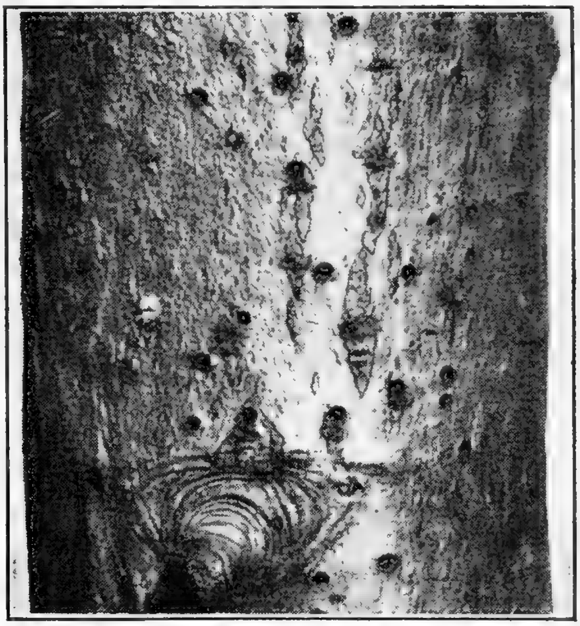

Fig. 134.—Exit holes of fruit-tree barkbeetle.

To prevent injury by this insect great care should be taken to remove all breeding places within or adjacent to the orchard. Sickly trees will harbor the fruit-tree barkbeetle and in this way large numbers of the pest will become established within the orchard. Cutting out and destroying infested trees and limbs and maintaining the trees in a thrifty condition will vastly reduce the injury of this pest. Where prunings are piled up and allowed to remain near orchards, the beetles often develop in numbers, attack more or less weakened trees, or even healthy trees, and by their repeated onslaughts do considerable harm, or eventually cause the trees to succumb. Thorough destruction of such prunings and weakened trees will usually correct such a situation, and the more or less healthy trees should be stimulated with a nitrogenous fertilizer, such as nitrate of soda, and cultivation. After a tree has once become infested there is no practical method of destroying the insects under the bark. A heavy application of whitewash in the spring just before the beetles begin their attack will act as a moderate preventive.

BUFFALO TREE-HOPPER.[56]

The injury caused by the buffalo tree-hopper is due to the punctures made by the females in egg laying and the scars resulting therefrom. The female, with her ovipositor, cuts two slits in the bark on the upper side of the smaller branches. The bark between the cuts is loosened and the twigs roughened and weakened (figs. 135 and 136). In most sections the buffalo tree-hopper is not an enemy of importance to the apple, though there are records of serious injury in the upper Mississippi Valley. Young trees usually suffer worst, and where the egg punctures are abundant growth of the twigs is retarded. It is a native species and is rather generally distributed over the Middle and Eastern States, ranging into Canada, but has always attracted most attention in the Middle West. The buffalo tree-hopper feeds upon a considerable number of pome and stone fruits, upon the locust, cottonwood, thornbush, etc., as well as numerous vegetables.

The insect winters in the egg stage in the little cuts made by the female. The eggs are one-tenth of an inch long, cylindrical, whitish, and some dozen or less are placed side by side in the incisions in the twigs. The eggs hatch in the spring and the young nymphs feed upon various weeds in the vicinity until they reach the adult stage. At this time the insect (fig. 137) is about three-eighths of an inch in length, grayish, triangular, with enlarged prothorax, suggesting in miniature the appearance of a buffalo.

The most practical method of control consists in keeping down the weeds and other food plants of the insect by clean cultivation in and around the orchard. In the work of pruning scarred twigs should be removed and burned to insure the destruction of the overwintering eggs.

PERIODICAL CICADA.[57]

Few insects have attracted as much public attention as the periodical cicada, more popularly known as the "17-year locust." In northern localities this insect appears every 17 years, or oftener where the broods overlap, whereas in the South the life cycle is completed in 13 years. The forthcoming of the locusts is usually heralded by announcements in the newspapers and by other agencies. Frequently the accounts of the impending danger to orchards and shade trees are much exaggerated and cause an unwarranted fear of destruction. The chief injury to trees is caused by the females ovipositing in the twigs; young orchards adjacent to woods often suffer severely, and in extreme cases young trees may be killed. Older trees suffer much less, particularly if the winter pruning is omitted previous to the "locust year." The punctured twigs (figs. 138 and 139) are more or less weakened and break off readily and are also more subject to attack along the egg scar by the woolly apple aphis.

The periodical cicada is a native pest and is found widely distributed over the Atlantic Coast States and the Middle Western States. The females oviposit in the apple, pear, and other deciduous fruit trees and many forest trees, as oak, hickory, etc., but avoid pines, cedars, and other trees that exude gummy substances.

In the spring of the "locust years" the nymphs leave the soil and migrate to the trunks, limbs, and foliage of adjacent trees, where they molt, the cast skins (fig. 140) remaining rather firmly attached to the point chosen. Within a week or so the females are actively depositing their eggs, which do not

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[56] *Ceresa bubalus* Fabricius. [57] *Tibicina septendecim* Linnaeus.

FIG. 135.—Injury to twigs by buffalo tree-hopper.

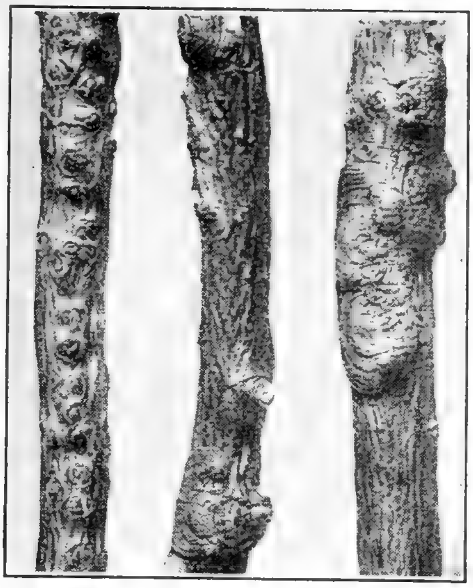


FIG. 136.—Work of the buffalo tree-hopper.

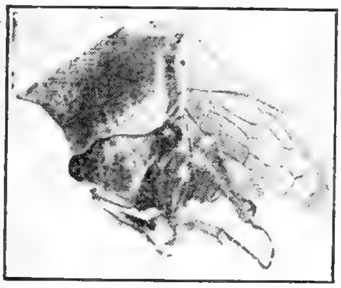


FIG. 137.—Adult buffalo tree-hopper. Enlarged.

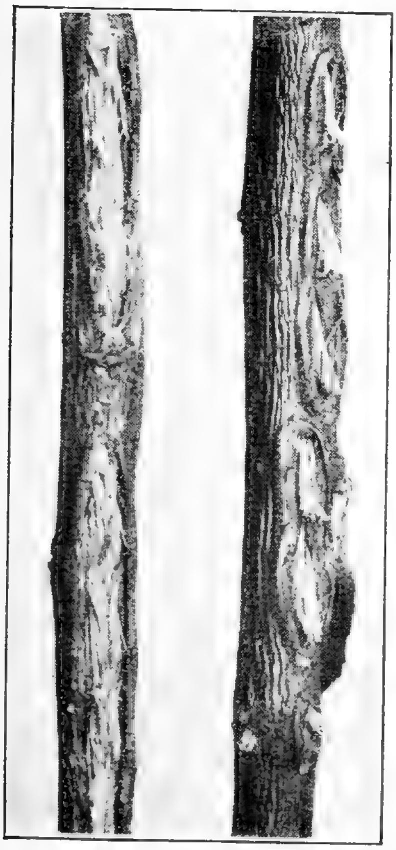


FIG. 138.—Injury to twigs caused by periodical cicada in depositing eggs.

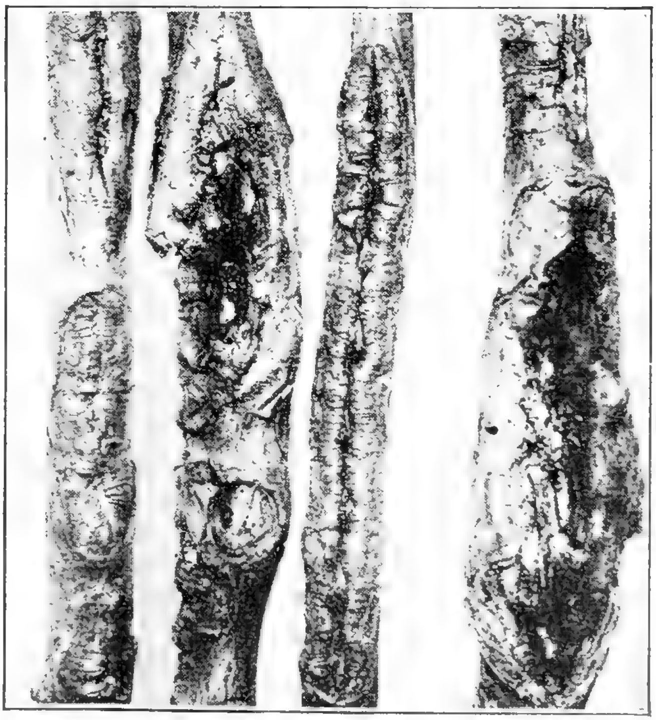


FIG. 139.—Appearance of punctured twigs a few years after cicada attack.

hatch until a month and a half or two months after being laid. The adult (figs. 141 and 142) measures about 1¼ inches and is black, the eyes, legs, and the margin of the upper veins being orange red. Near the tip of each of the forewings is a marking that resembles the letter **W**. The eggs are about one-twelfth of an inch in length, pearly white, and slightly curved. The newly hatched larva is yellowish white with reddish eyes. It burrows into the ground, where as it grows it continues to feed upon the roots of plants until the next "locust year" arrives. Probably no important injury follows this subterranean feeding, even in the worst infested localities.

FIG. 140.—Cast nymphal skin of periodical cicada. Enlarged.

As a matter of precaution it is best not to set out young orchards during the spring of a "locust year," and in orchards already established, especially of young trees, the winter pruning preceding the scheduled arrival of the cicada should be lighter than usual or omitted until the insects disappear. After the visitation has passed the injured wood should be pruned out and destroyed by burning before the eggs hatch. Little, if any, success has followed the use of insecticides against the adults. Prized plants around the home can best be protected from attack by use of mosquito netting or wrappings that will prevent the oviposition of the adults.

SNOWY TREE-CRICKET.[58]

Apple orchards more or less neglected and grown up with weeds and other rank vegetation or surrounded with such growths are sometimes injured by females of the snowy tree-cricket (fig. 143) in the course of its egg laying. The eggs (fig. 143) are deposited singly in punctures in the smaller branches of the apple and other trees. These punctures in themselves are of but little importance, but they often form a starting place for fungous diseases and thus become enlarged into cankerous brown spots of some size which do material injury as they develop. Colonies of the woolly aphis are often found at these places. The feeding and egg-laying habits of tree crickets favor the dissemination of bark diseases of the apple, as careful studies have shown.

FIG. 141.—Two periodical cicadas resting on twig.

The snowy tree-cricket passes the winter in the egg stage in the punctures made in apple twigs and other plants, the young developing in late spring. The crickets feed on a variety of substances, including such other insects as plant lice, plant material, and often ripe fruit, in which they eat out holes sometimes attributed to bees.

Well-cared-for orchards will not suffer from injury by this insect. Where tree-cricket cankers are found, they should be cut out and the surface treated with a good wound paint.

[58] *Oecanthus niveus* DeGeer.

ROUNDHEADED APPLE-TREE BORER.[59]

The roundheaded apple-tree borer, which is now widely distributed throughout the eastern half of the United States, is the most important of the apple-tree borers and is responsible for the killing of many young trees. The injury is caused by the larvæ or borers (fig. 144) feeding upon the inner bark and wood, several of which may often be found in the same tree. Infested trees may be detected by the reddish castings which are forced out through small holes near the base of the tree (fig. 145), and often there will be small oval holes in the trunk some 8 or 10 inches from the ground from which the adult has already escaped (fig. 146). The more important food plants include the apple, quince, pear, serviceberry, wild crab, and mountain ash.

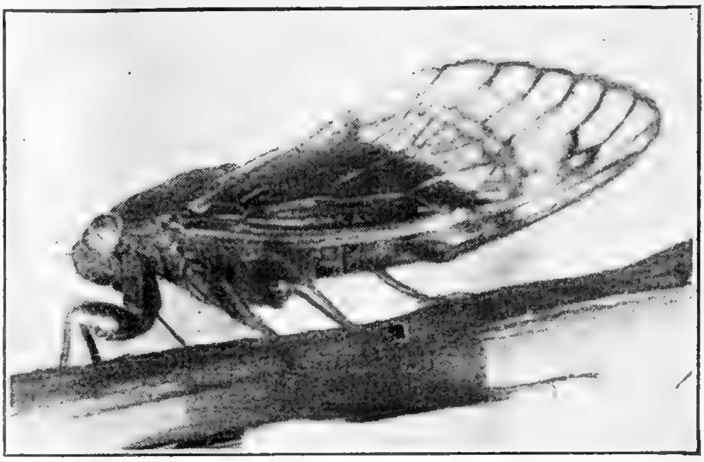


FIG. 142.—Adult periodical cicada. Enlarged.

The winter is passed in the larva stage within the burrow near the base of the tree, though the larvæ that are to transform in the spring to the adult stage are to be found in the pupal chamber. The larva, when mature, measures about an inch in length, is legless, and has a broad thorax with a relatively small dark head. The pupa (fig. 147) is yellowish white, with small spines on its back. Pupation occurs about the blooming time of the apple; and later, through further transformation, the adult (fig. 146) appears. The beetle measures about three-fourths of an inch in length, has long antennæ, and the wing covers are light brown with two longitudinal white stripes, which also are found on the thorax and head. When ready to issue during late spring and early summer, the beetle cuts its way through the bark, leaving an exit hole as described. After emergence it spends considerable time among the branches of the trees, where it feeds to a certain extent upon the bark and also on the midribs and stems of the leaves. The females (fig. 148) usually begin to oviposit within a week or 10 days after emergence. The rusty brown eggs, about one-eighth of an inch in length (fig. 149), are laid in small cuts made by the beetle with its jaws on the trunk near the base of the tree. Usually two or three eggs are deposited by a beetle at one time on the same tree. Upon hatching the larvæ burrow into the inner bark and feed thereon until late in the season, when they usually cut their way into the sapwood, where the winter is passed. In the spring the feeding is resumed, the larvæ penetrating the solid wood. Some individuals have a life cycle of 2 years, while others have one of 3 years.

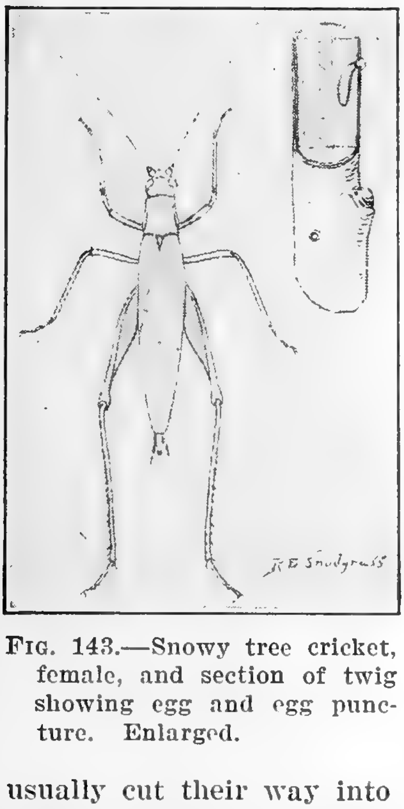


FIG. 143.—Snowy tree cricket, female, and section of twig showing egg and egg puncture. Enlarged.

[59] *Saperda candida* Fabricius.

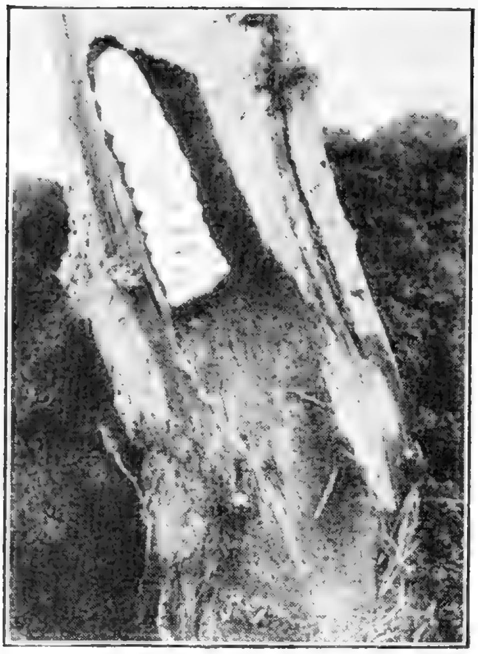


FIG. 144.—Roundheaded apple-tree borer, second summer in tree.

FIG. 145.—Castings of roundheaded apple-tree borer at base of apple tree.

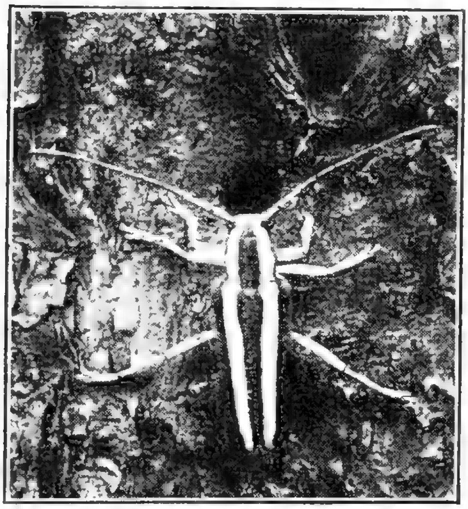


FIG. 146.—Adult roundheaded apple-tree borer just emerged from exit hole in bark.

FIG. 147.—Pupa of roundheaded apple-tree borer. Enlarged.

FIG. 149.—Eggs of roundheaded apple-tree borer. Greatly enlarged.

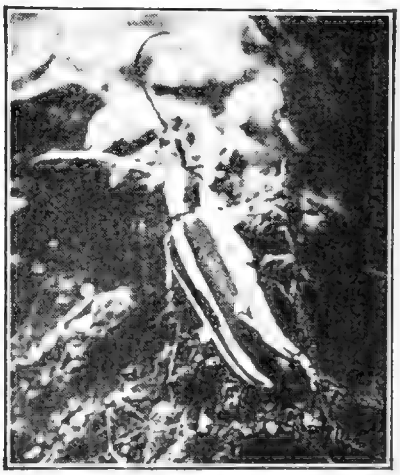


FIG. 148.—Adult female of the roundheaded apple-tree borer in the act of depositing an egg.

The borer with a 2-year life cycle eats out a burrow during the summer, forming at its end the pupal chamber in which it pupates the following spring, whereas the insect with a 3-year cycle feeds within the solid wood for another season and then prepares its pupal cell from which the adult issues the following year.

Worming trees by means of a knife and wire to hook out the larva from its burrow is the method of control most frequently practiced. The position of the gallery is best located by means of the stringlike mass of reddish castings pushed out at the base of the tree. When the larva is in the pupal chamber it can not be readily reached by the wire because the gallery is plugged with woody tissue; in this event a small piece of cotton saturated with carbon disulphid may be inserted in the burrow, after which the hole should be plugged with moist earth so as to confine the fumes. If worming is done regularly each fall as soon as possible after the eggs have hatched, and special attention given to finding and destroying the young borers still working in the sapwood, the task of worming will be lightened and the more serious injury to the tree from older borers avoided.

In the latitude of Washington, D. C., worming as a rule should be completed before September, while farther south it may be done a month or so earlier, and in the North it may be deferred until the middle of September.

Host plants other than cultivated fruit trees should not be allowed to grow near the orchards, since they serve as breeding grounds for the beetle.

Paints and washes are sometimes used to deter the beetle from ovipositing. Various results have been obtained from their use. If paint is employed, it should be of pure white lead and raw linseed oil mixed to a consistency somewhat thicker than that used in general painting. The earth should first be removed from the base of the tree to a depth of 3 or 4 inches and the bark scales and dirt scraped from the trunk for a distance of about a foot above the ground. The paint should then be applied to the prepared part of the trunk with a brush, and after it has dried the earth should be replaced.

Tree-protectors made of newspapers, building paper, wood veneer, and cylinders of fine-meshed wire screen, the tops of which have been plugged with cotton, are sometimes used to prevent the beetle from ovipositing around the base of the trees.

The arsenical sprays regularly used in commercial orchards against other insects are of some value in killing the adults, which feed to a certain extent upon the leaves and twigs as described.

FLAT-HEADED APPLE-TREE BORER.[60]

The flat-headed apple-tree borer is second in importance to the roundheaded borer and, unlike the latter, seldom attacks vigorous, healthy trees. It will, however, infest those that are weakened from various causes, particularly trees that lean strongly one way (fig. 150), thus exposing a portion of the trunk to the sun, where the beetles freely oviposit. The larva or borer (fig. 151) causes injury to apple trees (fig. 152) by feeding between the bark and sapwood of the trunk and larger branches. On young trees a single borer may nearly or actually kill them, especially newly planted trees that fail to start off right. A related species[61] is frequently complained of on the Pacific coast on account of its injuries to young trees. The larvæ usually are present on the sunny side of the trees, especially in the case of large ones, and the dead area may be enlarged from year to year by successive generations eating out the fresh tis-

[60] *Chrysobothris femorata* Fabricius. [61] *Chrysobothris mali* Horn.

FIG. 150.—A leaning tree having trunk exposed to direct rays of sun is very likely to be attacked by the flatheaded apple-tree borer.

FIG. 151.—Flatheaded apple-tree borer feeding between bark and wood of apple tree.

FIG. 152.—Apple tree girdled and killed by flatheaded apple-tree borers.

FIG. 154.—Eggs of flatheaded apple-tree borer. Enlarged.

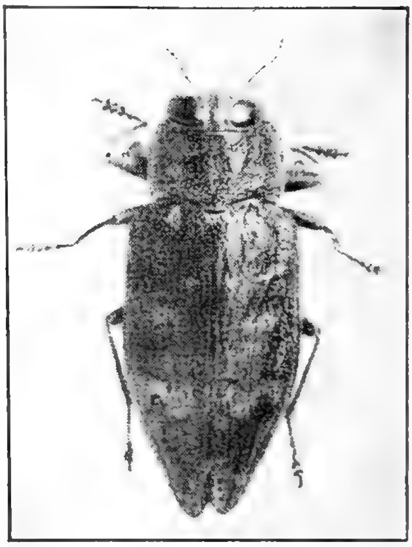


FIG. 153.—The flatheaded apple-tree borer (adult). Enlarged.

sues adjacent to the old. While this insect seldom produces visible castings, its presence nevertheless can be frequently detected by the darker and slightly depressed bark over the area in which the borers are feeding. The flat-headed borer is native to this country and is generally distributed in important fruit-growing regions. It feeds upon a wide variety of hosts, including the apple and other deciduous fruit trees as well as many forest trees.

The winter is passed in the larva stage within a pupal chamber formed at the end of a gallery which extends into the wood to a depth of an inch or more. In the South, however, the pupal chamber is generally constructed between the wood and the bark. The full-grown larva measures about an inch in length; is legless; has a broad, flat head, which has suggested its common name, and is pale yellow. The larva transforms to a yellowish pupa in the spring, and issues as an adult shortly after the apple blooms. The adult (fig. 153) is a rather flat beetle, having a dark metallic color, and measures about a half inch in length. The beetles are active and frequent the sunny side of the trees. After mating, the females search the bark for a crack or opening in which to deposit their eggs. The eggs (fig. 154) are about one-fiftieth of an inch long, ribbed, and yellowish. They hatch in the course of 2 or 3 weeks and the larvæ begin to gnaw their way beneath the bark, where they feed and develop, provided the trees are not in good health. The borer is unable to thrive in vigorous trees having a strong flow of sap, although it will sometimes continue to live in a dwarfed condition until the tree is weakened by another agency, thus giving the borer a chance to grow, in which case the life cycle may be extended to 2 years or more instead of the normal 1-year period.

The most practical means of dealing with this insect is to keep the trees resistant by proper cultivation, fertilization, pruning, and any other orchard practice that will maintain the tree in an upright, thrifty, and healthy condition. When borers are found, the most satisfactory remedy known is to cut them out with a knife, care being taken not to injure the trees.

SPOTTED APPLE-TREE BORER.[62]

The spotted apple-tree borer is sometimes of considerable importance in certain localities. Its injuries are somewhat similar to those of the roundheaded apple-tree borer, except that it more commonly works in the upper parts of the trunk and branches, giving the trees an unthrifty and sickly appearance. When abundant it frequently kills young trees and branches of older trees. The presence of this insect is most readily detected by means of the sawdust-like castings which are pushed out of the burrows or by the cankerous appearance of the infested wood. The general habitat of this native beetle ranges from Canada through the New England and Middle Atlantic States westward to Iowa, and it has also been reported from Texas. It has attracted most attention in parts of Michigan, Iowa, and Wisconsin. In addition to the cultivated apple, this insect is recorded as infesting the wild crab apple, thorn trees, and Juneberry.

The winter season is spent in the larva stage within the burrow, and during the winter preceding its transformation to the adult the insect is to be found in the pupal chamber at the upper end of its gallery, usually in the heartwood of a branch or small trunk. The mature larvæ or grubs (fig. 155), are legless, about an inch or slightly more in length, whitish, with brownish head and black jaws. In the spring the grubs change to yellowish white pupæ, about two-thirds

[62] *Saperda cretata* Newman.

FIG. 155.—Nearly mature larva of the spotted apple-tree borer working in heart of apple wood.

FIG. 156.—Pupa of spotted apple-tree borer.

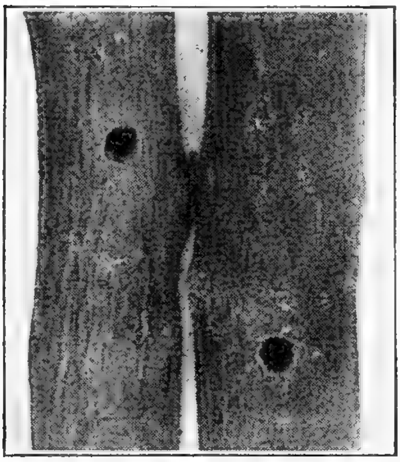


FIG. 157.—Exit holes made by beetles of the spotted apple-tree borer.

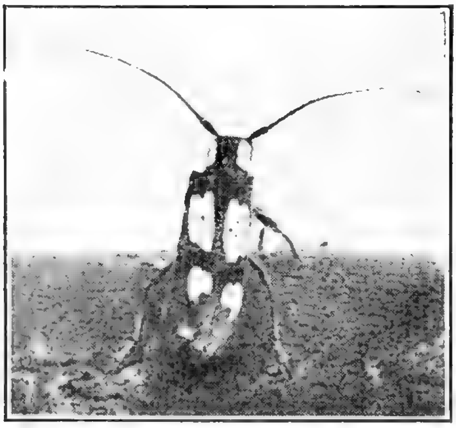


FIG. 158.—Female beetle of spotted apple-tree borer about to deposit an egg.

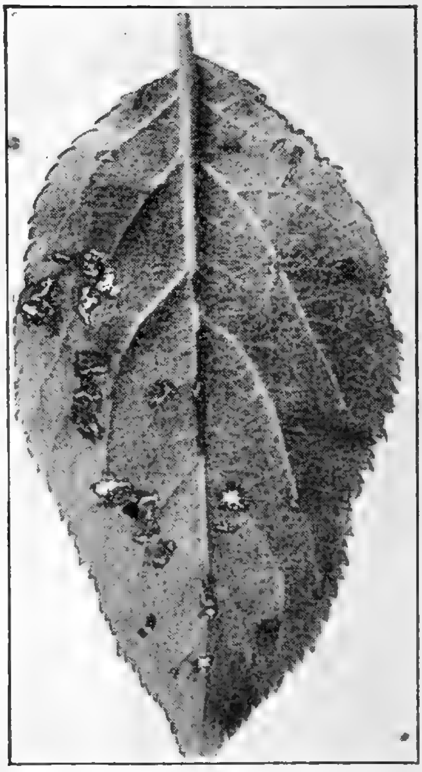


FIG. 159.—Apple leaf partly eaten by beetle of spotted apple-tree borer.

of an inch in length (fig. 156). Later the adult beetle gnaws its way through the bark and escapes through the small roundish exit hole (fig. 157) which has a diameter of about one-fourth of an inch. The female beetles (fig. 158) are approximately two-thirds of an inch or more in length, while those of the other sex are somewhat smaller. The brownish beetles have white sides and are most easily distinguished from the roundheaded apple-tree borer by the two white spots on each wing-cover and the white stripe on each side of the thorax. The beetles feed upon the tender bark of twigs, on leaf petioles, and also to a slight extent upon the leaves (fig. 159). The creamy white eggs (fig. 160), which soon become brownish, are inserted between the bark and the wood (fig. 161). Upon hatching the larva commences to gnaw out its burrow, and if two larvæ hatch from eggs placed in the same repository they usually feed in opposite directions, resulting in a more or less complete girdling of the branch. By the end of the first season, or early in the next, the larva usually tunnels into the heartwood, and in the case of a borer with a 2-year cycle completes its pupal chamber at the close of the second season. The general life cycle varies from 2 to 4 years, depending on latitude and other conditions, with perhaps 3 years as the common period over most of the area of its distribution.

Fig. 160.—Egg of spotted apple-tree borer. Enlarged.

Fig. 161.—Chain of punctures of spotted apple-tree borer in apple bark accompanying oviposition scar. Eggs were deposited at broad place about center of chain.

In all probability many of the beetles are killed previous to oviposition by means of the poison sprays employed against the codling moth and other chewing insects. In infested trees the larval tunnels can best be located by searching for the sawdust castings or the infested wood, as indicated by its cankerous appearance. The borers when found should be killed with a knife, wire, or other suitable tool. Where branches are heavily infested they should be pruned off and destroyed. As a further aid in reducing injury, it is advisable to cut down all of the wild host plants growing in the neighborhood of the orchard, thereby destroying natural breeding grounds.

APPLE CROTCH-BORER.[63]

The apple crotch-borer is of comparatively minor importance, although if searched for it may frequently be found in the roughened crotches of apple trees (fig. 162) or in bark wounds caused by other borers, by diseases, implements, etc. The injury is caused by the larvæ (fig. 163), which feed in the inner bark or occasionally make shallow burrows into the sapwood. Their presence results in slight injury to the tree, except in instances of severe infestation, when the affected part may be killed or in extreme cases the tree itself may die. The same trees

[63] *Aegeria pyri* Harris; also known as the pear borer.

are usually attacked year after year on account of the roughened or broken areas of the bark, and these places are preferred by the larvæ for feeding purposes. The apple crotch-borer is a native pest; it is rather generally distributed in the Eastern States and has also been found farther West—in Michigan, Missouri, Mississippi, and Texas. The recorded food plants, in addition to the apple, include the juneberry, thorn, mountain ash, and black-knot of the cherry.

During the winter the insect is in the larva stage, well protected in its silken hibernaculum, which is formed within its burrow. In the spring a cocoon (fig. 164) is made, usually beneath the bark scales, after which the

FIG. 162.—Young apple tree injured at crotch by the apple crotch-borer.

FIG. 163.—Larva of apple crotch-borer in hibernaculum.

FIG. 164. — Cocoon of apple crotch-borer, exposed by removing scales of apple bark. Enlarged.

FIG. 165. — Adult moth of apple crotch-borer. Enlarged.

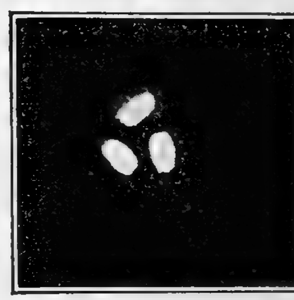


FIG. 166.—Eggs of apple crotch-borer. Enlarged.

pupa stage is entered. The full-grown larva is yellowish white, with a brown head, and averages about three-fifths of an inch in length. The brownish pupa is about one-third of an inch long. The adult, which issues during the summer, is a small moth (fig. 165) with a wing expanse of one-half to three-fourths of an inch. It has clear, fringed wings, the tips of which are metallic black. The upper part of the moth is purplish black, marked with white and yellow on the head, yellow on the thorax, and with three more or less distinct yellowish bands on the abdomen. The lower parts of the moth, including the legs, are conspicuously marked with golden yellow. The moths deposit their very minute, oval, glistening, brownish eggs (fig. 166) on roughened surfaces or in cracks or other broken places of the bark. Upon hatching, the larvæ feed on the inner bark as described. According to the life-history studies of the Bureau of Entomology, some individuals have a 1-year life cycle, while others require 2 years to complete their transformation from the egg to the adult stage, this difference being attributed to climatic and food conditions and the time of hatching.

Fortunately this borer works close to the bark surface, making it a comparatively easy matter to remove the larvæ with a knife without inflicting much injury to the tree. After the roughened bark has been scraped and the borers removed, it is advisable to paint the surfaces with either a coal-tar creosote or pure white-lead paint. If these surfaces are repainted from time to time, new infestations will be largely prevented. While this insect is not always readily detected, its location is usually indicated by a small drop of moisture and the dark pasty-like frass which is exuded from the feeding area.

WOOLLY APPLE APHIS.[64]

FIG. 167.—Aerial colonies of the woolly apple aphis.

The woolly aphis is unlike the other aphids found on the apple in that it attacks the tree both above and below ground. The aerial colonies when abundant are quite conspicuous (fig. 167). They are found upon the trunk, limbs, and twigs, being concentrated on tender growth or wherever the wood has been injured, as by tree-crickets, the periodical cicada, etc. The aphid colonies appear as whitish, cottony masses, beneath which are the reddish insects themselves. The twigs often become more or less deformed as a result of the attack. On the roots the aphids cause swellings and deformities (fig. 168) which often involve most of the roots of the tree, resulting in a sickly or stunted tree of but little fruiting capacity. It has been recently determined that the woolly apple aphis is native to America. Its present occurrence is wide, it being found in practically all of the apple-growing districts of the world. It is particularly serious in the semiarid regions of the West, where the dry climatic conditions apparently favor its development. The principal food plants are the apple and elm, and those of lesser importance include thorn apple, quince, pear, and mountain ash.

The life history of this insect is rather intricate. Briefly, winter eggs are laid in crevices of the bark on the elm and occasionally on the apple. The eggs deposited on the former are brownish and are covered with delicate, waxy hairs, and they hatch in the spring with the opening of the elm leaf buds, upon which the young aphids feed. As soon as winged aphids are produced on the elm some migrate to the apple, where they establish colonies which feed thereon during the summer. In addition to wintering in the egg stage, some wingless individuals remain above and below ground on the apple in certain districts where the winters are not too severe. Some of the root forms remain under-

[64] *Eriosoma lanigerum* Hausmann.

ground throughout their life. The wingless viviparous females are of a salmon brown color, changing with age to dark brown or purplish. The body is more or less concealed beneath a white, waxy covering, forming long, white tufts on the posterior parts. The winged viviparous females are brown to purplish, with dark brown to black head and thorax, depending on age. The body is covered with white or bluish white waxy threads, more prominent on the posterior portion. The wings are transparent and the appendages are partly black.

The aphid colonies above ground may be killed by means of a contact spray, as 40 per cent nicotine sulphate, three-eighths of a pint to 50 gallons of soapy water, made by dissolving 2 pounds of soap, or by the use of 10 per cent kerosene emulsion. Since these insects are well protected by their woolly covering the spray must be forcibly applied, care being taken to soak each colony very thoroughly. It is extremely difficult to effect satisfactory control of the root-infesting forms. Many treatments, such as tobacco refuse applied about the roots, fumigation with carbon disulphid, etc., have been tried, but none can be unqualifiedly recommended. The most practical method is to fertilize and cultivate the trees so as to keep them in a thrifty, growing condition in spite of the aphids that may inhabit the roots.

FIG. 168.—Nodular roots as a result of woolly apple aphis attack.

MISCELLANEOUS INJURIES.

Although the primary purpose of this publication is to acquaint the fruit grower with the injuries and means of control of the more important apple insects, it is believed that brief mention of other agencies, exclusive of diseases which at times occasion more or less damage, may be of some interest and value.

FROSTS AND FREEZES.

The occurrence of heavy frosts and freezing temperatures shortly after the fruit has set or while it is still quite small frequently results in deforming the fruit, the skin of which will often be marked with the so-called frost ring or band (fig. 169), which appears as a more or less distinct belt of brown corklike tissue. These frost bands sometimes completely encircle the fruit and are often conspicuous at harvest. In some instances small cracks develop in the affected area. Another type of frost injury is sometimes in evidence at the calyx or blossom end (fig. 170), in which will be found one or more small pockets or pits. Since it is practically impossible to fill these pits with poison, such fruit is quite susceptible to codling-moth injury.

HAIL.

The attempts of orchardists to grow perfect fruit are often vitiated by uncontrollable factors, among which hail plays an important rôle. Hailstorms of varying severity occasion local losses in one part of the country or another practically every year. If the injury does not occur too near harvest, the hail pits will usually heal over as small corky areas. The damage, however, is not confined to the hail marks, since pronounced codling-moth injury sometimes follows in the wake of the hail, particularly when the storm occurs during the active hatching period of this pest, which gains ready access to the flesh of the fruit by way of the broken skin. Apples on the outside and exposed portions of the trees are naturally injured the most, and it sometimes happens that only one side of the tree is affected, depending upon the direction from which the storm has come.

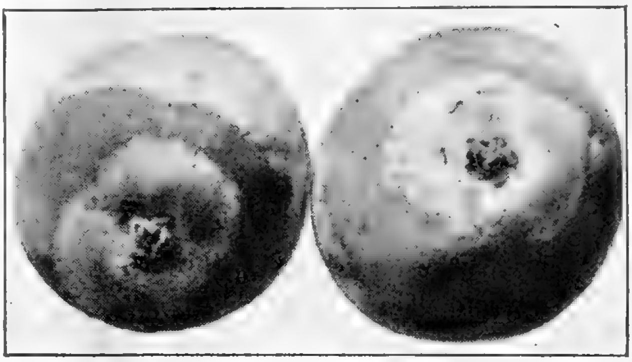


Fig. 169.—Apples injured by frost, producign the so-called "frost ring."

WIND.

The wind is at times responsible for a certain amount of injury to the fruit, causing the so-called "limb rub." The skin of apples thus affected is more or less discolored where it has been bruised by chafing against a branch or limb.

SPRAY BURN.

Spray solutions, such as combinations of arsenate of lead and lime-sulphur or arsenate of lead and Bordeaux mixture, sometimes cause distinct injury to the fruit and foliage. The fruit is often russeted (fig. 171), especially when the spray is applied too forcibly, and in the case of mixtures containing Bordeaux when used during the calyx and first cover-spray treatments or later in the season when followed by much damp or rainy weather. The foliage may be injured by either of the foregoing combinations, and this is particularly true in the case of weak and unthrifty trees. Lime-sulphur injury to the fruit often follows if the spray is applied during midsummer, under conditions of high temperature and bright sunshine. The affected fruit is greatly disfigured by a somewhat circular brownish black spot, which is sometimes as large as or larger than a half dollar (fig. 172). Apples on the southwest side of the tree are most likely to be damaged. In the eastern United States this type of injury has rarely been commercially serious, though sometimes conspicuous. In hot, sunny regions, where this form of injury is of frequent occurrence, fruit growers should use the sulphur sprays only in the cooler spring weather.

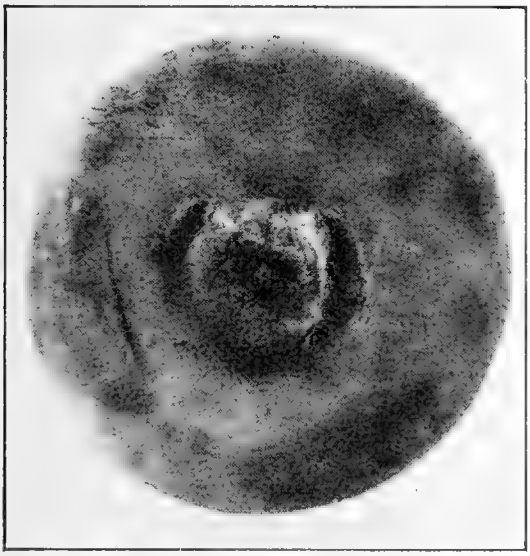


Fig. 170.—Frost injury, calyx end of apple. Codling moth larvæ frequently enter the apple through the frost pits.

INJURIES FROM TREE INJECTIONS.

Every now and then "tree doctors" put in an appearance and endeavor to sell materials which they guarantee will free the tree of all noxious pests.

Usually these compounds are to be injected into the tree trunk on the theory that they will be carried by the sap to all parts of the tree, thereby destroying the undesirable parasites. Such injections are without value and may cause severe injury (fig. 173). Fruit growers would do well to employ only the materials and methods recommended by their State experiment station or the United States Department of Agriculture.

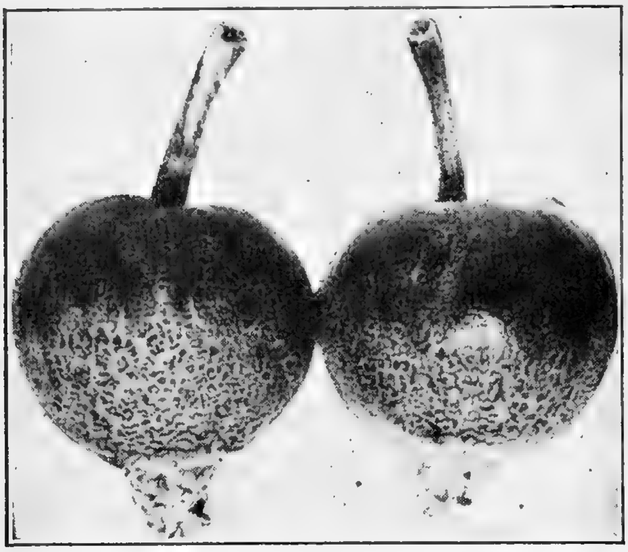


Fig. 171.—Apples russeted by Bordeaux mixture.

SUN SCALD.

During very hot periods the fruit, particularly that on the southwest side of the tree, may be heated to such an extent as to cause large dark discolorations of the skin. Where this trouble is prevalent the damage may be somewhat reduced by not pruning the susceptible portion as heavily as the rest of the tree. The trunks of trees, especially those in young orchards, are sometimes blistered on the southwest and west sides by the hot afternoon sun. A similar type of injury is more commonly produced by severe winter freezing and rapid thawing by the afternoon sun. To overcome this trouble trees may be protected by shading them with wooden strips driven into the ground rather close to the tree. The planting of high-growing cover crops or the intercropping of the young orchard with corn or other tall crops will also serve to protect the trees from too strong an exposure during the summer season.

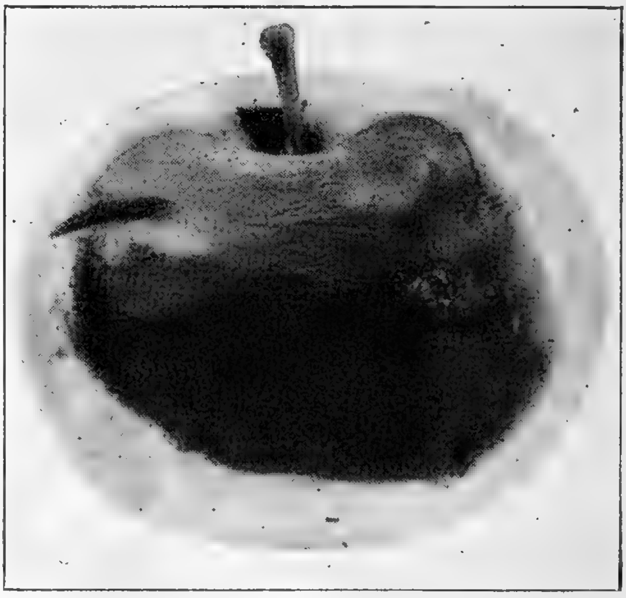


Fig. 172.—Typical lime-sulphur burning on apple.

SPRAY MATERIALS.[65]

In connection with the control of apple insects and diseases, many insecticides and fungicides have been employed both in an experimental way and in actual orchard practice. In addition to the so-called standard spray materials commonly used by commercial orchardists a very large number of proprietary compounds are now on the market. Since the active ingredients of the latter are usually made up of one or more of the standard spray materials, combined with fillers of inert substances, it is obvious that there is no particular reason for using them in preference to the standard spray materials. As a matter of economy and efficiency, the apple grower

[65] For more complete information on spray materials see United States Department of Agriculture Farmers' Bulletin 908.

would do well to employ the spray materials enumerated below, which, if rightly used, will give satisfactory results against the more important apple insects and fungous diseases.

ARSENATE OF LEAD.

Arsenate of lead is the most reliable and efficient poison for chewing insects. It is sold in both the powder and paste forms, the former being preferable, since it is more readily handled and can be held over from one year to the next by keeping it in a dry place. It can be combined with nicotine solutions and with either lime-sulphur or Bordeaux mixture for the simultaneous control of chewing and sucking insects and fungous diseases.

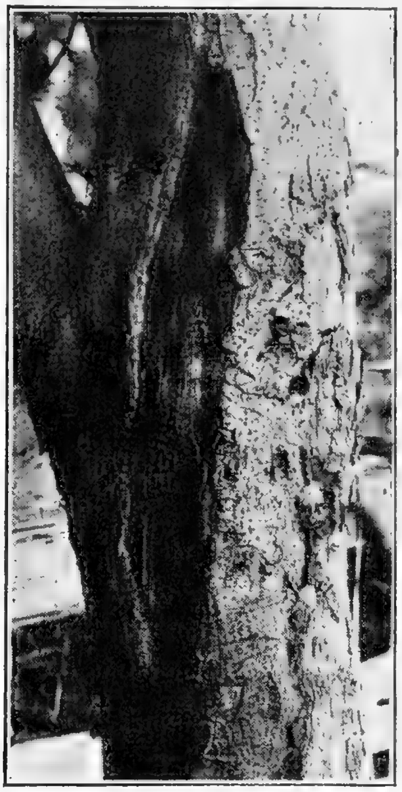


FIG. 173.—Tree injured by use of compound sold by "tree doctor."

NICOTINE.

Nicotine, either commercial, as 40 per cent nicotine sulphate, or homemade decoctions, is the best contact insecticide for sucking insects such as apple aphids, red bugs, etc. If used alone, soap should be added as a spreader, but if combined with mixtures containing lime-sulphur solution the soap should be omitted. When added to Bordeaux mixture and arsenate of lead a pound or so of soap to 50 gallons of spray may be used if desired.

KEROSENE EMULSION.

Kerosene emulsion is a relatively cheap and effective contact spray for sucking insects, but unless very well made and carefully used it may cause foliage injury. It has a further disadvantage in that it can not be used in combination with the other standard spray materials.

LIME-SULPHUR.

Lime-sulphur is used both as an insecticide and as a fungicide. It is recommended as a dormant spray against the scale insects and blister mite, and at greatly diluted strengths as a summer spray for apple scab and certain other diseases.

BORDEAUX MIXTURE.

The well-known fungicide, Bordeaux mixture, is used against certain diseases, notably apple bitter-rot, which are not held in check by lime-sulphur.

SOLUBLE OILS.

Soluble or miscible oils, homemade or proprietary, may sometimes be employed to advantage as dormant sprays for scale insects, the fruit-tree leaf-roller, etc. Injury may follow from their use, and it is therefore safer to apply lime-sulphur solution for scale insects.

DUSTING MATERIALS.[66]

The dry application of insecticides and fungicides has been tried experimentally and commercially for many years. In some instances satisfactory re-

[66] For more complete information on dusting materials see United States Department of Agriculture Farmers' Bulletin 908.

sults have been obtained, but, on the whole, dust mixtures have not given as efficient control as liquid sprays, and in certain apple districts have been quite ineffective. The dust mixtures now usually employed contain 10 per cent of lead arsenate and from 75 to 90 per cent of finely divided sulphur. A filler, such as hydrated lime or gypsum, is often desirable, as its admixture makes a better flowing dust and lessens the cost of the mixture. It is believed that a 75 per cent sulphur content will yield as good results as a higher percentage. A complete dust mixture, containing arsenate of lead, sulphur, and nicotine, has been tried out during the past few years, the nicotine having been added in an effort to combat apple aphids, red bugs, etc. Some success has been reported with this mixture, but the quantity of nicotine required makes the application somewhat expensive. An effort is now being made to develop a good copper sulphate and lime dust to replace the sulphur. Some promising results have been obtained, but further tests are necessary to determine fully its efficiency against fungous diseases.

FIG. 174.—Construction of tree band made of cotton and tarred paper.

TREE-BANDING MATERIALS.[67]

Bands of sticky material 4 to 5 inches wide applied around tree trunks sometimes may be used to advantage to prevent caterpillars, climbing cutworms, and certain other insects from climbing trees. These bands are also employed to prevent nonflying and wingless moths, such as the gipsy moth, cankerworm moths, tussock moths, etc., from ascending trees to deposit their eggs. Cotton batting and wire screen also are used in making protective bands.

The indiscriminate use of these bands, as well as mechanical barriers, is to be discouraged. Their use in parks is sometimes noted on trees which are not subject to attack by insects against which they would have value. As a rule, it is advisable to obtain advice as to their use from entomologists.

FIG. 175.—Completed tree band of cotton and tarred paper with band of sticky material.

STICKY TREE BANDS.

Sticky bands are sometimes injurious to the tree, but injury may be avoided by spreading the adhesive on a strip of heavy paper encircling the tree trunk.

[67] For more complete information on tree-banding materials see United States Department of Agriculture Farmers' Bulletin 908.

A form of band that has given satisfactory results is made from cheap cotton batting and single-ply tarred building paper. The cotton should be cut into strips about 2 inches wide and wrapped around the tree trunk so as to fill all the crevices of the bark. Over the cotton is placed a strip of tarred paper (fig. 174) about 5 inches wide, drawn tightly and securely tacked where it overlaps. The sticky material is then spread on top of the paper (fig. 175).

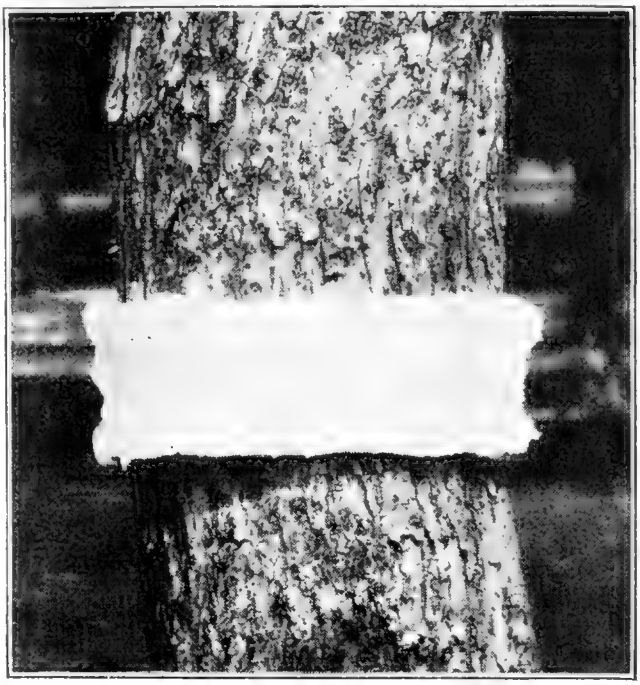


FIG. 176.—Method of construction of cotton tree band.

COTTON BATTING.

Barriers other than sticky bands are sometimes used to prevent insects from crawling up trees.

Bands of cotton batting about 6 to 8 inches wide are effective as long as the cotton remains fluffy. Wrap the band around the tree trunk and securely tie the bottom edge by means of stout twine (fig. 176). The upper edge should then be turned down over the string, forming a flange of loose cotton all around the tree (fig. 177).

SPRAYING APPARATUS.[68]

It is generally recognized by progressive fruit growers that the sprayer and its equipment are very important factors in the production of clean fruit. Fortunately, it is possible to obtain satisfactory outfits which, with proper care and attention, will give years of good service. Although the first cost of a well-made sprayer may appear somewhat high, no fruit grower can afford to be without a reliable outfit that will meet his requirements during the critical spray periods. The purchase of an efficient sprayer is an investment that will pay very liberal dividends. The capacity of an outfit should be larger than needed under ideal working conditions, since unfavorable and unforeseen circumstances may interfere and make it necessary to have reserve power with which to complete the work in time. Large-scale operators should have an extra

FIG. 177.—Completed cotton tree band.

[68] For more complete information on spraying apparatus see United States Department of Agriculture Farmers' Bulletin 908.

sprayer or two to provide against emergencies, and extra parts should be kept on hand to replace those that are broken or worn.

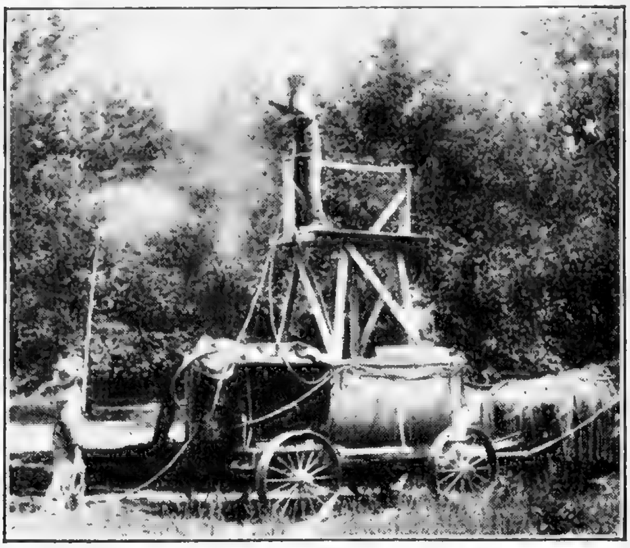


FIG. 178.—A power spray outfit equipped with tower for spraying tall trees.

For those having relatively few trees, a hand-pump outfit, as a barrel pump, may suffice, but generally speaking it is better economy to employ a power sprayer (fig. 178), even in the case of comparatively small acreages. Reliable power outfits are made in different sizes to meet the demands of small to large growers.

The hose and couplings should be of the best materials, since these are subject to considerable pressure and strain, particularly in the case of high-power sprayers.

The selection of the proper spray nozzles, rods, or spray guns will depend largely upon the capacity of the outfit and other factors.

A power machine for applying dust materials is shown in figure 179.

APPLE-SPRAYING SCHEDULES.

As has been explained in the foregoing pages, fruit trees and fruits are simultaneously attacked by many insects and fungous diseases, as the codling-moth, plant-lice, apple scab, etc. It is therefore desirable, and fortunately possible, by a combination of insecticidal and fungicidal materials, to effect the control of these several troubles by one and the same spray application, as by a spray of dilute lime-sulphur, arsenate of lead, and 40 per cent nicotine sulphate. Entomologists and pathologists have given much study to developing combination treatments of this kind in order to save the grower the extra cost and time of separate treatments. Also, spray schedules have been developed for the more important insect and fungous diseases of the apple, peach, grape, and the like. While it is always desirable that an orchardist know as much as possible about his insect and fungous pests, yet he will be able to obtain much success in their control simply by carefully following a series of spray applications timed so as to treat most effectively the various troubles present on the trees or fruit. Although it is not possible by the following of

FIG. 179.—A power dusting outfit at work.

spray schedules to control all of the troubles of the apple, a very large proportion of those controllable by sprays can be kept down by the use of the spray-schedule plan. In the subsequent pages schedules are presented covering the principal orchard districts of the country, which may be modified in accordance with the needs of individual orchardists. In this connection, it should be borne in mind that the relative abundance of pests varies from year to year as influenced by weather and other conditions. The apple grower should therefore be constantly on the alert and prepared to cope with any unusual conditions that may arise from time to time. If the fruit grower is not well acquainted with his insect and fungous troubles, he will do well to consult the State agricultural experiment station, the United States Department of Agriculture, or some other competent agency interested in the suppression of orchard pests.

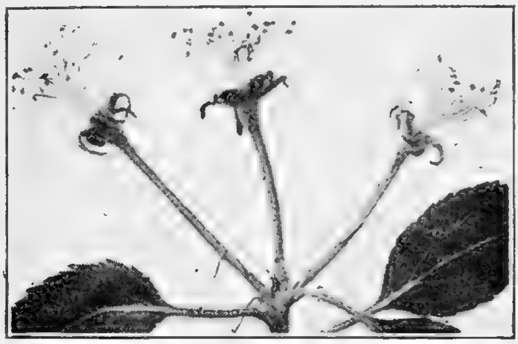


FIG. 180.—Proper stage at which to begin calyx application.

THE CALYX SPRAY.

The so-called "calyx spray" or "petals-off" application is generally recognized as the most important spray for the apple during the growing season and is particularly valuable against the codling moth. The primary object of this application is to fill each calyx cup with poison in order to kill the worms that attempt to enter the fruit through the calyx or blossom end. The time within which this spray can be effectively applied is limited and every effort should be made to do the work within the prescribed period. The spraying should be begun as soon as the petals have dropped (fig. 180) and should be completed before the calyx cups have closed (fig. 181). As an insurance in covering the orchard in time it is often desirable to begin the spraying when 85 to 90 per cent of the petals have dropped, but care should be taken not to spray earlier on account of possible injury to the honeybees.

FIG. 181.—Too late to make calyx application.

It is well known that certain varieties of apples bloom earlier than others and that with each variety there is more or less variation in the development of the bloom. The orchardist should therefore carefully inspect the blossoms and time the spraying with reference to those most advanced. Under ordinary circumstances the center blossom is the most advanced and the most likely to set fruit.

The development of the calyx cup of the Baldwin from the time the petals fall until the cup has closed is shown by means of the vertical sections in figures 182, 183, 184, and 185. In figure 182, which represents the cup just after the dropping of the petals, it will be noted that the sepals are about at right angles to the flowering parts and form a broad, shallow cup which can be readily coated with the poison spray. Six days later,

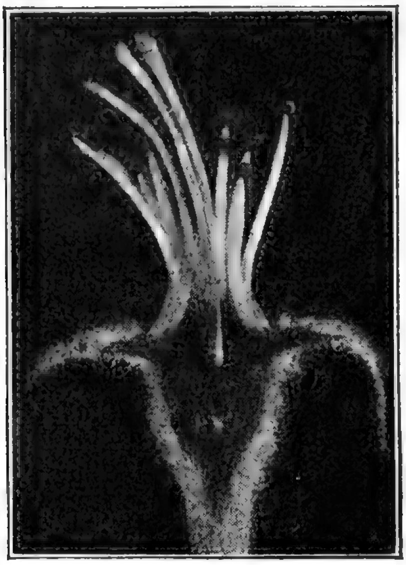


FIG. 182.—Vertical section of apple calyx cup. Petals have just dropped.

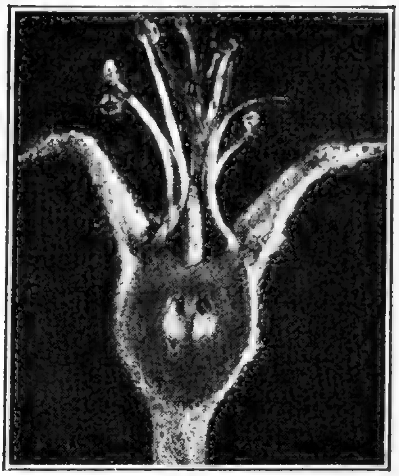


FIG. 183.—Vertical section of apple calyx cup six days after petals dropped.

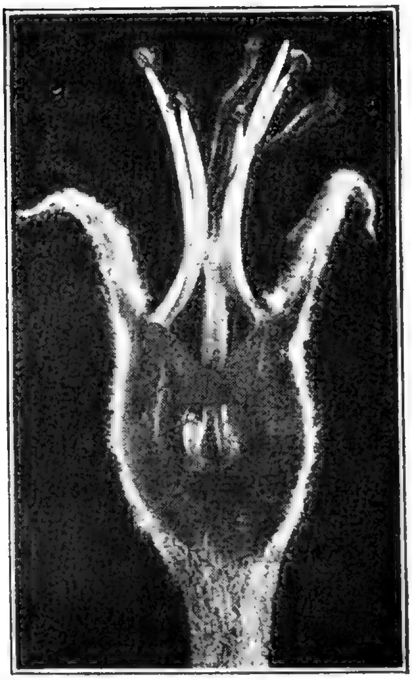


FIG. 184.—Vertical section of apple calyx cup eight days after petals dropped.

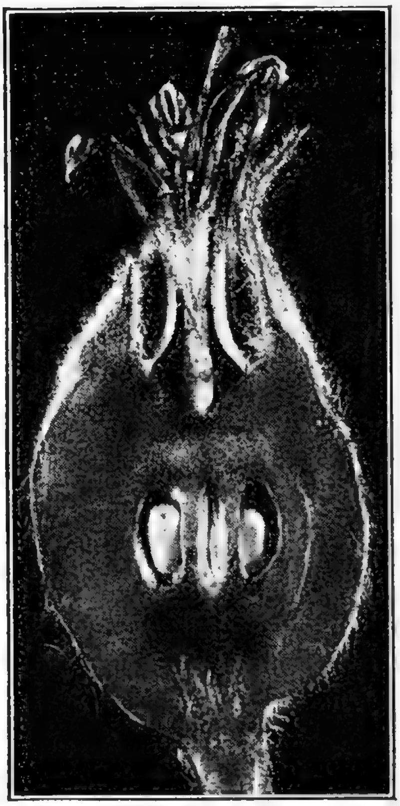


FIG. 185.—Vertical section of apple calyx cup ten days after petals dropped.

as shown in figure 183, the sepals have grown upward, making the cup somewhat V-shaped. In figure 184, which represents the cup 8 days after the petals have dropped, the sepals have advanced further toward the closing point, forming a U-shaped cup. Spraying at this stage is still effective, since the cup is open sufficiently to admit the poison. Two days later, however, or a total of 10 days after the petals have dropped, as shown in figure 185, the sepals have grown together and the cup is practically closed. At this stage of development it is impossible to force the poison into the cup, and hence too late to apply the calyx spray.

The rapidity of closing of the calyx cup varies somewhat with the variety and with the weather conditions. If the spraying is begun when 85 to 90 per cent of the blossoms have dropped, the time within which the calyx application should be made will usually cover a period of a week to 10 days. The orchardist, however, should not depend upon the longer period, but, instead, should provide against unfavorable weather and other unforeseen interruptions by employing sufficient help and spray machines to complete the work within a week.

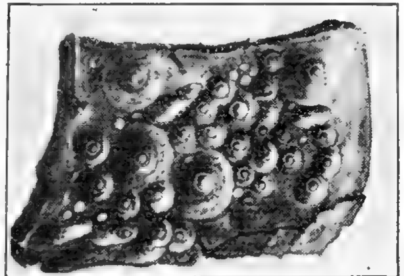


FIG. 186.—San Jose scale. Enlarged.

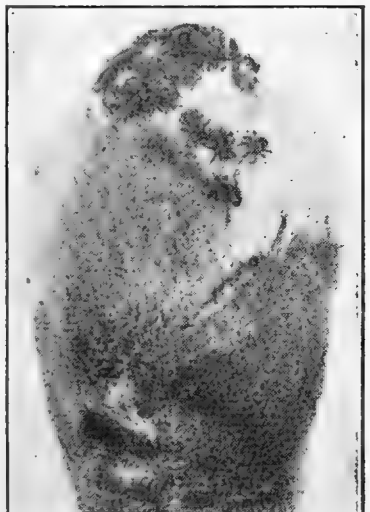


FIG. 187.—Proper stage at which to make delayed dormant application.

TABLE I.—*Apple-spraying schedules.*[1]

Time of dormant and delayed dormant applications.	Spray materials and dilutions.	Dormant and delayed dormant applications for all fruit districts.
"*Dormant.*"—The dormant spray may be applied at any time (except during freezing weather) after the leaves drop in the fall until the buds swell in the spring. As a matter of economy and efficiency it is preferable to make the dormant application after the trees have been pruned. This treatment is chiefly for the control of the scale insects and pear-leaf blister-mite.	Concentrated lime-sulphur (32° Baumé), 6½ gallons with water to make a total of 50 gallons. For the blister-mite 5½ gallons of lime-sulphur diluted to 50 gallons is effective.	It is very important to spray all scale-infested orchards, using lime-sulphur solution at the strength indicated. In California, crude-oil emulsion is extensively employed against scale insects. If mildew is prevalent, the pruning off of the mildewed tips during the dormant period will aid in checking the disease.
"*Delayed dormant.*"—If, in addition to scale insects, aphids are present, the above dormant treatment may be delayed until the bud tips show green. The trees should be sprayed at this time with dormant strength lime-sulphur and nicotine, a combination which is effective against scale insects and aphids. The spraying should be completed by the time the leaf tips have commenced to separate in order to avoid possible injury to the unfolding buds and to obtain satisfactory results against the aphids. If it is desired to spray for the aphids only, use the same quantity of nicotine, adding 2 pounds of soap to each 50 gallons of water.	Use lime-sulphur as directed above for the scale insects, adding ⅜ pint of 40 per cent nicotine sulphate to each 50 gallons. Do not add soap to the above combination.	This is the most important single spray application for apple aphids, since at this time they are clustered on the bud tips and thus fully exposed to the spray. In large orchards, however, there is some danger in delaying the treatment for scale insects until this time, since unfavorable weather conditions may prevent covering the orchard within the specified period.

[1]Directions for control of fungous diseases furnished by Bureau of Plant Industry, United States Department of Agriculture.

FIG. 188.—Much too late to make delayed dormant application. Note apple aphids feeding at base of leaves. In most sections the first application for apple scab should be made at this stage.

Time of summer spray applications for the more important insects and fungous diseases.	Spray materials and dilutions.
"*Pink cluster-bud.*"—This spray should be applied when the blossom buds first begin to separate and should be completed before any of the blossoms open. It is a very important application for apple scab wherever this disease is prevalent. It is also of value in the control of the plum curculio, tent caterpillars, cankerworms, etc. If aphids are present and the leaves are not too badly curled, the addition of nicotine to the spray will aid somewhat in reducing the infestation.	For chewing insects and fungous diseases use arsenate of lead powder 1 pound, or paste 2 pounds, combined with lime-sulphur (32° Baumé) $1\frac{1}{2}$ gallons diluted with sufficient water to make 50 gallons. Nicotine sulphate (40 per cent), at the rate of $\frac{3}{8}$ pint, may be added to the above for apple aphids and red bugs.

New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.
Central Mississippi Valley and the Ozark district.	**West-Central States.**	**Semiarid Western States.**	**Pacific Northwest.**	**California.**
I. Arsenate of lead and lime-sulphur.	I. Arsenate of lead and lime-sulphur.		I. Arsenate of lead and add lime-sulphur if apple scab, powdery mildew, or other fungous diseases are present.	

TABLE I.—*Apple-spraying schedules*—Continued.

FIG. 189.—Proper time to make calyx application.

Time of summer spray applications for the more important insects and fungous diseases.				Spray materials and dilutions.
"*Calyx*" or "*petals-off.*"—Spray as soon as blossom petals have dropped and complete the application before the calyx cups have closed. Use good pressure and spray thoroughly so as to fill every calyx cup. This is the most important single application for the codling moth and is of value against the plum curculio, apple scab, etc.				Arsenate of lead and lime-sulphur as in the first summer application.
New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.
Central Mississippi Valley and the Ozark district.	West-Central States.	Semiarid Western States.	Pacific Northwest.	California.
II. Arsenate of lead and lime-sulphur.	II. Arsenate of lead and lime-sulphur.	I. Arsenate of lead. Fungicides are seldom necessary.	II. Arsenate of lead and add lime-sulphur if fungous diseases are present.	I. In Pajaro Valley use neutral arsenate of lead and iron sulphid in all summer applications.

Fig. 190.—Apples infested with the codling moth.

Time of summer spray applications for the more important insects and fungous diseases.	Spray materials and dilutions.
"*Two to four weeks after 'petals-off' application.*"—This application is important for the first brood of the codling moth which begins to hatch within this period and for other chewing insects, apple scab, leaf-spot, and blotch. Where blotch has been prevalent, use Bordeaux mixture in place of the lime-sulphur, and complete the spraying not later than 3 weeks after the falling of the petals. In certain sections where blotch is epidemic, an intermediate spray application should be given about midway between the above and that indicated below.	Arsenate of lead and lime-sulphur as in the first summer application, except that Bordeaux mixture (3–4–50) should be used in place of the lime-sulphur in districts where blotch is present.

New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
III. Arsenate of lead and lime-sulphur.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch. Where blotch is severe make an intermediate application midway between III and IV.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch. Where blotch is severe make an intermediate application midway between III and IV.	III. Arsenate of lead and lime-sulphur.
Central Mississippi Valley and the Ozark district.	**West-Central States.**	**Semiarid Western States.**	**Pacific Northwest.**	**California.**
III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur. In sections where blotch is severe make an intermediate application midway between III and IV.	III. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to blotch. Where blotch is severe make an intermediate application midway between III and IV.	II. Arsenate of lead. Where the codling moth is abundant make one or two additional applications between II and III.	III. Arsenate of lead. In certain sections an intermediate spray for the codling moth between III and IV will be of value.	II. Neutral arsenate of lead and iron sulphid.

TABLE I.—*Apple-spraying schedules*—Continued.

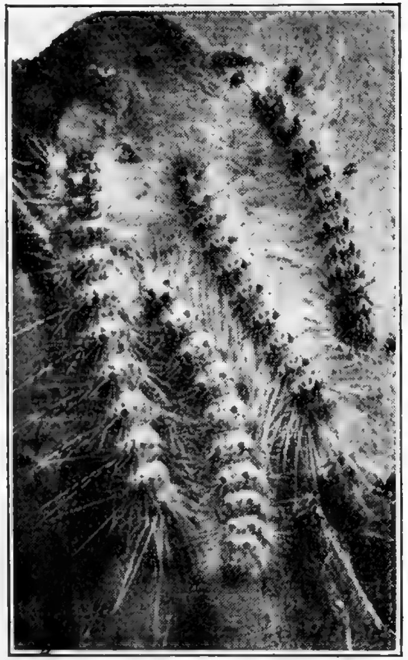


FIG. 191.—Fall webworm caterpillars and others are common during midsummer.

Time of summer spray applications for the more important insects and fungous diseases.	Spray materials and dilutions.
"*Eight to ten weeks after 'petals off' application.*"—A very important application in all districts having two or more broods of the codling moth and for many species of caterpillars and other chewing insects as well as for bitter-rot, blotch, and late scab infection. Where bitter-rot has been serious spray about 6 to 7 weeks after "petals off" application.	Same spray materials as above except that if Bordeaux mixture is used the 4-4-50 formula should be employed.

New England States.	Middle Atlantic States.	Southern Atlantic States.	Ohio Valley.	Great Lakes.
IV. Arsenate of lead and lime-sulphur.	IV. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in sections having varieties susceptible to bitter-rot and blotch.	IV. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in bitter-rot and blotch districts.	IV. Arsenate of lead and Bordeaux mixture in place of lime-sulphur in bitter-rot and blotch districts.	IV. Arsenate of lead and lime-sulphur.

Central Mississippi Valley and the Ozark district.	West-Central States.	Semiarid Western States.	Pacific Northwest.	California.
IV. Arsenate of lead and Bordeaux mixture.	IV. Arsenate of lead and Bordeaux mixture.	III. Arsenate of lead.	IV. Arsenate of lead.	III. Neutral arsenate of lead and iron sulphid.

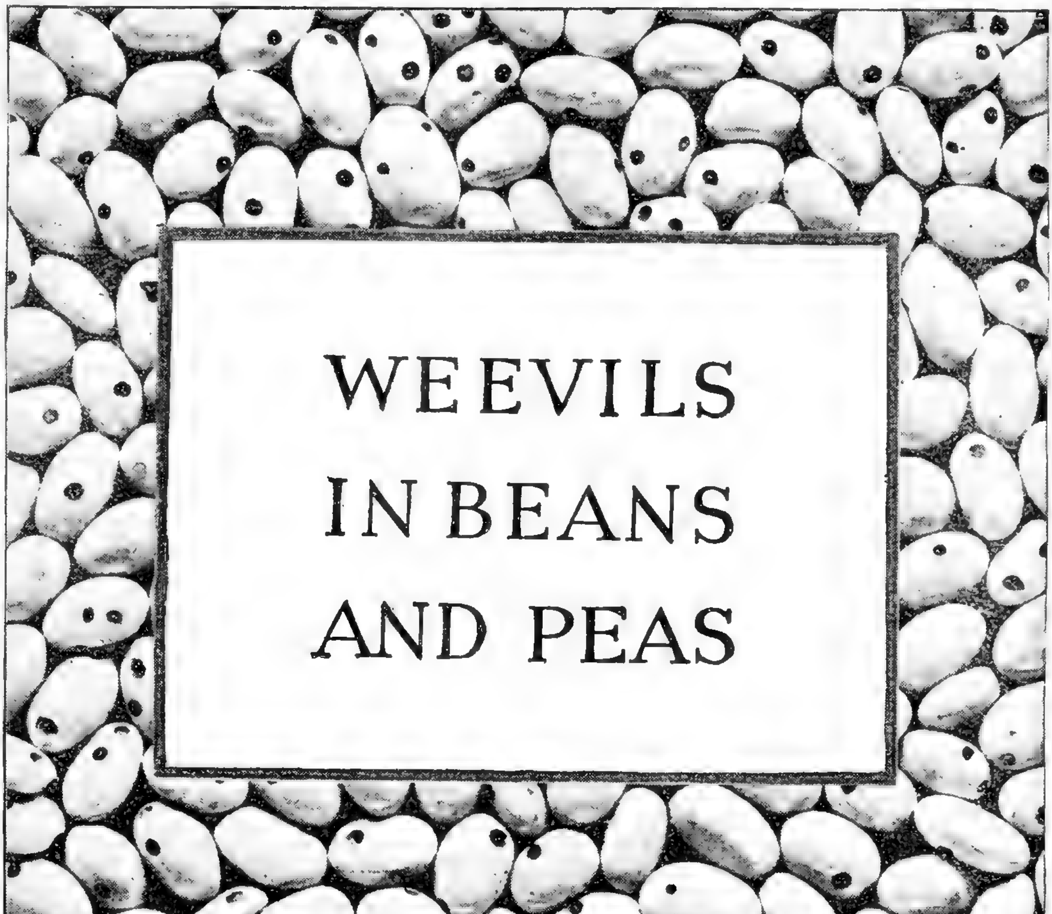
FIG. 192.—Wormy apple due to the codling moth.

Time of summer spray applications for the more important insects and fungous pests.	Spray materials and dilutions.
Additional treatments where the codling moth and bitter-rot are prevalent. Where late spraying is necessary, the fruit at harvest may be more or less covered with spray residue. This should be removed from the fruit before it is barreled or boxed.	Same spray materials as above.

Southern Atlantic States.	Ohio Valley.	Central Mississippi Valley and the Ozark district.	West-Central States.	Semiarid Western States.	Pacific Northwest.
Depending upon the locality, varieties, weather, and other conditions, from two to four additional treatments of arsenate of lead and Bordeaux mixture will often be necessary.	Depending upon the locality, varieties, weather, and other conditions, from two to four additional treatments of arsenate of lead and Bordeaux mixture will often be necessary.	One or two additional treatments of lead arsenate and Bordeaux mixture about 2 weeks apart and in severe bitter-rot cases make additional applications of the Bordeaux arsenate of lead spray.	If the codling moth and bitter-rot are prevalent, apply additional sprays of arsenate of lead and Bordeaux mixture.	In the control of the codling moth it will often be necessary to make one or two additional treatments after III.	In the control of the codling moth it will often be necessary to make one or two additional treatments after IV.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1275



WEEVILS IN BEANS AND PEAS

BEANS, peas, and cowpeas are often damaged seriously in storage and in the field by weevils. Velvet beans, soy beans, and vetches are rarely infested in this country. Bean and pea weevils not only destroy much of the Nation's food in the form of leguminous crops but are responsible for a curtailment in the acreage planted to these crops. They never attack corn and wheat.

A large percentage of the initial infestations occurs in the field, where the parent weevil lays her eggs on or in the pods. The grubs, upon hatching, burrow into the seeds by gnawing a hole no larger than a pin prick. This entrance hole is usually not observed, hence the often expressed erroneous belief that the adult weevils that eat out from the seed, leaving behind a round hole about one-sixteenth of an inch in diameter, have " developed from the germ."

The most injurious bean and pea weevils in the United States can breed generation after generation in dried seeds in storage. During the hottest summer weather one generation requires from 18 to 30 days for development. Female weevils may lay as many as 50 to 58 eggs a day, though the average total number of eggs laid by an individual during her life is about 100. Infested seeds in bulk usually heat, thus producing temperature and moisture conditions most favorable for the rapid development and vigorous breeding of weevils.

Infestations in beans and peas can be quickly and effectively stamped out by fumigation with carbon disulphid, carbon tetrachlorid, or hydrocyanic-acid gas, and by means of heat or cold storage. Weevils can be prevented from breeding in storage by mixing dust or air-slaked lime with the seeds. Concerted action by a community of growers has been known greatly to reduce weevil infestations and is recommended unreservedly for consideration in commercial bean-growing areas.

In brief: Plant weevil-free seeds, harvest as soon as possible, treat to kill weevils, and store where seeds can be protected from reinfestation by weevils spreading from infested seeds.

Preventive and remedial measures are described fully in this bulletin.

Washington, D. C. August, 1922

WEEVILS IN BEANS AND PEAS.

By E. A. Back,

Entomologist in Charge, Stored-Product Insect Investigations, Bureau of Entomology.

CONTENTS.

SERIOUS LOSSES CAUSED BY BEAN AND PEA WEEVILS.

BEAN AND PEA WEEVILS are by no means new pests. They belong to a class of insects that cause farmers and merchants an annual loss of many millions of dollars. One Province of Canada alone suffered from the ravages of the pea weevil to the extent of over $1,000,000 in a single year. It was estimated in 1902 that the acreage in field peas in Ontario would have been 1,000,000 instead of the actual 532,639 planted, had it not been for fear of the pea weevil. Since the introduction from Europe of the broad-bean weevil into California about 1909, the pest is estimated to have reduced the acreage planted to Windsor beans 25 to 75 per cent, and in Alameda County, formerly a large producer, there is now practically no commercial acreage of these beans. The common bean weevil has been one of the chief factors in discouraging the production of field beans south of the latitude of New York, except in the higher altitudes, and is to-day one of the worst enemies of garden beans of all varieties grown in the East. Few realize that the ravages of this weevil have forced farmers of many sections—as in the coastal regions of the Middle Atlantic States—to discontinue the production on a commercial scale of this valuable food crop and to turn their attention to other crops. The cowpea is now recognized as one of the most valuable cover crops for enriching the soil of the Southern States, and agriculturists claim that one of the drawbacks to its more general use for this purpose and for fodder is the susceptibility of cowpea seed to weevil attack. The cowpea weevils are the worst pests of cowpea seed. They are a big factor in maintaining, in years of normal production, the high cost of seed, and in the consequent curtailment of the use of this plant as a soil builder. These weevils, also, because of the rapidity with which they destroy cowpeas grown for human consumption, have caused seedsmen and merchants to view with suspicion cowpeas grown in certain sections of the South, and this attitude has had a depressing effect upon the production of cowpeas for food. Yet the South is a veritable Eldorado for the production of leguminous crops for food once weevils are controlled. It is evident, therefore, that bean and pea weevils should be charged not only with the damage they cause leguminous foods actually produced but also with the indirect losses to the country due to the reduction in the areas planted to beans, peas, and cowpeas.

FIG. 1.—Navy beans showing the emergence holes of weevils. Each of these holes is made by a weevil as it matures in the seed and leaves by cutting out a piece of the skin. All except the five small beans at the bottom have been injured by the common bean weevil. The five small beans were grown in Central America and are infested by the Mexican bean weevil. About natural size.

LOSSES OFTEN DISCOVERED TOO LATE.

Injury to edible legumes usually is observed first after the crop has been in storage for several months. Many believe that once the crop has been harvested it needs no further attention. Seeds put away at time of harvest are sometimes not examined again until the following planting season, when they are found "buggy" or "weevily" and badly damaged. The town or city gardener has proudly put away for winter consumption beans grown during the previous summer, only to find them worthless as food and full of

FIG. 2.—Field peas in bloom. Adult pea weevils begin laying their eggs on the young pods in the field. It should be remembered that the bean and pea weevils begin their attack on the seed while the crop is developing in the field. Photo by Vinal.

holes and honeycombed by grubs when later he opens the jar or sack in which they have been stored. Wonder is often expressed that seeds apparently sound when put away for the winter, and kept always well covered, should be found later injured by weevils. Because small round holes (see title page and Fig. 1) and weevils appear later in seeds seemingly perfect when harvested, a belief is current among many that bean and pea weevils develop spontaneously from the germ of the seed. That there is no foundation for such a belief is shown by the facts following.

HOW BEANS AND PEAS BECOME INFESTED.

Bean and pea weevils, like many other insect pests, pass through several marked changes in form and habits before reaching maturity. The story of development is shown in Figure 3. The weevil that is

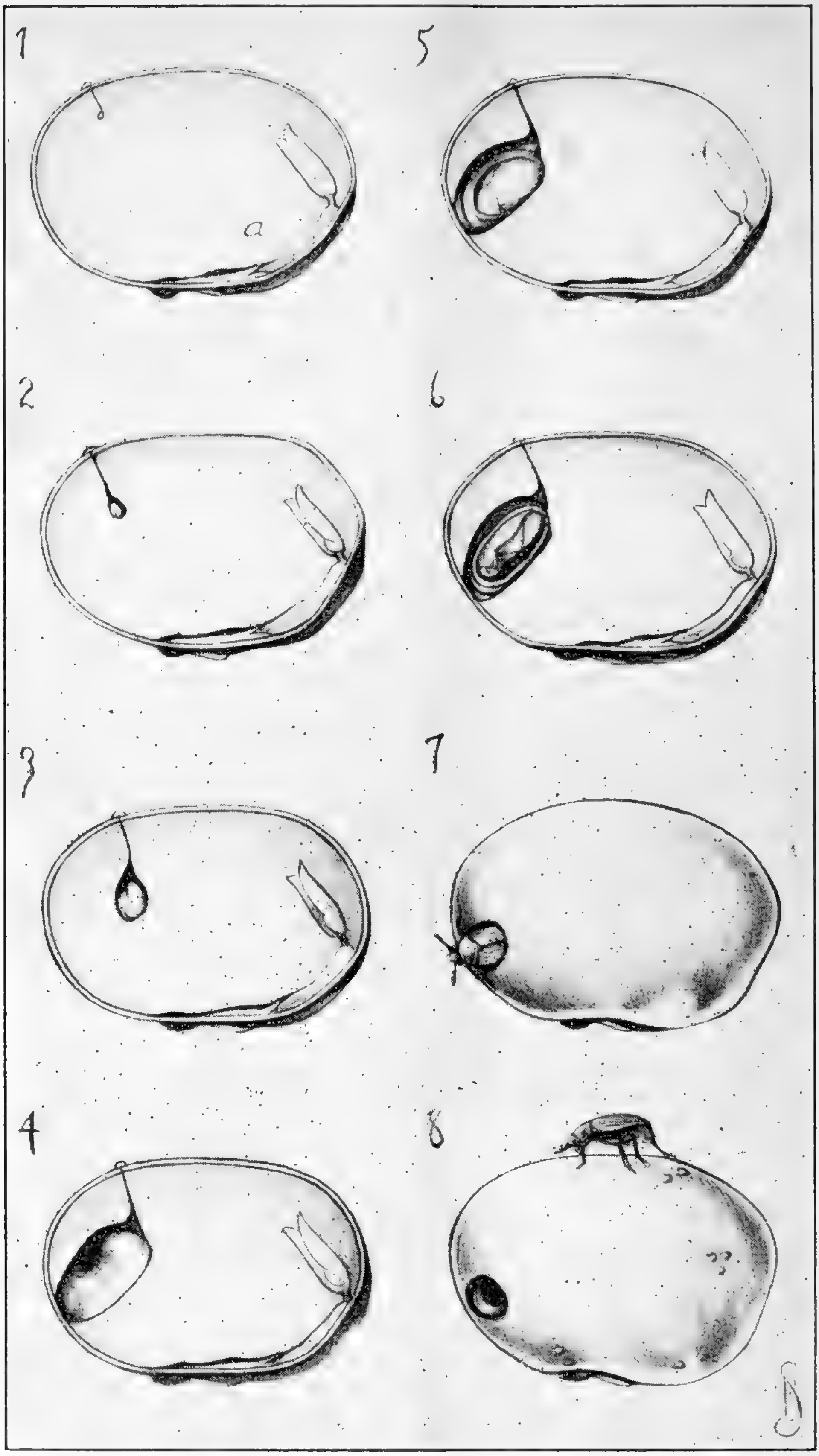


FIG. 3.—Life cycle of a bean or pea weevil: 1, Cross-section of seed showing embryo or germ at *a*, and on upper left side an eggshell and the small burrow made by the newly hatched grub from the underside of egg into the seed; 2, 3, and 4, larva or grub in different periods of growth, the larva of 4 being full grown; 5, pupa or resting stage which is intermediate between the larva and the adult; 6, side view of beetle within the pupal cocoon and ready to gnaw the round hole in the seed coat so it can crawl out of the seed; 7, beetle has eaten a circular hole in the seed coat and is crawling out; note that this emergence hole is some way from the point of entry; 8, female beetle laying eggs upon the seed.

seen crawling about among the seeds is the parent insect. Many of these fly from the storage room or house to the fields where beans and peas (Fig. 2) are growing. As the bean and pea pods develop, the mother weevil lays whitish eggs, either on the outside or within the pods. These eggs are so small that they are often not noticed, for they appear as mere white specks upon the pods. From these eggs there hatch white grubs that burrow their way through the pod into the soft developing beans or peas. Because these grubs are so very tiny, the holes through which they enter the seeds are too small to be seen unless one searches for them with a microscope. Usually beans become infested first when they are nearly or quite full grown. As seeds expand and harden in the final ripening proc-

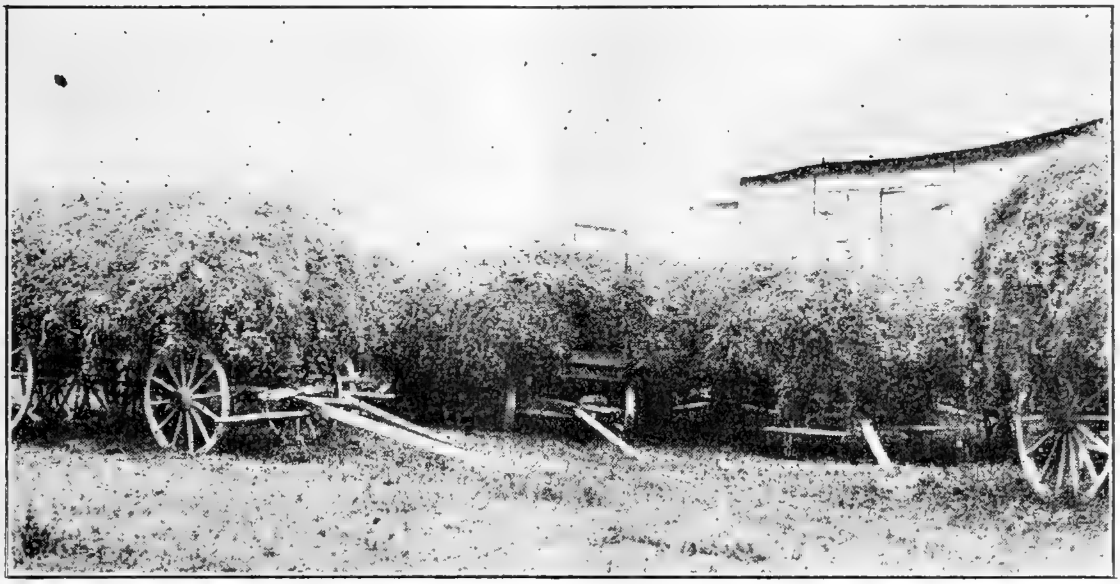


FIG. 4.—Wagon loads of field peas brought to mill to be thrashed. Remember that the pea weevil, the broad-bean weevil, and the lentil weevil are the only weevils mentioned in this bulletin that can not breed in dried seeds in storage. For this reason any infestation by these weevils occurs only in the field while the crop is maturing; hence the weevil grubs are in the seeds at the time they are harvested, shelled, or thrashed, and any treatment at that time, if done thoroughly, will prevent the development of holes in seeds resulting from the emergence of adult weevils.

ess the holes in the skin through which the grubs entered become less and less easy to find. The wound in the skin either becomes entirely healed over or remains similar in appearance to a small pin prick.

Since beans and peas mature much faster than the weevil grubs within them, it happens that the weevil grubs are comparatively small or little developed, in many instances, when the crop is harvested (see Fig. 4) and placed in storage. Thus many seeds that appear outwardly in excellent condition in reality have weevil grubs hidden away in their interior, as shown in Figure 3.

WHERE WEEVILS IN STORAGE COME FROM.

At harvest time grubs developing from eggs laid on or in the pods in the field may have devoured very little of the seed contents, but if the seeds are stored in a warm place, or in a climate where the weather is sufficiently warm, they continue to feed and become well grown. When well grown they have eaten out of the seed contents a cavity somewhat larger than themselves and extending outward to, but not pucturing, the skin of the bean. (Fig. 5.) The grub then changes or transforms into the pupa (Fig. 10, *c;* Fig. 12, *c*) and later into the adult. This adult has a pair of sharp jaws which it uses like a pair of scissors to cut out a circular flap (see Fig. 6) in the bean skin, thus making the small round hole which is, to most gardeners, the first evidence that insects are in their beans. Through these openings the adults crawl out and by their presence in sealed jars and other containers cause much concern.

Fig. 5.—Beans in which the common bean weevil grubs have become full grown and have eaten out from the interior of the bean to, but not puncturing, the skin. As they transform to adult, each insect darkens and this dark color shows through the thin skin and makes the dark, sometimes bluish, translucent spots in beans. Such spots indicate that seeds are infested. It should be remembered that while the grubs are still growing they are white, and seeds do not indicate their presence by any such dark spots as shown above. Considerably enlarged.

DESTRUCTION CONTINUES IN STORAGE.

With the exception of the pea weevil that attacks the different varieties of peas, the broad or Windsor bean weevil, and the lentil weevil, the weevils attacking beans and cowpeas continue to produce generation after generation in dried seeds in storage. (Fig. 7.) The pea and the broad-bean weevils will die in storage and can not reproduce unless they can find growing plants in which to lay eggs. But the ordinary bean and cowpea weevils lay eggs for successive generations as readily upon dried seeds in storage as upon the growing plants in the field. As each generation of weevils reduces the value of seeds for planting and for food, steps should be taken to kill, at harvest time, such grubs as may be in the seeds and thus prevent further losses. If this is not done the seeds become honeycombed by the feeding of generations of grubs and may be reduced to a powder. (Fig. 8.) Because bean and cowpea weevils can breed in dried seeds it is important not to store uninfested seeds near seeds that are infested, for the weevils spread rapidly and will soon infest the newer seed.

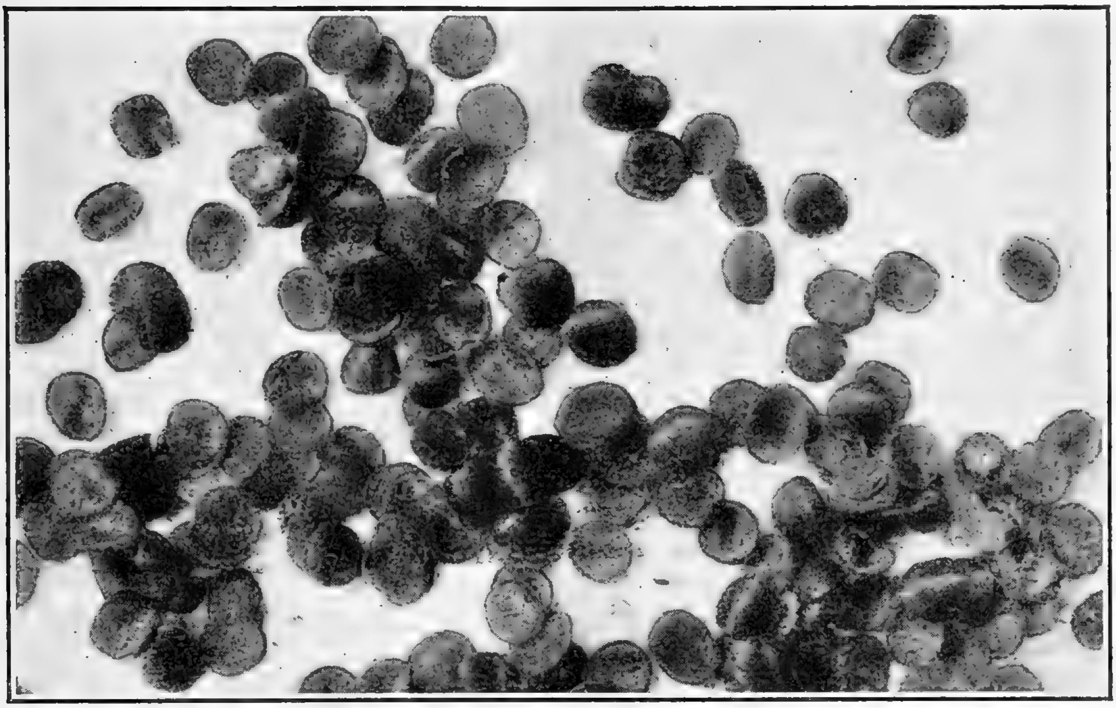


FIG. 6.—In escaping from beans, peas, or cowpeas, or any host, weevils leave behind them the small round holes familiar to all. In making these holes they use their jaws to cut around the dark spots shown in Figure 5 and then push away the circular flap of skin just as one opens a tin can of preserved fruit with a can opener. These circular bits of skin, shown above, about 4 times natural size, may be found among the seeds.

THERE ARE DIFFERENT KINDS OF WEEVILS.

Injury to leguminous crops is caused by more than one insect. Those considered in this bulletin are the pea weevil,[1] the common bean weevil,[2] the cowpea weevil,[3] the four-spotted bean weevil,[4] the broad-bean weevil,[5] the lentil weevil,[6] and the Mexican bean weevil.[7] These are all commonly found in supplies of beans, peas, cowpeas, or lentils in this country. Other species are sometimes found in imported seeds, but will not be discussed here.

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[1] *Bruchus pisorum* Linnaeus.
[2] *B. obtectus* Say.
[3] *B. chinensis* Linnaeus.
[4] *B. quadrimaculatus* Fabricius.
[5] *B. rufimanus* Boheman. [6] *B. lentis* Boheman. [7] *Spermophagus pectoralis* Say.

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GENERAL DESCRIPTIVE FACTS.

The bean and pea weevils of the United States are all very small. None of them is longer than one-eighth to one-fifth of an inch.

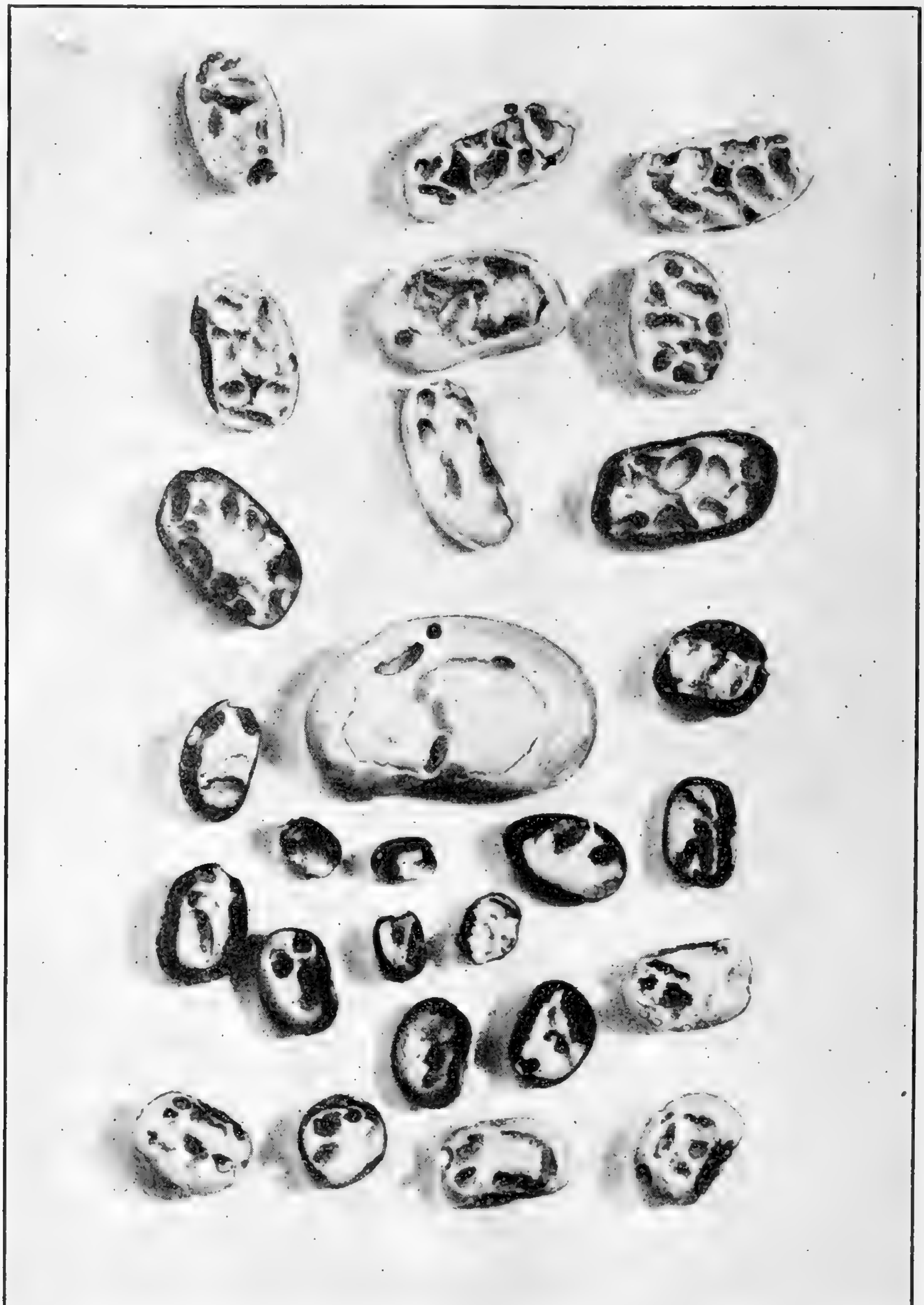

FIG. 7.—Various types of beans and cowpeas cut lengthwise to show how severely they may be damaged by bean and cowpea weevil grubs. Such beans and cowpeas are not fit for human food. Slightly enlarged.

They are dull-colored with markings of white or black. For the general shape, size, and arrangement of these markings, see Figures 10, 12, 13, 16, 19, and 20. Their eggs are from one-fiftieth to one-twenty-fifth of an inch long, white or whitish, and appear as specks (see figs. 14 and 15) when laid on beans and cowpeas in storage.

The larvæ, or grubs, naturally are very small when first hatched and are white in color. After feeding they become somewhat maggotlike in general appearance, being nearly cylindrical, fleshy, dis-

FIG. 8.—Leguminous crops may be reduced to a powder by the continued feeding of weevil grubs. In the bottom of sacks or boxes in which weevily beans or cowpeas are held for a long time one finds quantities of dead weevils and the powdered remains of the seeds such as are shown above. About natural size.

tinctly wrinkled, more or less curved in outline, and not more than one-fourth of an inch long and usually less.

By the time the grub has become full grown it has eaten out in the seed contents a cell in which to transform to the pupa or chrysalis. Before transforming it secretes a substance which hardens into a white, filmy cell about itself, and this serves to protect the helpless pupa while the changes to the adult are taking place. For the general shape and appearance of the grub and pupa see Figures 10, 12, and 16, *b* and *c*, and Figure 13, *c*. The pupal cells are shown in Figure 22. For the general life cycle see Figure 3.

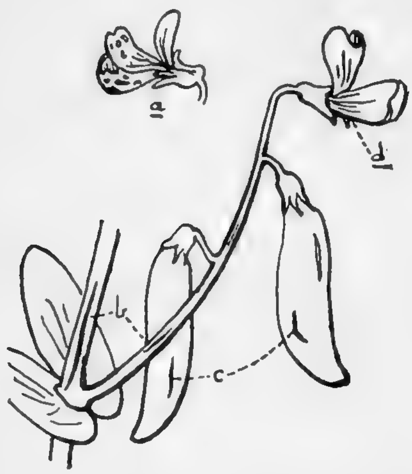

FIG. 9.—Plant of garden pea showing, at *a*, holes in blossom where pea weevil beetles have fed; at *b*, slits in stem; and at *c*, cuts in pods made by the feeding beetles. The beetle finds its favorite shelter at *d*. (Skaife.)

THE PEA WEEVIL.[8]

The pea weevil is the most serious enemy of the field or garden pea. It now occurs over almost the entire globe wherever peas are cultivated. It is scarcely known, however, in the colder countries of northern Europe and does comparatively little damage for the most part in the coldest sections of Canada and the United States. Continuous cropping of land to peas naturally leads to a constant increase in the number of pea weevils, as evidenced by the fact that garden peas grown almost anywhere in the United States, except in places in our more northern States or in high altitudes, are apt to be badly affected. This pest was causing serious damage to garden peas in Pennsylvania, New Jersey, and southern New York as early as 1748.

The pea weevil is a small grayish or brownish-gray beetle about a fifth of an inch long and marked with black and white spots as shown in Figure 10. The short line to the right of *a* in the illustration gives the actual length of the beetle. The adults appear on the vines when the peas come into bloom. They are said to feed principally on the petals of the pea flowers and on the succulent tissues of the stems and pods as shown in Figure 9. While they eat holes in the petals and gnaw out long narrow slits in the stems, they do not appear to damage the plants materially, as the damaged flowers produce normal pods and the slits in the stems soón heal over and do not cause wilting.

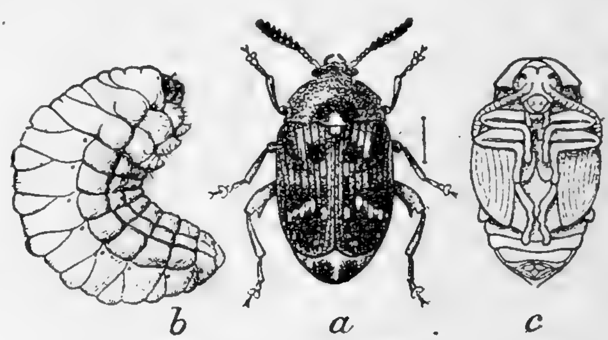

FIG. 10.—Pea weevil: *a*, Beetle; *b*, larva or grub; *c*, pupa. The line to the right of the adult (*a*) represents the actual length of the beetle, and the sizes of the larva and pupa are in proportion. (Chittenden.)

The adults show a strong tendency to remain dormant during the season of the year when growing peas are not available for attack.

[8] *Bruchus pisorum* Linnaeus.

Thus while certain beetles having access to pea plants lived only four or five weeks, others were found alive in dried seeds 14 months after the seeds were gathered. The female weevils lay their yellowish eggs singly upon the surface of the pods to which they attach them with a peculiar viscid secretion. The young grub upon hatching gnaws through the pod and burrows into the seed where it does practically all its feeding. While as many as six young grubs have been found in single seeds, it is seldom that more than one matures and emerges. (See Fig. 11.)

The length of time required for the eggs to hatch and for the grub or larva to mature into the adult of the next generation varies with the climate. In the District of Columbia adults have appeared as early as July 21. Others have been reared as late as the middle of August. A very considerable portion of the beetles mature and leave the seeds in the latter part of the summer in the latitude of Washington, D. C., but farther north and in higher altitudes the adults remain in the peas until the following spring, when they emerge in storage or are planted with the seed. It is in the adult stage that the weevil passes the winter, hibernating either in secluded spots in fields or buildings or in the pea seed itself. *The pea weevil has only one generation a year and can not reproduce in dried peas.*

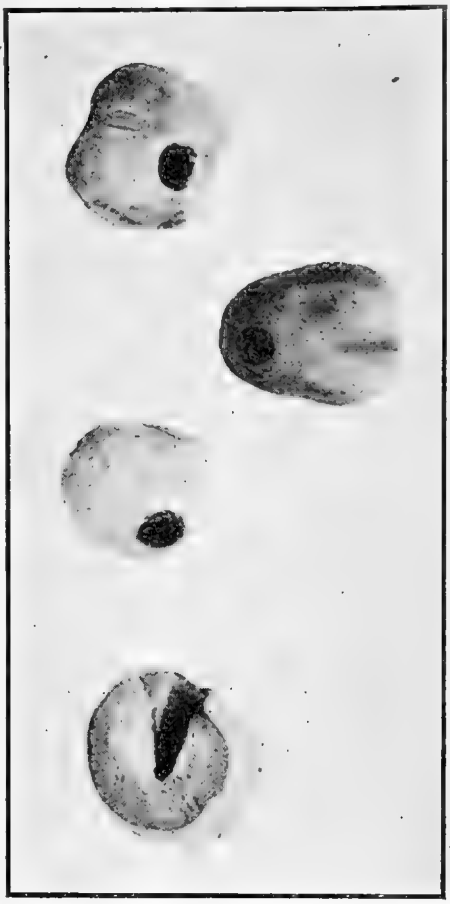

FIG. 11.—Garden peas showing exit hole of the pea weevil. Note that only one weevil develops in a single pea. One seed has been sectioned to show cavity made by grub. Enlarged.

THE COMMON BEAN WEEVIL.[9]

The common bean weevil is the most formidable enemy to the culture of beans in the United States as well as in many other countries. It occurs in nearly every State, the Territory of Hawaii, and is generally distributed throughout Mexico, Central America, and South America. It has been found in beans imported from southern Europe, Persia, India, China, Algeria, South Africa, Madeira, the Azores, and the Canary Islands. Commerce has carried it to all the larger markets of the world. So severe is its attack in the warmer sections of this country that dried beans for seed and for food are grown mostly in the more northern States and California.

[9] *Bruchus obtectus* Say.

In the coastal region of the Middle Atlantic States and farther south bean growing is made very difficult, if not rendered unprofitable, by the unmolested increase of the bean weevil.

The bean weevil is smaller than the pea weevil, being only about an eighth of an inch long, and shaped and marked as illustrated in Figure 12. The adult, or beetle, is so coated with fine hairs that it appears brownish gray or olive color. Unlike the pea weevil, the bean weevil not only can develop in growing beans in the field, but also can breed generation after generation in dried beans in storage.

The adults may live as long as nine weeks, though usually two weeks represents their more normal length of life during the active season. Of course, adults may remain alive in a dormant condition for several months in dried seeds during cold weather.

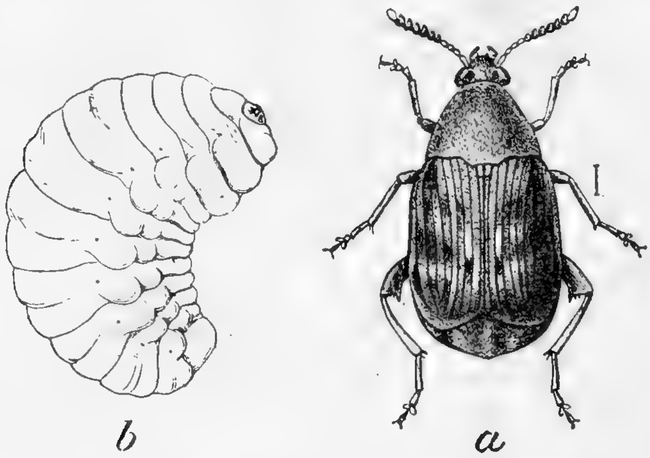

FIG. 12.—Common bean weevil: *a*, Beetle; *b*, larva or grub; *c*, pupa. The short line to right of the beetle (*a*) represents its real length. (Chittenden.)

The female weevils fly from storage or hibernating quarters early in summer and from then on may be found upon the bean plants. While the weevils lay their eggs in largest numbers through cracks in the pod that develop during the drying-out of the pod, the female has been observed to gnaw holes in green pods and to lay her eggs through such holes. Eggs are never glued to the outside of the pod as is the habit of several other species of bean and pea weevil. In storage the eggs are laid singly and loosely (i. e., unattached) among the seeds. As many as 26 eggs may be laid by a single female in one day, and a total of 85 eggs during her life. Sometimes as many as 67 eggs have been found laid through a crack in a bean pod.

As many as 28 weevil grubs have been found in a single bean. All varieties of garden beans are attacked, even lima beans being severely damaged during 1920 and 1921 in New England.

Experiments have demonstrated that the eggs of the bean weevil require from 5 days in the hottest weather to 20 days at a cooler temperature to hatch, and that the larvæ or grubs become full grown in from 11 to 42 days and the pupæ in from 5 to 18 days, according to the temperature. It requires 21 to 80 days at least, according to the season and locality, for a generation of the bean weevil to develop. In the District of Columbia there may be as many as six generations a year. The warmer the climate the greater the number of generations and the consequent damage done by the grubs.

In a climate similar to that of the District of Columbia and adjacent parts of Maryland and Virginia adults of the first generation started in the field begin to emerge as early

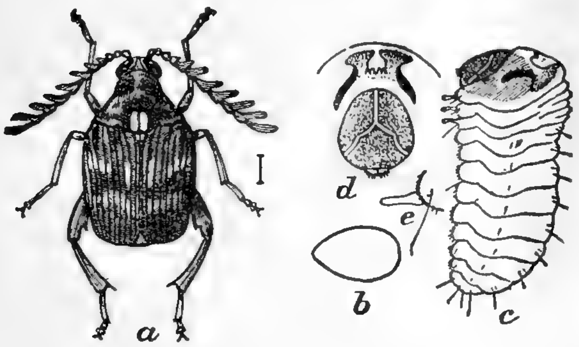

FIG. 13.—Cowpea weevil: *a*, Adult male; *b*, eggs; *c*, postembryonic larva; *d*, front view of head of same; *e*, thoracic leg of same. *a*, Much enlarged; *b–e*, more enlarged. (Chittenden.)

as October If the fall is early and the seeds are stored in a cold place no adults may emerge before the following spring. If seeds are stored in a warm place adults may emerge at any time during the winter. After emergence in storage the adult females lay eggs either on the beans or on the sides of the receptacles in which the seeds are stored.

THE COWPEA WEEVIL.[10]

The cowpea weevil (Fig. 13) is a foreign species first described from China but now widely distributed in dried seeds over the entire United States. It has been recorded from every continent and is likely to be

FIG. 14.—Different varieties of cowpeas showing infestation by cowpea weevil. Seed about natural size; the white specks on the seeds are the eggs of the weevil.

[10] *Bruchus chinensis* Linnaeus.

found in cowpeas in any commercial center. Although it prefers cowpeas (see Fig. 14) and is, with the four-spotted bean weevil, the worst pest that the cowpea has, it may attack the common pea, pigeon pea, lentil, chick-pea, mung bean, and common white bean.

The adult weevil is about an eighth of an inch long and may be distinguished from weevils discussed in this bulletin by the elevated ivory-like spots near the middle of the body, as shown in Figure 13.

Like the bean weevil, the cowpea weevil usually begins to infest cowpeas while they are developing in the field by laying its eggs upon the pods. It also is able to breed generation after generation in stored cowpeas and often reduces them to a powder. Because of the very warm weather of the Southern States, where the cowpea weevil is most severe in its attack upon cowpeas, the grubs mature very fast and often the adults may emerge as soon as the crop is ripe. In a fairly warm or indoor temperature six to eight generations may mature annually in a climate like that of Washington, D. C.

FIG. 15.—A cowpea seed showing eggs of a cowpea weevil. The eggs of bean and pea weevils vary in shape but are always small, ranging in length from one-fiftieth to one twenty-fifth of an inch. They are white or whitish, and may be laid anywhere upon the outside of the seed, as indicated here, or in cavities in the seed made by a previous generation of grubs, or on sides of containers such as burlap sacks, barrels, etc. The eggs can be distinctly seen on seeds, as tiny white specks. Much enlarged.

The beetles may live as long as 36 days, although the average life is probably about 12 days. At an average temperature of about 70° F. eggs may hatch in 8 days, larvæ become full grown in 17 days, and the pupa stage passed in 7 days; thus giving 32 days as the time required for the development of one generation from egg to adult. During very hot weather a generation may mature in as few as 18 days (egg, 3 days; larva, 12 days; pupa, 3 days) to 21 days (egg, 4 days; larva, 13 days; pupa stage, 4 days). During cooler weather 45 days (egg, 10 days; larva, 25 days; pupa, 10 days) and 60 days (egg, 10 days; larva, 40 days; pupa, 10 days) were required. Of course this period may be extended to cover three or four months during winter weather.[11]

[11] Chittenden, F. H. The Cowpea Weevil, U. S. Dept. Agr., Bur. Ent. Bul. 96, Pt. VI, 1912.

The adults live on an average 5 or 6 days during the hottest weather, to as many as 30 to 40 days during the winter months of the Gulf Coast States. Activity is likely to cease entirely at a mean temperature of 50° F., or below, when the insects will seem dead to all outward appearances and only resume activity upon the appearance of warm weather. While the immature stage may be passed in as few as 16 to 17 days, 21 days is closer to the normal time required during hot summer weather. The longest period for larval development yet recorded is 88 days, from December to March, in Texas, when the temperature ranged from 22° to 86° F. There may be from 8 to 10 generations a year in the Gulf Coast States.

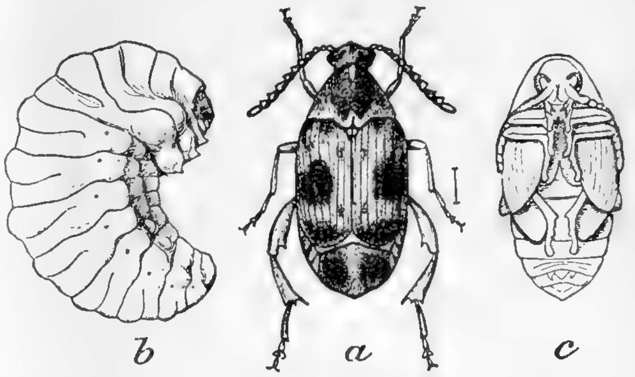

FIG. 16.—Four-spotted bean weevil: *a*, Beetle; *b*, larva or grub; *c*, pupa. Enlarged. (Chittenden.)

FIG. 17.—Chick-peas affected by the four-spotted bean weevil. Compare these with the two sectioned chick-peas at the bottom of Figure 22. Enlarged.

THE FOUR-SPOTTED BEAN WEEVIL.[12]

The four-spotted bean weevil somewhat resembles and is a trifle larger than the cowpea weevil, but may be distinguished from it not only by its more slender body but by the four black spots upon its wing covers as shown in figure 16.

In 1885 this species was found to be swarming on black-eyed peas from Texas exhibited at the Atlanta Cotton Exposition. Since then

[12] *Bruchus quadrimaculatus* Fab.

it has been found attacking cowpeas throughout the Southern States and as far north as Iowa and is probably present wherever cowpeas are grown. The cowpea is its favorite host food, although peas and beans are attacked (see Fig. 17). It is undoubtedly a more serious pest of cowpeas than the cowpea weevil discussed above because it seems to be more hardy. Although females may lay eggs upon the pods in the field, it breeds most prolifically in seeds in storage, gluing its small white eggs to the seeds.

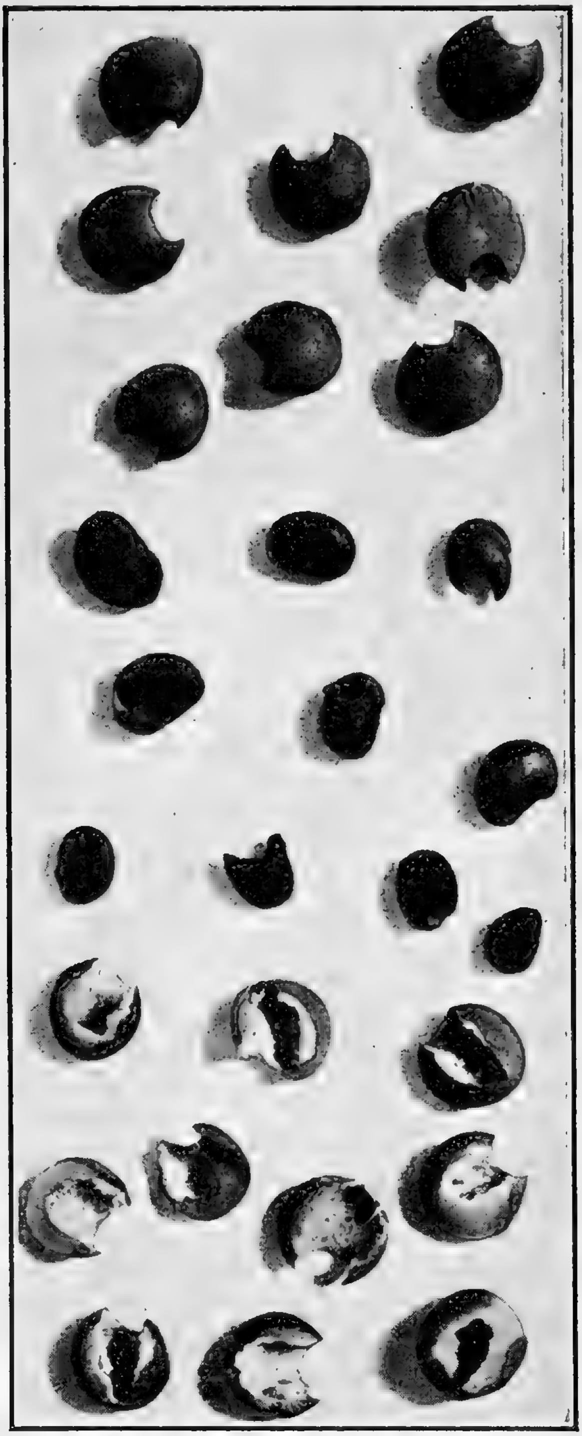

FIG. 18.—Lentils of two varieties showing injury by the lentil weevil. While only one lentil weevil matures in a single seed, it is capable of practically destroying that seed, as indicated by the sectioned seeds at the bottom of the illustration. Somewhat enlarged.

THE LENTIL WEEVIL.[13]

The lentil weevil is not known to be established in this country at the present time, although it has been found repeatedly in imported lentils from Europe. It is an enemy of the lentil crop in middle and southern Europe, Egypt, and Syria. While lentil growing is on the increase in this country, it is hoped to keep this pest from becoming established in North America.

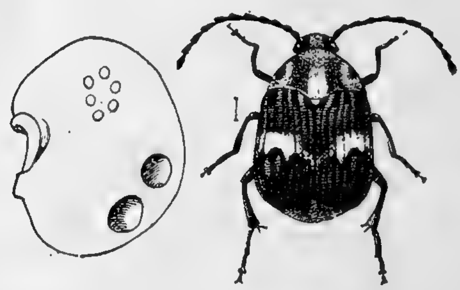

FIG. 19.—Mexican bean weevil: Adult weevil with line to left indicating actual length. Infested bean to left showing two emergence holes and six eggs. (Chittenden.)

The lentil weevil, only one of which matures in a single seed, resembles somewhat the pea weevil but is only about an eighth of an inch long. Like the pea and broadbean weevils, it has but one generation a year. Lentils showing the

[13] *Bruchus lentis* Boheman.

emergence holes and injury caused by this weevil are illustrated in Figure 18.

THE MEXICAN BEAN WEEVIL.[14]

The Mexican bean weevil is an inhabitant of South and Central America and is frequently found at our Pacific and Atlantic ports, infesting beans imported from these countries. It attacks beans and cowpeas. It breeds continuously in dried seeds and is capable of being as injurious as the common bean weevil, as indicated by the five small beans affected by this pest, shown at the bottom of Figure 1. For the size, shape, and coloration of this insect, see Figure 19. The adult lays her eggs upon the seeds, to which they are stuck by a cement similar to that used by the cowpea weevil (Fig. 15.) While occasionally intercepted at ports of entry for many years past, this species does not appear to have become established in the United States.

FIG. 20.—Adult of the broad-bean weevil. Greatly enlarged. (Chittenden.)

THE BROAD-BEAN WEEVIL.[15]

The broad-bean weevil closely resembles the common pea weevil, being about the same size, one-fifth of an inch long, and of similar

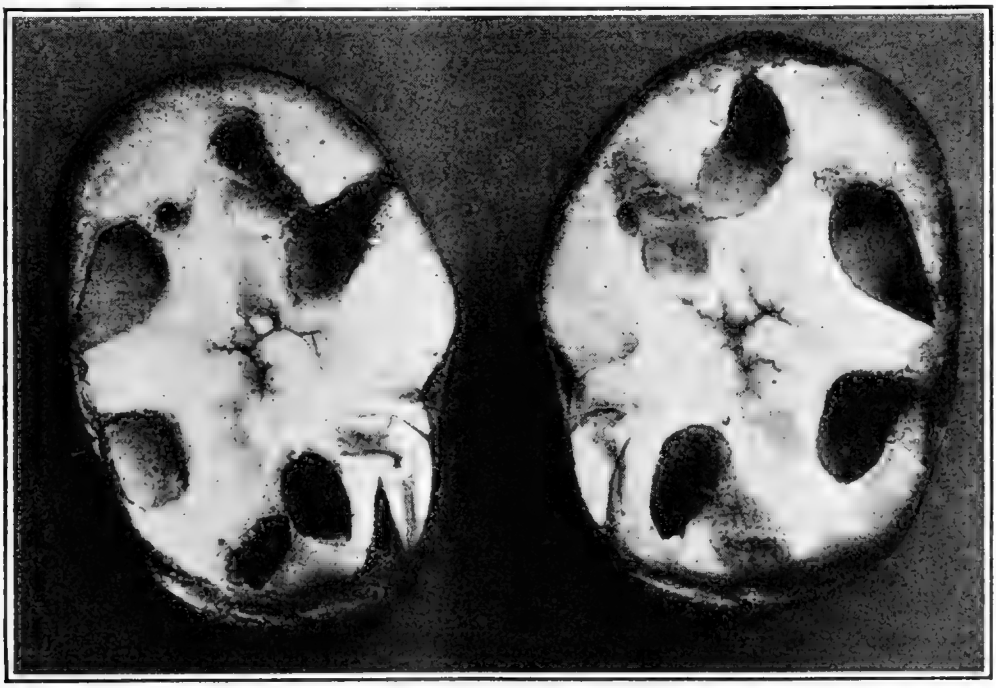

FIG. 21.—A broad, horse, or Windsor bean, grown in California, cut open to show the damage caused by grubs of the broad-bean weevil. Only one generation of this weevil occurs each year. As each cavity represents the feeding of one grub, this bean is badly affected. Considerably enlarged.

appearance. It can, however, be readily distinguished by its much narrower thorax and fainter markings, as a comparison of Figures 20 and 10 will show.

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[14] *Spermophagus pectoralis* Say. [15] *Bruchus rufimanus* Boheman.

The broad-bean weevil (Fig. 20), sometimes called the European bean weevil, is common and destructive in Europe and North Africa. While it feeds upon various sorts of beans and peas, it appears to prefer the broad or Windsor beans (see Fig. 21). Although it has been found from Canada to Texas in Windsor beans imported into various parts of this country, the first discovery of its definite establishment in the United States was made in 1909 at San Luis Obispo, Calif., where it was injuring the broad or Windsor bean (*Vicia faba*) grown for stock feed.

Since then, and up to 1920, it has spread to include the coastal counties of California, from Sonoma to San Luis Obispo, besides San Benito, Santa Clara, Alameda, San Joaquin, Sacramento, Yolo, and Napa. Practically every bean entering the warehouses of New York is often more or less damaged by this pest. A single grub in its development consumes approximately 3 per cent of the bean. Sometimes as many as six weevils develop in a single bean. Beside the actual amount of seed consumed there must be considered the frass of the insect left behind in the seed and this still further reduces the value of the crop. It has been stated that of the entire broad-bean crop of California for the years 1916, 1917, and 1918, 31.21, 18.01, and 43.08 per cent, respectively, were above the 15 per cent limit of weevil infestation allowed by the Federal pure food law, and therefore could not be shipped unless hand picked. In 1916 the average percentage of infestation for the entire 1916 crop in the Halfmoon and Gilroy regions was above the 15 per cent limit, while the same is true for the Sacramento and Halfmoon districts for the 1918 crop. After a campaign of seed fumigation in San Mateo County during 1918, 1919, and 1920, it was reported that the percentage of the broad bean crop infested 15.1 per cent or more was reduced from 43 per cent in 1918, to 21 per cent in 1919, and to 17.8 in 1920. Since beans uninfested, or infested less than 15 per cent, were worth during these years from 5 to 6 cents per pound, and others only 2¼ to 3 cents, it is easy to appreciate the dollars and cents value of concerted action among growers in applying cheap, but effective, remedial measures.

The following biologic facts are taken from a report of experiments conducted at Alhambra, Calif.[16] The egg stage lasts from 9 to 18 days, the larva stage from 10 to 15 weeks, the pupa stage from 7 to 16 days, and the beetle lives from 1 to 8 months. The eggs are laid on the green bean pods in the field from the middle of March to the middle of May; the larvæ reach maturity from August to October, while the adults can be found from August to the following June. The broad-bean weevil has but one genera-

[16] Campbell, R. E. The Broad-Bean Weevil. U. S. Dept. Agr. Bul. 807. 1920.

tion each year and can not start new generations in dried seed in storage. That is, such beetles as emerge from the seeds in storage have developed exclusively from eggs laid in the field upon the green pods and can do no further injury in warehouses.

WHY WEEVILS LIMIT ACREAGE PLANTED TO CERTAIN LEGUMINOUS FOOD CROPS.

It has been pointed out already that infestation nearly always takes place in the field while the crop is maturing. With garden or Canada peas, lentils, and broad or Windsor beans infested with the pea weevil, the lentil weevil, and the broad-bean weevil, respectively, this is always the case, for these weevils never breed in dried seeds. Other species that breed in dried seeds, as well as in the field, may spread in storage to uninfested seeds and badly infest them. It is generally known that the colder the winters the shorter the growing season and the fewer the bean and pea weevils that survive the cold of winter and are ready to fly to the fields to start the infestation of the growing crop by laying eggs upon the pods. The farther south one goes the more mild the winters become, the longer the growing season, and the greater number of weevils that can live through the winter.

As far south as the District of Columbia and the adjacent tidewater country of adjoining States, therefore, overwintering weevils attack the beans and peas in large numbers and succeed in years favorable for them in laying so many eggs upon the pods that each developing bean becomes affected and often may support as many as 20 to 28 weevil grubs. Because of the long, warm falls and the length of time the plants are allowed to remain in the field after the crop has ripened, either standing in the ground or pulled and stacked, these grubs are given every opportunity to develop into adults or at least to become very well grown in an unusually large number of cases, and therefore they cause greater damage than do weevils in bean fields farther north. Thus beans grown in latitudes south of New York City, except in higher altitudes, as in the mountainous regions of the Alleghenies, become more infested than those grown north of that latitude. As weevils in beans are not killed so easily as are many other insects, and as their presence in numbers in beans is objectionable whether beans are grown for food or for planting, even when the grubs have been killed (see Fig. 22), the growing of beans on a commercial scale for dried seeds has largely been given up in our more southern latitudes. This explains the question often asked why beans and peas grown in portions of California, Michigan, New York, Washington, Oregon, or Idaho, or even in Canada, find their way into our southern markets, which one would expect should be supplied by southern-grown beans and peas. Practically all the dried beans grown for seed and for food are grown in these northern States where the bean weevils are not able, because of climatic checks, to cause so much damage. Of course weevils do not affect the growing beans to be eaten green, as "string beans" or green shelled beans, for such beans are not, at the time of gathering, infested; or if infested, the grubs are too small to interfere with their value as food.

FIG 22.—Beans (six upper seeds) and chick-peas (two lower seeds). The skin of the beans has been removed to reveal the cavities eaten out by the common bean weevil grubs. The grubs have been killed by fumigation and have turned black. Note the white paper-like cell or cocoon about each of the grubs. The chick-peas have been cut open to show how the larvæ of the four-spotted bean weevil can burrow to the very center of the seed. Slightly enlarged.

GERMINATION AFFECTED BY WEEVIL ATTACK.

The germination of beans, peas, and cowpeas is likely to be seriously affected by the development of weevil larvæ. If the embryo is destroyed by the larva, or if too much of the bean substance is eaten, the seeds can not grow.

Beans as badly infested as those shown in Figures 1, 7, and 23 are worthless for planting. As the young bean or pea plant depends upon the food stored in the seed to give it its first start, the destruction of any portion of the seed by weevils lessens by so much the vigor of the plant. In one experiment on record, only 50 per cent of infested beans germinated, and of these 30 per cent were so badly injured that they could not develop into normal plants. The smaller the seed, the greater proportional damage a single weevil grub can cause. One grub ruins a small cowpea seed (see Fig. 14) or a lentil (see Fig. 18), whereas it would not so seriously affect a large seed like the lima bean. The germination of broad beans infested with 1, 2, 3, and 4 or 5 broad-bean weevils was found to be reduced from a normal of 95.7 to 82.7, 72.7, 71.1, and 69.6 for new crop seed. In examining 50 garden peas infested by the pea weevil 33 were found with the embryo wholly or partially destroyed and in another case only 69 out of 275 infested peas had undamaged embryos or germs.

HEATING DUE TO INFESTATION.

It is a well-known fact that beans and peas, as well as grains, will heat if insects become sufficiently abundant in them. In bean warehouses where the seeds are stacked as shown in Figures 26 and 27, centers of weevil infestation can be detected by walking past the tiers of sacks and allowing the hand to pass over the sacks. Experience soon makes it easy to detect heating sacks. Heating seeds also produce an odor quickly detected by experienced persons when they enter a warehouse after it has been closed for a few hours.

The ability of bean and pea weevils to produce heating of the seeds is of great importance. Were it not for this ability, owners could

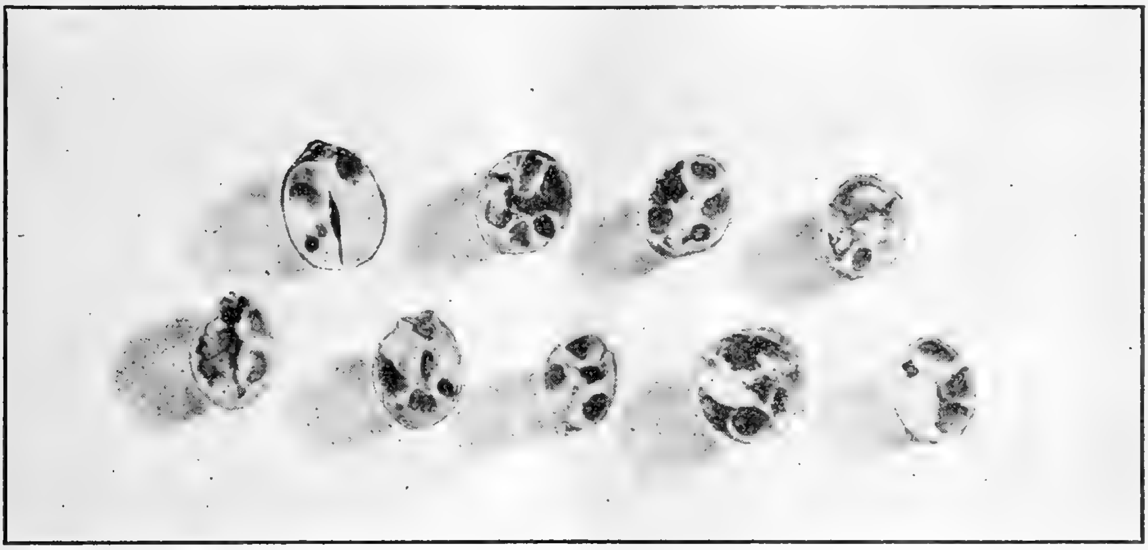

FIG. 23.—Navy beans cut crosswise to prove how the common bean weevil can ruin seeds for eating or planting. About natural size.

rest assured that if warehouses were open to outdoor temperatures below 50° F. no injury from weevils would take place. Certain weevils develop most quickly when the temperature ranges between 75° and 95° F. and egg laying is greatly stimulated by these higher temperatures. At temperatures ranging from 75° to 95° F. development of the four-spotted bean weevil has been known to be completed in as few days as 18; hence heating caused by weevil infestation, with the accompanying increase in moisture content of the seeds, may result in an outbreak of weevils at a season of the year when least expected. The temperature of a 240-pound sack of chick-peas infested by the cowpea weevil and the four-spotted bean weevil may be raised by infestation to at least 103° F. It is not uncommon in some warehouses to find a considerable number of sacks the temperature of which has been raised to over 80° or 90° F. In one instance, when the daily maximum temperatures ranged between 50° and 58° F., sacks within 2 feet of an open window registered 102° F. The temperature in the spaces between heating sacks was raised in this warehouse from 58° F. to a minimum of 70° F. and a maximum of 78° F. At 58° F. adult weevils were too cold to migrate, but at 70° to 78° F. they were very active and were spreading from heating sacks to surrounding sacks and laying eggs upon previously uninfested seeds.

This effect of heating, due to infestation upon spread of injury from sack to sack, to say nothing of increase in infestation within the individual sacks during cold weather, should be understood by those holding beans and peas, else a genuine loss will come upon them unawares. Fumigation with hydrocyanic-acid gas (p. 29) kills the insects, reduces the temperature to normal, and stops spread. Fumigation with carbon disulphid or carbon tetrachlorid will doubtless do the same.

REMEDIES.

No group of seed pests can be more easily controlled in storage than pea and bean weevils. Once seeds are dried and housed they can be protected from destruction. Owners should watch their crop and apply treatment at the first sign of infestation. Any remedy that lessens the number of weevils present in the field has a direct effect upon the number of weevils to be fought in storage, and vice versa.

DO NOT PLANT INFESTED SEEDS.

If seeds are planted that contain weevils, the adults emerge from the seed after it has been planted and live in the field until the pods are sufficiently developed to receive the weevil eggs. They add their numbers to those in the field that have migrated from the place of seed storage. To plant peas, beans, and cowpeas containing living weevils only invites a "buggy" crop. Since the pea and broad-bean weevils can not breed in dried seeds, peas intended for planting may be held over for one year in tight paper bags so that the weevils that emerge can not live but will die before the second spring. Beans and cowpeas affected by other weevils should be treated.

PRACTICE CLEAN CULTURE.

In gathering the crop leave as little of it as possible in the field. Seeds scattered on the ground or left in scattered pods on the dried vines can carry the pest over winter and furnish a supply of weevils the following summer to offset the trouble taken to kill the weevils in storage and in seeds for planting.

HARVEST, THRASH OR SHELL, AND SACK AS SOON AS POSSIBLE.

Because some adult weevils emerge in the late summer and fall, according to the latitude, leguminous crops subject to weevil attack should be harvested as soon as possible after reaching maturity. The seed should be thrashed or shelled at the earliest possible moment in order that the seeds may be more easily and cheaply treated to

Fig. 24.—Storing beans, peas, or cowpeas in the pod will not prevent the weevils from ruining the beans if they are already in the seeds. Neither will it prevent them from emerging, as indicated by the holes they have made in the pods shown above in making their escape from the seeds. One pod has been cut to expose the infested beans within. Work of the common bean weevil. Enlarged.

keep the weevil grubs from feeding and maturing. Storing in the pod does not confine the weevils. The grubs continue their development and transform to the adult in the unshelled as well as in the shelled seeds. Adult weevils can gnaw their way out of dried pods, as shown by the exit holes in the pods of Figures 24 and 25. The weevils in large bulks of unthrashed or unshelled beans or peas can not be satisfactorily treated. There is only one answer to the often-asked question, "Is it better to store beans or peas in the pod or shelled?" Shell the seeds and treat them if you expect weevil injury.

FIG. 25.—Pod of field pea showing exit hole of cowpea weevil. This pod was taken from a bale of field-pea hay grown in Florida and indicates that even field-pea hay grown only for cattle food may be instrumental in offsetting community cooperation to lessen weevil injury. Somewhat enlarged.

FUMIGATION.

Weevils may be killed in storage by fumigation with carbon disulphid, carbon tetrachlorid, or hydrocyanic-acid gas.

CARBON DISULPHID.

Fumigation with carbon disulphid (CS_2) is one of the simplest remedies for weevils. The nature and use of this fumigant is discussed in Farmers Bulletin 799, which can be had upon request from the United States Department of Agriculture. Carbon disulphid is purchased as a liquid in iron drums or tin cans and weighs about $10\frac{1}{2}$ pounds per gallon at ordinary temperatures. Upon exposure to air the liquid evaporates or volatilizes, forming a foul-smelling gas that is about twice as heavy as air. Because the gas is heavier than air and evaporates more quickly if a larger surface of the liquid is exposed to the air, the liquid should be poured out into shallow pie tins or similar shallow dishes and placed upon the top of the seeds to be fumigated. Seeds will not be injured or poisoned if the liquid is sprinkled or poured directly upon them. In estimating the amount of carbon disulphid needed, the amount of cubic space in the container in which the fumigation is done should always be considered—not the amount of space occupied by the seeds.

If used according to directions, carbon disulphid will not injure the germination of thoroughly dry seeds or affect their value for food. The disagreeable odor passes away after seeds fumigated have been aired. While carbon disulphid has become a standard fumigant and has been used for years without trouble by many individuals and firms, it is always timely to call attention to the fact that the gas is explosive and inflammable if fire is brought close to it during fumigation. By fire are meant even a lighted cigar, lighted lantern, or the spark from an electric fixture.

Seeds to be fumigated should be placed in an air-tight container. This may be a tin pail, wash boiler, barrel lined with heavy paper, galvanized-iron garbage can, or other receptacle, or a specially constructed fumigation box or room, according to the amount of seed to be fumigated. One of the simplest satisfactory containers for fumigation on a small scale is a water-tight barrel. The tighter the receptacle the better the results. Satisfactory results can not be secured if fumigation is attempted in a room full of cracks.

Carbon disulphid should be used at the rate of from 4 to 20 pounds to each 1,000 cubic feet of space to be fumigated, the amount to be used varying with the tightness of the container and the temperature. The liquid should be poured over the top of the seeds to be fumigated or poured into shallow dishes set upon the top of the seeds. It quickly vaporizes, and as the gas is heavier than air, it sinks to the bottom of the container, filling all the air spaces. Fumigation should continue from 24 to 48 hours, although most of the actual killing is done during the first 6 to 8 hours of exposure. It is always better to use too much rather than too little carbon disulphid.

Beans, cowpeas, and peas can be stored and fumigated conveniently in water-tight barrels. These should be filled to within a few inches of the top with seeds. In fumigating, pour one-half cup or more of carbon disulphid on the seeds and then cover the top of the barrel with a double thickness of heavy wrapping paper tied tight around the top, or several sacks weighted down with boards. A wooden cover is also useful in keeping in the fumes.

Fumigation with carbon disulphid to give the best results should be carried on at or above a temperature of 75° F. It is not effective at temperatures below 60° F. After fumigation the seeds should be examined occasionally and given a second or third fumigation should living weevils be found.

Carbon disulphid costs from 6 to 25 cents a pound. The following quotations were made during January, 1922, by a large producer of carbon disulphid:

55-gallon drums of 550 pounds, at 6½ cents per pound, drums $12 extra.[17]
10-gallon drums of 100 pounds, at 7½ cents per pound, drums $5 extra.[17]
5-gallon drums of 50 pounds, at 7½ cents per pound, drums $5 extra.[17]

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[17] Cost of drum refunded if drum is returned f. o. b. factory in good condition within four months of shipment.

50-pound cans, at 12½ cents per pound, including can.
10-pound cans, at 17 cents per pound, including can.
5-pound cans, at 20 cents per pound, including can.
1-pound can, at 25 cents per pound, including can.

To the above price must be added transportation costs. Farmers throughout the country can purchase carbon disulphid of local drug stores, but prices under such conditions often are exorbitant. County agents, boards of trade, or other public-spirited local organizations can purchase carbon disulphid and furnish it at cost to farmers in vicinity. This has been done in certain southern towns with the result that farmers have secured carbon disulphid of excellent quality[18] at lowest price. If local firms can not supply carbon disulphid, the names of firms in a position to fill orders may be obtained upon application to the Bureau of Entomology, U. S. Department of Agriculture.

Remember, if you do not get results with carbon disulphid the trouble is (1) with the way you apply it; (2) your container is not tight; (3) your dealer has sold you poor liquid; or (4) you have fumigated when it is so cold that no one can get good results.

Remember that large business firms and many farmers use carbon disulphid successfully and that its use on farms is on the steady increase. Nothing speaks better for any control measure than its steady use by successful business men, no matter whether they are farmers or seed brokers.

CARBON TETRACHLORID.

Carbon tetrachlorid (CCl_4) is a fumigant that has been used as a substitute for carbon disulphid in fumigation work, since it has the advantage over carbon disulphid of being noninflammable. When pure, carbon tetrachlorid is a thin, transparent, colorless liquid, with a pungent, aromatic odor. Except for being noninflammable, it is similar to carbon disulphid in all essential features, from the standpoint of application. It costs from 11 to 60 cents a pound and is not more than one-half as effective as carbon disulphid. It is not likely to take the place of carbon disulphid because of its inferior killing qualities and its somewhat great cost per pound. Its great advantage is its noninflammability.

If carbon tetrachlorid can not be had from local firms the names of firms supplying this chemical may be obtained upon application to the Bureau of Entomology, U. S. Department of Agriculture.

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[18] Unscrupulous dealers sometimes sell inferior lots of carbon disulphid. Dealers selling liquid containing less than 98 to 99 per cent actual CS_2 violate the Federal Insecticide Act and are liable to prosecution in Federal courts.

HYDROCYANIC-ACID GAS.

Fumigation with hydrocyanic-acid gas is recommended when large quantities of beans, peas, cowpeas, or chick-peas are found infested

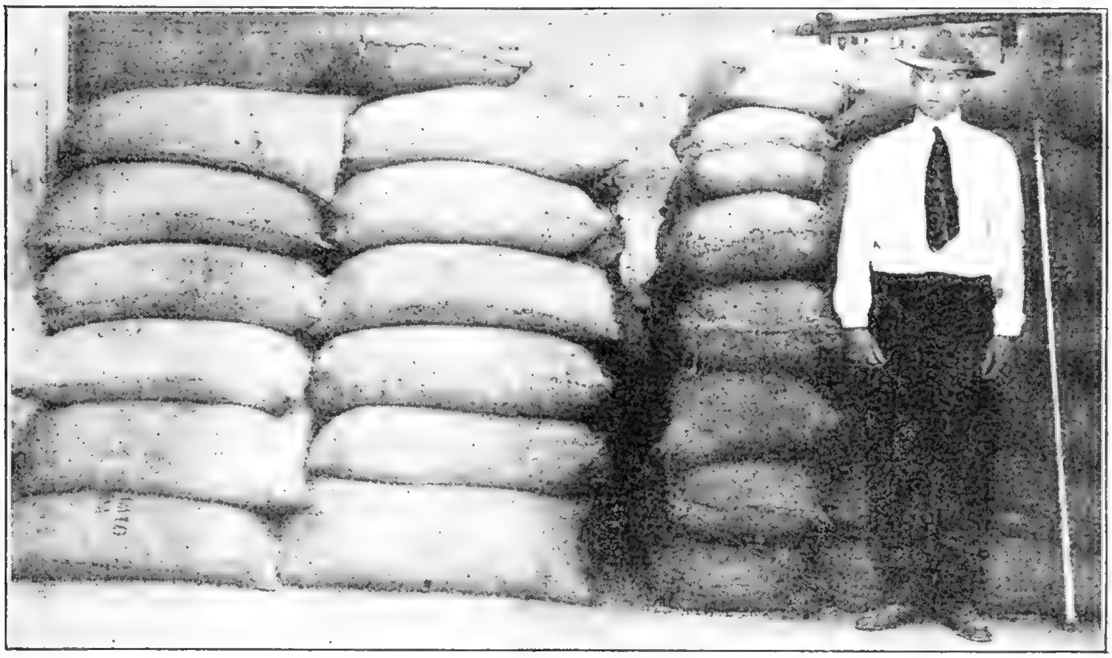

FIG. 26.—Carload lots of 240-pound sacks of chick-peas as stacked in badly infested warehouse. Samples taken throughout length of sack proved that hydrocyanic-acid gas penetrated to the very center and that infestations were killed.

FIG. 27.—Interior view of warehouse containing thirty thousand 240-pound sacks of chick-peas with a retail value of $861,000 at time of treatment. Infestations breaking out under such abnormal storage conditions were controlled by fumigation with hydrocyanic-acid gas.

with weevils. The seeds must be in sacks and so stacked that the gas can reach several sides or portions of the sacks. Chick-peas stored in

240-pound sacks, and stacked as shown in Figures 26 and 27, were almost perfectly protected by fumigation. It has been found in the fumigation of warehouses, sometimes as large as 150 by 150 by 20 feet, and containing as many as thirty thousand 240-pound sacks of chick-peas, that hydrocyanic-acid gas can be depended upon to eliminate infestations almost completely. Fumigation with this gas for the control of bean and pea weevils has proved so satisfactory that its use is now an established practice with certain firms. The dosage should be increased from 1 to 2½ pounds of cyanid for each 1,000 cubic feet of space to be fumigated. **Since it is extremely poisonous, hydrocyanic-acid gas should be used only by responsible persons who are thoroughly informed on the subject of fumigation.** As the gas is lighter than air and readily escapes, does not injure the seeds for planting or for food, injures no warehouse equipment, and is noninflammable when mixed with air in the proportions used in fumigation, it lends itself for use in almost any warehouse section if the fumigation is properly timed and supervised. For further information secure from this department Farmers' Bulletin 699 and Department Bulletin 872, which give full particulars of procedure.

HEAT.

Heat as a means of killing weevils in legumes is growing in favor. Small quantities of seed grown on the farm or in the town garden can be treated by placing them in an oven after they have been spread rather thinly in shallow pans and heating them to 120° to 145° F. for several hours. An old remedy is to dip seeds into boiling water for one minute. Holding seeds in boiling water for more than one minute will injure their value for planting purposes and exposure for even one minute has been known to affect germination. On removal they should be spread out immediately and dried rapidly.

Weevil development in large quantities of beans, peas, and cowpeas can be stopped by a process known as kiln-drying. This process consists in heating the seeds to a temperature of 120° to 145° F., or higher, while they are being passed through a machine called a drier. This treatment not only removes a portion of the moisture in the seeds but also kills all insects in them. The loss of moisture may be an item of importance if sales are made by the pound, yet investigators claim that seeds containing 20 per cent of moisture or less are not easily infested by weevils, hence excessive drying with the heat not only kills the weevils but renders seeds less susceptible to reinfestation.

The embryos of the common bean weevil are killed when exposed to 125.6° F. for 10 minutes; the newly hatched larvæ die in 7 minutes at 131° F.; full-grown larvæ in beans die in 20 minutes at 131° F.; and pupæ die in beans when exposed for 25 minutes at 131° F. Adults are killed by a 4-minute exposure to 131° F. These data can not be relied upon when large masses of seed are to be treated. The investigator who obtained them found that 9 hours were required for the center of 2 quarts of beans inclosed in a tight paper bag to reach the surrounding temperature of 131° F. Cowpeas infested with the four-spotted bean weevil were not absolutely sterilized from an insect standpoint when exposed to 140° F. for 5 minutes, though all the weevils were killed when the seeds were exposed to this temperature for 10 minutes in an oven. These results in killing the four-spotted bean weevil were secured under conditions more favorable than those likely to occur in commercial bean establishments, hence it was recommended that seeds be exposed in commercial treatment to 146° F. for 20 to 30 minutes. Temperatures above 150° F. seemed to weaken the resulting plants, but germination took place even after the seeds had been subjected to 190° F. for 10 minutes. Commercial coffee roasters are used by certain bean brokers for the destruction of weevils by heat. Seeds have been treated by the carload in such roasters and guaranteed to remain free from injury by bean weevils at least during transit in carload lots. A list of firms that manufacture apparatus for heating seeds will be furnished upon application. As is done in kiln-drying, the seeds should be spread out in order that all may be affected quickly and uniformly by the heat. When thus spread out an exposure to 131° F. for 1 hour should be sufficient.

Heat is not recommended for the control of the broad-bean weevil in broad or Windsor beans. Exposure to temperatures ranging from 120° to 140° F. for 5 to 40 minutes did not kill this apparently more hardy insect and the higher temperatures had an injurious effect upon germination.

COLD AND COLD STORAGE.

Weevils will not feed and cause damage at low temperatures. It is not known at what temperature development ceases, but no development takes place at or below 50° F. Cowpeas can be kept free from weevils if held in storage at a temperature of 32° to 34° F. It is claimed that exposure for a season at this temperature does not affect the germinating power of the seed. Investigations conducted in this bureau and not yet completed indicate that no stage of the common bean weevil can withstand 56 days of cold storage at 31 to 32° F., although they may survive more than 66 days at 36° F. The larvæ, it appears, succumb to cold storage temperatures more readily than do pupæ or adults.[19] The storage room should be kept as dry as possible and the seeds should be handled in sacks as in warehouses. It is interesting to note that cowpeas held for a season at 32° to 34° F. were found to lose their germinating power no sooner on removal to normal temperatures than cowpeas not thus exposed to cold. Seeds removed from cold storage to warm temperatures are likely to sweat, and if care is not taken to eliminate this surface moisture by drying or proper ventilation moldiness may result. There is some doubt as to the real need of incurring the expense of cold storage as seeds can be protected more cheaply by fumigation under storage conditions thought by the majority of seed owners to be better for the seeds.

LIME OR DUST AS PROTECTION TO SEED.

In the Southern States, where weevils cause such great injury to stored seeds, certain farmers have resorted to mixing their seed cowpeas with dry road dust or air-slaked lime. Tests prove that the storage of cowpeas with air-slaked lime at the rate of 1 part by weight of lime to 6 to 8 parts of peas is a great help in protecting seeds. The dust or lime does not necessarily kill the weevil grubs developing in the seeds if these are already in the seeds at harvest time, but it prevents adult weevils either from emerging or, if they succeed in emerging, from laying their eggs on the seeds for successive generations. The dust or lime, in other words, prevents continued breeding in storage. Either substance would probably be a nuisance if mixed with cowpeas intended for food if the seeds contained many emergence holes, as the lime or dust would work into these holes and be difficult to remove. If seeds are known to be free from weevils and are stored in tight barrels, bins, or other similar containers, a top layer of air-slaked lime about ½ to 1 inch thick, if maintained, will prevent weevils from gaining access from without and starting an infestation.

COMMUNITY EFFORT TOWARD CONTROL.

Anyone can protect beans and peas from further weevil injury after they are once dried and in storage. If loss occurs in storage, owners have only themselves to blame, for weevils can be effectively controlled at a cost very slight as compared with the value of the seeds protected and the increased value of the seeds after thorough treatment.

But no one person can prevent his beans and peas from becoming infested while they are developing in the garden or field unless he

[19] Original data (unpublished) by A. O. Larson and P. Simmons.

and his neighbors are willing to get together and pledge to treat their seeds in storage. Many adult weevils fly to fields from storage, or remain in fields harvested in a slack manner. A negligent neighbor may be the cause of much neighborhood infestation by the flying of his weevils to developing crops or into warehouses.

Community effort to reduce weevil losses can be made effective in localities where beans and peas are grown on a commercial scale. It is doubtful if concerted action can be secured in towns or cities where there are many small gardens yielding but a few seeds, for these small quantities of seed are of too little value to move their owners to action. The University of California during 1918–1920 conducted a campaign of community effort, in San Mateo County, Calif., directed against the broad-bean weevil (p. 19) and found that by working through the county agent and fumigating the crops after they were placed in storage the infestation in the field was reduced from 43 per cent in 1918 to 21 per cent in 1919 and to 17.8 per cent in 1920. The county agricultural agent has here a worth-while field for action along with his many others. To succeed, all farmers in a district should treat their seeds and destroy promptly refuse from cleaning machines.

TREATMENT DOES NOT PREVENT REINFESTATION.

Treatment of legumes subject to infestation by weevils that can breed generation after generation in storage will not keep them free from weevils if they are stored so that adult weevils can get to them and lay eggs on them. The application of remedial measures may kill all weevils in the seed at the time of treatment, but it should be remembered that no treatment has a lasting effect in preventing reinfestation from outside sources. Seeds once treated should be stored in rooms free from adult weevils, or placed in tight barrels or sacks made of closely woven material, and should be examined occasionally as a guard against subsequent infestation.

When large quantities of seeds are brought together under one roof, they usually represent the crops of many farmers whose local conditions may have varied to such an extent that one carload lot of seed may be free of infestation while the next may be slightly or heavily infested. Experimental work has proved that sacking seeds in one thickness of light-weight close-weave muslin will prevent uninfested seed from becoming infested even though there are many weevils and weevilly seeds close by. It is not practical in large seed warehouses to use sacks of light-weight muslin, yet a study in 1917–18 of conditions in large warehouses containing many carload lots of seed indicates the value of closely woven sacks. Jute sacks with

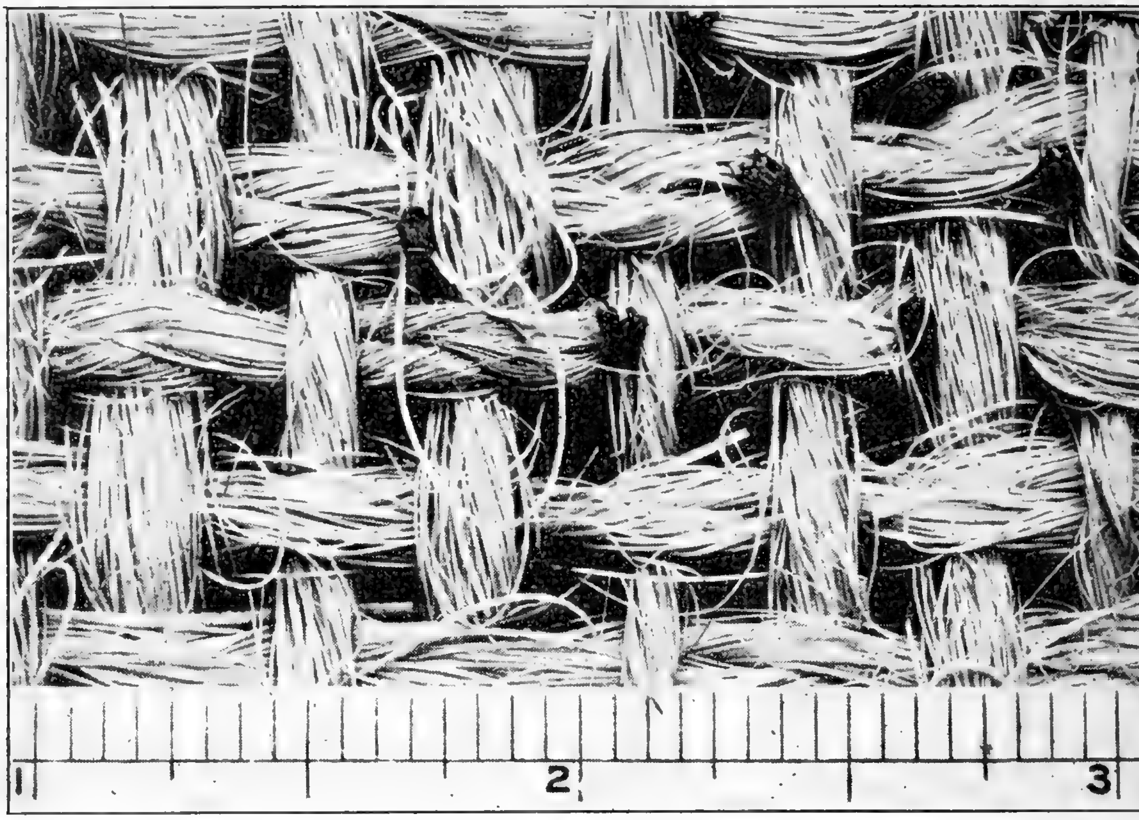

FIG. 28.—Section of jute sack having four strands to the inch. Such sacks are of no value in preventing spread of infestations from sack to sack in warehouses. The adult weevils can leave or enter such sacks at will.

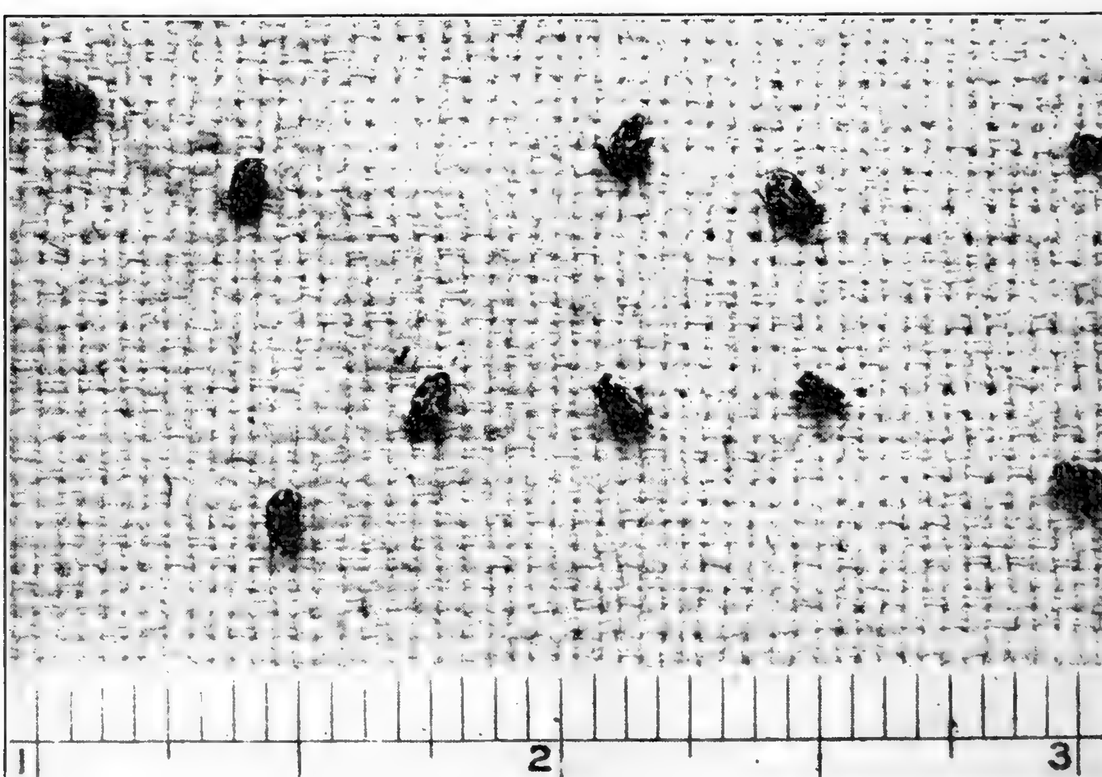

FIG. 29.—A heavy cotton close-woven sack with 24 strands to the inch. Sacks made of this material are on the market and have proved their effectiveness not only in preventing weevils from leaving the sacks but also in protecting uninfested seeds from infestation from without.

but four strands to the inch (such as shown in Fig. 28) are no protection to the seeds within the sacks and do not prevent weevils developing in the sacks from crawling out and migrating to and laying their eggs upon seeds in other sacks of similar weave. But seeds sacked in heavy cotton sacks of close weave with 24 strands to the inch are apparently perfectly protected from infestation from without (Fig. 29). Some such sacks contained badly damaged and heating seed but the infestation was held within them and prevented from spreading to adjoining sacks by the tightness of the sacks. The common bean weevil, the cowpea weevil, and the four-spotted bean weevil can eat holes in paper sacks and escape, but do not eat through cloth. There is a great deal in favor of a tight cloth sack, not only for protecting uninfested seeds from infestation from outside sources but also in preventing infestations from spreading.

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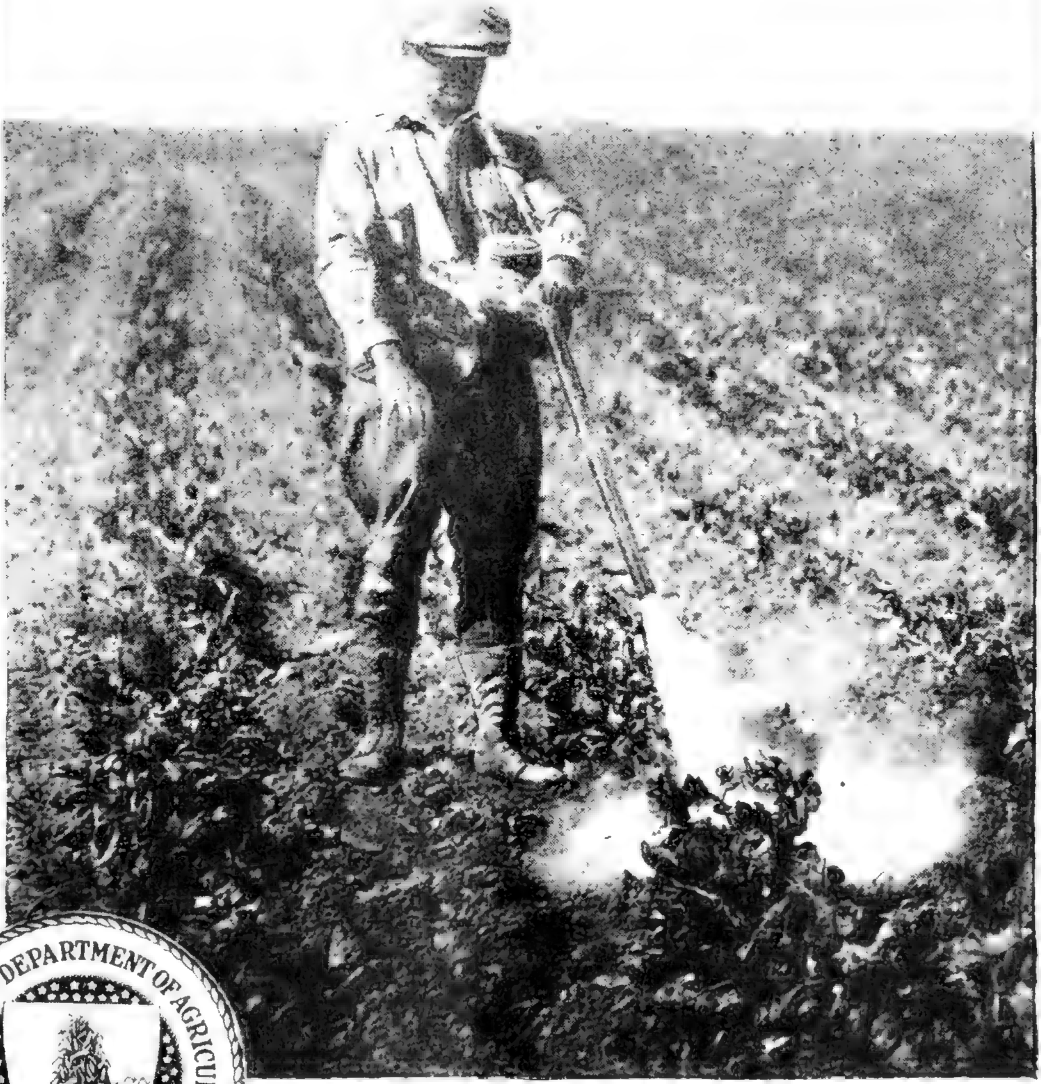
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1282

NICOTINE DUST FOR CONTROL OF TRUCK-CROP INSECTS



OUTBREAKS OF INJURIOUS INSECTS, particularly aphids and thrips, are often serious handicaps to the growing of vegetable and truck crops. These have been hitherto combated mainly by the application of contact liquid sprays, the one most commonly used being nicotine sulphate. Because of several objections to this method of control, however, the practice of applying nicotine in a dust carrier has recently been adopted to a considerable extent, especially in California, as well as in other States.

This bulletin gives the reasons for adopting nicotine dust and tells of what it is composed, the proper time and method of application, and the strength to use. Different types of dusting machinery are described, and the work for which they are best adapted is indicated. Information is given for the treatment of the onion thrips, cucumber beetles, the melon aphis, cabbage aphis, and pea aphis, and the possibility of the control of similar insects on other crops is mentioned.

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NICOTINE DUST FOR CONTROL OF TRUCK-CROP INSECTS.

ROY E. CAMPBELL,

Assistant Entomologist, Truck-Crop Insect Investigations, Bureau of Entomology.

CONTENTS.

REASONS FOR ADOPTING NICOTINE DUST.

AN INSECTICIDAL DUST has several advantages over a liquid spray. It can be applied much more easily and quickly than a spray, and a dust hopper can be refilled in much less time than a spray tank. The dust particles reach more insects than the spray, particularly on the undersides or in curled leaves. Power dusters cost less than power sprayers, while hand dusters are easier to carry and to operate than hand sprayers. Usually much less than 100 pounds of dust is required to cover an acre, while to spray the same area requires at least 100 gallons, weighing 800 pounds; on this account dusters can be operated on wet ground and side hills inaccessible to sprayers. For spraying with nicotine sulphate, a soap spreader is required, and the whale-oil or fish-oil soap commonly used must be heated to dissolve it, which causes delay and is a disagreeable task avoided when the dust is used.

With the dusting method, as with the spraying method, combination treatments for insects of different kinds, mites, and certain fungous diseases can be given, and for this purpose nicotine dust can be combined with powdered lead arsenate or dry sulphur.

WHAT IS NICOTINE DUST?

Nicotine dust is simply a certain amount of the standard solution of nicotine sulphate, containing 40 per cent nicotine, thoroughly mixed with a dust carrier. This carrier must be fine, light, cheap, inert as far as action on foliage is concerned, and of a material with which the nicotine will mix freely but not become permanently absorbed.

Kaolin, the first material extensively used, was the best carrier in so far as the first four points are concerned, but was found to absorb and tie up some of the nicotine, making it unavailable for action on the insects. Two forms of lime are now used, namely, refuse lime from sugar-beet mills and pure hydrated lime. Finely ground sulphur is also used to a considerable extent for amounts up to about 70 per cent of the carrier.

In making the dust, regardless of what carrier is used, a certain amount of lime is added. A chemical reaction takes place, in which the nicotine is set free from the sulphate. The active ingredient in the finished product is therefore nicotine, which is more active than nicotine sulphate. Because of this reaction, and also because of the fact that the killing is done by the nicotine, the dust should be called nicotine dust rather than nicotine sulphate dust.

The use of powdered sulphur in the carrier along with the lime makes a more effective dust than when hydrated or sugar-beet lime alone is used, because the sulphur releases the nicotine more readily than does the lime, and therefore the nicotine-sulphur dust is more active than the nicotine-lime dust. By using from 10 to 40 per cent of sulphur in the carrier, the amount of the nicotine-sulphate solution added can be reduced at least 1 or 2 per cent, and the same results obtained as with the higher strengths in lime alone. Sulphur, on the other hand, is more difficult to pulverize than lime and is heavier. It is also unsuitable for use on melons and other cucurbits, which may be severely injured by it.

To insure killing all the insects, each particle of the dust should be impregnated with nicotine. This necessitates thorough mixing with the best machinery obtainable. As machinery is expensive, the dust is made almost entirely by commercial manufacturers, and sold ready to use. It would be entirely feasible, however, for large-scale growers and growers' associations, etc., to install the proper machinery and manufacture their own dust, at considerably less cost than the present retail price.

HOW TO PREPARE THE DUST.[1]

This dust can be made of the following combinations of materials, which act as carriers, to which the desired amount of nicotine sulphate is added: Kaolin and lime; sugar-beet lime and hydrated lime; hydrated lime; lime and finely ground sulphur. Various pro-

[1] Adapted from Department Circular 224, U. S. Dept. Agr., "Nicotine Dust for Control of the Striped Cucumber Beetle," by W. H. White.

portions of the different materials are used, of which the formulas given below are typical:

FORMULA NO. 1.

Four per cent nicotine sulphate, equivalent to 1.6 per cent nicotine.

100-pound lots.			*12½-pound lots.*		
Kaolin	pounds	72	Kaolin	pounds	9
Hydrated lime	do	24	Hydrated lime	do	3
Nicotine sulphate	do	4	Nicotine sulphate	ounces	8

FORMULA NO. 2.

Five per cent nicotine sulphate, equivalent to 2 per cent nicotine.

100-pound lots.			*12½-pound lots.*		
Hydrated lime	pounds	95	Hydrated lime	pounds	12
Nicotine sulphate	do	5	Nicotine sulphate	ounces	10

FORMULA NO. 3.

Six per cent nicotine sulphate, equivalent to 2.4 per cent nicotine.

100-pound lots.			*12½-pound lots.*		
Hydrated lime	pounds	54	Hydrated lime	pounds	6¾
Finely-ground sulphur	do	40	Finely-ground sulphur	do	5
Nicotine sulphate	do	6	Nicotine sulphate	ounces	12

In the preparation of this dust it is very important that the nicotine sulphate be thoroughly mixed with the carrier. This can be accomplished by first mixing and sifting the materials composing the carrier, then combining the required amount of nicotine sulphate with the dust, adding the nicotine slowly and mixing all thoroughly. The nicotine sulphate can be added to the dust by the use of any convenient sprinkler. A pint fruit jar with a metal top from which the porcelain has been removed, punched with holes by the use of a 6-penny nail, makes a good sprinkler. After the addition of the nicotine sulphate the mixture should be run through a fine sieve, 20 meshes to the inch, with the aid of a brush. This last operation should be repeated at least three times. Be sure that all the material is worked through the sieve, since if this be neglected a large quantity of the nicotine may be lost.

A very satisfactory and simple method of mixing the dust consists of a box (Fig. 1) with a detached cover in which a sieve is placed and an ordinary floor brush with a handle is attached. A slot is cut in the side of the box so as to allow operation of the brush with the cover on. The cover to a large extent prevents the escape of the dust during the mixing process and consequent inconvenience to the operator.

The dimensions of a box in which 12½ pounds of the dust can be conveniently mixed are as follows: Length, 15 inches; width, 10 inches; depth, 12 inches.

The sieve is constructed of brass screen, 20 meshes to the inch, tacked to a frame 4 inches deep.

The sieve fits snugly inside of the box and rests on a strip 5½ inches from the upper edge of the box.

The brush is an ordinary floor brush with edge trimmed off so that the corners and edges of the sieve may be reached.

The handle, 20 inches in length, attached at right angles to the brush, is so constructed that the brush will rest in a level position over the entire length of the sieve and that the end of the handle will come through a slot in the upper end of the box.

If a large quantity of dust will be needed during the season, a mechanical mixer will be found more satisfactory than the home-

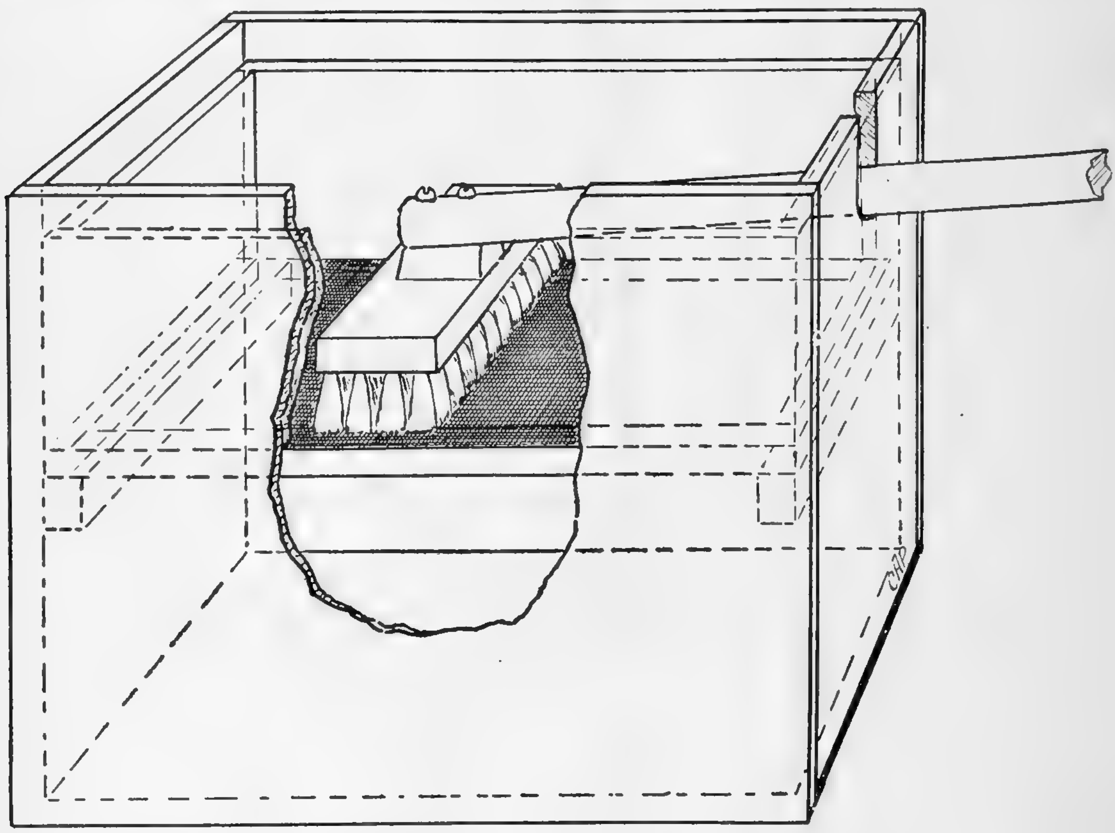

FIG. 1.—A mixer for use in preparation of small quantities of nicotine dust. (White.)

made one. A sifter and mixer such as is used by bakers can be procured in several sizes, any one of which will mix and sift the dust thoroughly, rapidly, and economically.

COMBINATIONS OF NICOTINE DUST WITH OTHER INSECTICIDES AND WITH FUNGICIDES.

It has long been the custom in spraying operations to combine two or more insecticides, or an insecticide and a fungicide, when different types of insects or a disease and an insect are infesting one plant. This practice can be continued to a large extent with dusting; in fact, some combinations are more satisfactory in the dust form than as sprays.

Powdery mildew is a common disease of peas which is most successfully combated with sulphur. The use of a nicotine-sulphur dust, in which the carrier is about 70 per cent finely ground sulphur, will control not only the mildew but also the pea aphis. In parts of southern California peas are damaged by the beet army worm [2] and by cutworms. These may be combated, especially when the insects are young, by including in the mixture 10 per cent of powdered arsenate of lead.

On cabbage, the nicotine dust will kill the aphis and also some cabbage worms, but if the latter are numerous, the nicotine-arsenate of lead combination may be used. This is also effective against flea-beetles on tomatoes.

Nicotine-sulphur dust should be used cautiously on cucumbers or melons, as more or less burning of the foliage may result, especially in very hot weather. This dust is partially effective against the red spider and is effective against mildew.

ACTION OF NICOTINE DUST.

The action of nicotine dust on insects is similar to that of nicotine sulphate in a liquid spray, i. e., nicotine fumes or vapors, entering the breathing pores of the insect, kill by paralyzing the nervous system. With the dust, this action becomes effective more quickly. Within a minute after the application, aphids and some other insects show evidence of extreme distress. Aphids elevate their abdomens as though trying to stand on their heads, and soon fall. Some beetles and small bugs lose the power of locomotion almost immediately, but continue to move their legs and antennæ convulsively for a few minutes before becoming completely paralyzed.

Because nicotine fumes are the active ingredient, killing is brought about in three ways: First, by covering, or partially covering, the body of the insect with dust: second, by covering the foliage or ground about the insect; third, by enveloping the whole plant with a cloud of dust which penetrates to all parts of the foliage. The first is obviously the surest method. With the material on the body of the insect, the nicotine fumes are certain to enter the spiracles, or breathing pores, causing almost instant death. The second and third methods, where the fumes suffocate or repel any insects in the immediate vicinity of the dust, are more like fumigation. As a matter of fact, in the usual dusting operation all three conditions are present. The mere making of a cloud of dust about the plant, however, is not sufficient. This cloud must be driven in and throughout the foliage in order to reach all the insects.

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[2] *Laphygma exigua* Hübn.

TIME OF APPLICATION.

Since the fumes of nicotine in this dust must be depended upon to kill the insects, two factors are of importance in its application, viz, the stillness of the air and the temperature. The longer the cloud of dust remains around the infested plant, the more likely the insects are to be killed by the fumes. On the other hand, if a wind is blowing, not only the cloud of dust itself, but the fumes also, will be blown away. Therefore it is desirable to apply the dust when the air is still. Usually this is early in the morning or just at dusk. At these times, also, the humidity being higher, the dust remains close to the ground.

The effectiveness of the dust is also dependent on the volatility of the nicotine, which is greatly increased at a high temperature, resulting in a much quicker and more thorough killing. Hence, from this standpoint alone, the application is best in the warmer portion of the day. If, however, a breeze is blowing, the value of the temperature may be entirely offset by the rapid diffusion of the fumes.

Dust should not be applied either when the wind is blowing or on a day when the outdoor temperature is much below 65° F.

NUMBER OF APPLICATIONS.

Such insects as aphids and thrips reproduce very rapidly. No matter what method of control is used, therefore, whether it be dusting or spraying, under conditions favorable to the insect a reinfestation may take place, even though a high percentage may have been killed. On this account it is not to be expected that at all times one dusting will be sufficient for an entire season. Sometimes one application will be sufficient, but it may be necessary to dust twice or even three times. In fact, many growers plan for a second application, timing it to check the second infestation before it begins to be serious.

All dusting and spraying should be done with the idea of preventing infestation and the resulting damage rather than trying to stop an infestation after it has become heavy. This is always the easier, cheaper, and more profitable way. If the grower waits until the field is quite generally infested before starting control measures, even though practically all the insects present are killed, it is probable that they will have already done considerable damage to the plants and reduced the crop accordingly. The grower, then, may feel that the control measures were not worth while, whereas, if they had been undertaken earlier, the damage would have been prevented and a larger crop produced.

STRENGTH OF NICOTINE TO USE.

Some of the smaller, frailer aphids, such as the walnut aphids, are easily controlled with a dust containing only 2 per cent by weight of nicotine sulphate solution, but the ordinary insect against which it is used requires at least 4 per cent. This amount, when carefully applied, will control most aphids and thrips. For ordinary commercial purposes a 5 per cent strength is most commonly used, and is to be recommended. For certain insects which are more resistant to the action of insecticides, from 6 to 8 per cent is required, and in some cases a 10 per cent strength is used. If the application is carefully and thoroughly made, the lesser strengths will do satisfactory work in most cases.

All formulas in this bulletin refer to the percentage by weight of the ordinary commercial solution of nicotine sulphate, which contains 40 per cent nicotine. As the nicotine only is the active ingredient, and is the material referred to by some writers, the difference in the two is as follows:

Percentage of the commercial solution of nicotine sulphate containing 40 per cent nicotine added to the dust.	Per cent of pure nicotine in the dust.
2	0.8
4	1.6
5	2.0
6	2.4
8	3.2
10	4.0

This is the theoretical amount of nicotine contained in the dust. As a matter of fact, some of the nicotine volatilizes during the mixing, and is lost. Although the manufacturer may put in the full amount of the nicotine-sulphate solution shown in the left-hand column, his guarantee of the amount of pure nicotine in the finished product will be somewhat less than the corresponding amount given in the right-hand column.

As nicotine is the killing agent, the buyer should ascertain which of the foregoing methods is used in labeling the dust, and he will avoid the mistake of buying a dust containing 4 per cent of the nicotine sulphate solution, thinking it contains 4 per cent pure nicotine.

LOSS OF STRENGTH.

Since the nicotine in this dust is very volatile some of the killing power is likely to be lost if the dust is held for any length of time in open containers. When first used the dust was put up in burlap sacks with paper liners, and, as it was used within a short time, there was little or no loss of strength. It is the present practice to put up practically all the dust in air-tight containers, such as sheet-iron drums, but even in these it is not advisable to hold the dust longer than necessary. The grower should buy or make his dust only for immediate needs. It should be the policy of dealers to keep on hand just enough freshly made dust to keep ahead of the needs of customers, and manufacturers should make the dust only as ordered. This will insure a supply of freshly made, active dust which, when applied as directed, will control many of the pests that damage truck crops.

TYPES OF DUSTING MACHINERY.

Several types of dusting machines are now available, from small hand dusters, adequate only for small back-yard gardens, to large power-driven outfits, suitable for extensive acreages.

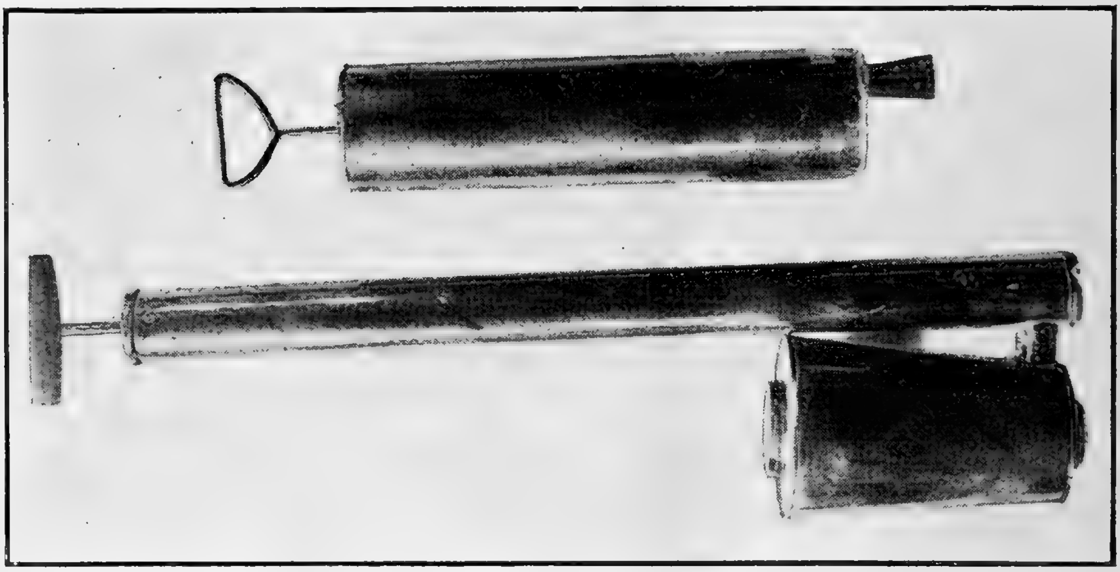

FIG. 2.—Two types of small hand dusters suitable for backyard gardens.

HAND DUSTERS.

Figure 2 shows two types of small hand dusters suitable only for very small areas, such as home gardens or a few ornamental plants. These machines have no feed regulator and the dust application is not entirely uniform. No attempt should be made to use them except on an area of a few dozen plants. They retail at about $1 each.

For smaller commercial acreages there are two types of hand dusters which do very satisfactory work. One, the hand-operated bellows duster (Fig. 3; Fig. 14, at right) was found best adapted to plants, such as cucumbers and melons, grown in hills. The dust is applied in puffs, as the air is forced from the bellows. The dust feed can be regulated, both as to quantity and as to its fineness or coarseness. These dusters are also well adapted for use on small trees, vines, and shrubs. An average maximum of 2 acres can be covered in a day with one of these machines under favorable conditions. They weigh from 15 to 20 pounds each and the capacity of the hopper is approximately the same weight of dust. The machine is carried strapped on the back of the operator. The cost is from $17 to $20 each.

The other type of hand machine, the blower gun (Fig. 6; Fig. 14, at left), in which the air pressure is supplied by a rapidly revolving fan, is operated by a hand crank and gears. The flow of dust is continuous, and the amount can be regulated by an adjustable feeding device. This type of machine is particularly adapted to row crops, as the continuous flow permits the operator to keep up a steady walk alongside the row, directing the cloud of dust so as to cover it com-

FIG. 3.—Hand-operated bellows type of duster used in applying nicotine dust to melons for the melon aphis.

pletely. Since no time is lost between puffs, the blower gun will cover a somewhat larger acreage than the bellows type, but will use a little more material per acre.

Both types of hand dusters, and especially the blower gun, are rather laborious to operate. It has been demonstrated on small plots that almost 1 acre per hour can be covered with this type of duster, but such a pace can not be maintained for any length of time. Partly because of the toilsomeness of the operation, and more particularly because of the desirability of making the application when the air is still, the practice has arisen of applying the dust only for a few hours in the morning or evening. The average ground covered daily would not be over 4 acres. Hand-blower guns weigh about 10 or 12 pounds and have a hopper capacity of 6 or 8 pounds of dust. Most of them are carried resting against the abdomen, with straps over the shoulders. The retail price of these machines is from $15 to $25 each.

HORSE-DRAWN DUSTERS.

The one-horse duster is a new type developed in the South in response to the demand for a machine intermediate between the hand and power outfits for use in combating the boll weevil. Many farmers had acreages too large to be economically covered by hand machines, yet too small to warrant the expense of a power outfit. The situation has been the same in the development of methods of applying nicotine dust; i. e., there has been a demand for an inexpensive, intermediate machine which will cover up to 10 acres a day, and can be operated by a horse and one man. The essential features of these machines are: A large hopper with a capacity of 50 to 60 pounds of dust, a positive and easily regulated dust-feeding device, a high-speed fan, and a set of discharge pipes to deliver the dust to two rows of plants. A single traction wheel runs between the rows, and through a series of gears supplies power to operate the revolving fan. A clutch on the main shaft of the wheel permits it to be released so that all working parts of the machine stop when it is being moved to or from the field.

Recent tests with the one-horse duster in applying nicotine dust to truck crops indicate that it is very well adapted to such work, but the machine must have a feeding device capable of delivering up to 60 or 75 pounds of dust per acre. Figures 7, 8, and 9 show one of these machines being used against the pea aphis. Crops like cabbage and peas can be gone over with such a duster at the rate of from 10 to 15 acres a day. The one-horse duster retails at from $100 to $150.

A larger machine having two wheels and drawn by two horses operates on the same principle, but is capable of covering almost double the acreage. This machine has not been used for nicotine dusting, but should be suitable for an acreage larger than that covered by the one-horse duster, and where the power outfit is not desired. These machines retail at from $250 up.

POWER DUSTERS.

The power duster, while used more extensively on fruit trees, is well adapted to truck crops. In the machine commonly used, the hopper holds about 100 pounds of dust. A mechanical and easily regulated device allows the desired amount of dust to feed into the discharge pipe through which the air is blown from a rapidly revolving fan. The latter is attached by means of a belt to a 2-horsepower gasoline engine. For certain occasions the single large tree-dusting hose can be used, and the dust blown out over considerable areas of the crop. This is sometimes desirable in crops grown in plots (see Fig. 10) or where the plants are so large that to drive down the rows would do considerable damage. This is also a good method of application for such plants as melons or cucumbers.

A small power outfit with two discharge pipes, used successfully in controlling an infestation of the melon aphis in a casaba field, is shown in Figure 4. It covers the field at a rate of 1 acre an hour, using from 50 to 75 pounds of dust. The feed can be regulated so that any amount per acre desired can be applied. The machine should be elevated somewhat, preferably on a small wagon rather

FIG. 4.—Power-operated fan duster used with success in a badly infested melon field.

than on a sled. This outfit, with engine, costs about $150, while the larger outfit is retailed at $350.

The most satisfactory method of dust distribution from power outfits for truck crops grown in rows is through a series of pipes, covering six or eight rows at a time. For some crops the pipes are adjusted to shoot directly down on the rows, a pipe to each row, while on others the pipes hang down between the rows close to the ground and discharge the dust at right angles, toward the rows on each side. The first type is best for plants where the infestation is in the upper leaves, or where it is necessary to drive the dust directly down into the plants, while the second type has been found most satisfactory where it is desirable to direct the dust toward the underside of the leaves. Such a machine will cover about 4 acres an hour. Figures

12 and 13 show one in operation against the onion thrips in the Coachella Valley.

THE MELON APHIS.[3]

The melon aphis is a serious enemy of melons, squash, cucumber, cotton, and several other crops, the damage varying from year to year, and in different localities, from slight and scattered infestations of little consequence to severe infestations causing a total loss of the crop. As these insects feed almost entirely on the lower surface of the leaves, frequently causing them to curl, it is difficult to obtain satisfactory control with a liquid spray. If sufficient time and care are taken to insure the covering of all leaves, particularly the underside, the operation becomes too expensive, and if such care is not taken the percentage of aphids killed is too low to make spraying worth while.

A cloud of fine dust blown into the plant and hovering over and about it, however, penetrates to all parts of the foliage, coming in contact with the underside, and even into the curled leaves. This is especially true when the end of the discharge pipe is placed in the midst of the foliage, and with a spoon-shaped nozzle attachment by which the cloud of dust is directed upward, to the under surface of the leaves.

Since melons, cucumbers, etc., are usually grown in hills, and it is desirable in dusting them to pay special attention to directing the blast of dust, the bellows type of hand duster (Fig. 3; Fig. 14, at right) is very satisfactory for this work. With such a machine one man can cover up to 2 acres of full-grown melons or cucumbers a day, using up to 50 pounds of dust per acre. On smaller plants a greater acreage can be covered, and with less dust.

It is characteristic of the melon aphis to appear early in the season, when the plants are small, and often to infest plants seriously here and there in the field. If left unchecked, these plants will be sufficiently damaged to produce little or no fruit, and the aphids are likely to spread to all parts of the field. Such scattered infestations are troublesome to spray with a large outfit, while knapsack or small compressed-air sprayers are almost equally unsatisfactory. With a duster of the type shown in Figure 3, however, it is easy and inexpensive to go over the field as often as necessary, dusting the infested plants, and thus not only killing the aphids in these early infestations and stopping the damage to the young plants, but also preventing the aphids from spreading and infesting the entire field.

The small power outfit shown in Figure 4 can be used on large acreages of well-grown plants, or where it is desirable to get over

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[3] *Aphis gossypii* Glover.

a field quickly. It will dust a melon field at the rate of almost 1 acre per hour, but is likely to use more dust than the hand machines.

Dusting for this aphis was found to be satisfactory on all kinds of melons, cucumber, and squash.

THE CABBAGE APHIS.[4]

The cabbage aphis, a cosmopolitan and widely distributed pest, which often causes serious damage to cabbage, kale, cauliflower, turnips, and related crops, is not infrequently held in check by cold weather or driving rains, but in many seasons, when there is a lack

FIG. 5.—Dusting for the cabbage aphis. Note cloud of dust completely covering all parts of infested plants.

of these conditions, the insects multiply very rapidly, which results in serious infestations and heavy damage to thousands of acres of cabbage and cauliflower.

As with the melon aphis, it is difficult to obtain a satisfactory killing of the cabbage aphis by spraying, because the colonies of aphids are usually on the underside of the leaves, or are protected by the compact foliage of the growing head. Further, the aphis colonies cause the leaves to curl, rendering it almost impossible to reach them with spray. But the cloud of dust blown into the plant entirely surrounds it, and the fine particles drift in among the infested leaves, reaching a large percentage of the aphids (see Fig. 5).

[1] (*Aphis*) *Brevicoryne brassicae* L.

Extensive experiments showed that a dust containing less than 4 per cent of commercial nicotine-sulphate solution did not secure an efficient killing, and also that the slight increase in the percentage killed with strengths above 6 per cent did not justify the increased cost of the extra nicotine sulphate. It was determined that for ordinary commercial purposes, a 5 per cent strength was most satisfactory, considering both the killing obtained and the cost per pound.

The following figures, showing the cost of dusting, were furnished by a cabbage grower, who successfully checked an infestation of this aphis in his fields, using the hand dusters described:

On cabbage less than half grown:	
Dust, 30 pounds, at 15 cents	$4.50
Labor at $3.25 per day	1.65
Total cost per acre	6.15
On cabbage over half grown:	
Dust, 50 pounds, at 15 cents	7.50
Labor at $3.25 per day	1.85
Total cost per acre	9.35

With a one-horse duster it is possible to cover a little over an acre of infested cabbages an hour, applying any desired amount of dust up to about 60 pounds per acre. While this machine is more wasteful of material than the hand dusters, its greater speed considerably reduces the cost of application, as shown by the following:

300 pounds dust, at 15 cents	$45.00
One man and horse, per day	5.00
Total cost for 10 acres	50.00
Total cost per acre	5.00

This gives a cost of $5 per acre, as compared with $6.15 with the hand machines.[5]

THE PEA APHIS.[6]

The pea aphis is well distributed over nearly the entire country, and under favorable conditions multiplies with great rapidity, causing severe losses to the pea crop. This happens far too often to suit the pea grower, who, in order to prevent this loss, must adopt control measures. In many localities the growing of peas has been largely abandoned because of the regular appearance of this pest. All forms of peas and sweet peas, as well as other legumes, are subject to attack.

[5] The price of nicotine dust has been high, but, due partly to adjustment of economic conditions and particularly to greater competition in its manufacture and sale, this price will undoubtedly be lowered somewhat another season. Labor prices may also be lower. Therefore, in figuring the cost of dusting the local price of both labor and dust must be considered, as they will probably differ from those given in this bulletin.

[6] (*Macrosiphum*) *Illinoia pisi* Kalt.

The pea aphis is considerably larger than most other aphids and is more resistant to insecticides. In both liquid spraying and dusting a higher strength of nicotine is required for effectiveness than is ordinarily used. Not less than a 6 per cent strength of dust should be used, while many growers prefer 10 per cent. Several large seed companies in California have used the 10 per cent strength on their sweet peas for three seasons, and are much better satisfied with the results than with any previous control work with liquid sprays.

All types of dusters employed were used with success on peas. For a hand duster, the fan type is very satisfactory, as the continuous flow of dust permits the operator to make the application at a steady walk, holding the discharge pipe directly over the row (Fig. 6; Fig. 14, at left). It may use a little more dust than the bellows type, but will cover the acreage much more rapidly, at least 1 acre more a day.

FIG. 6.—Hand-operated fan duster in use against the pea aphis.

One-horse dusters in operation in a pea field are shown in Figures 7, 8, and 9. Under average conditions a machine of this type will cover about 1 acre an hour. A power outfit with a single discharge hose used successfully in plots of sweet peas is shown in Figure 10. Until the peas are large it is better to use the discharge pipes similar to those in Figures 12 and 13. Such outfits are used by several large seed companies in California, applying as high as 100 pounds per acre of a 10 per cent dust and covering 3 to 4 acres per hour.

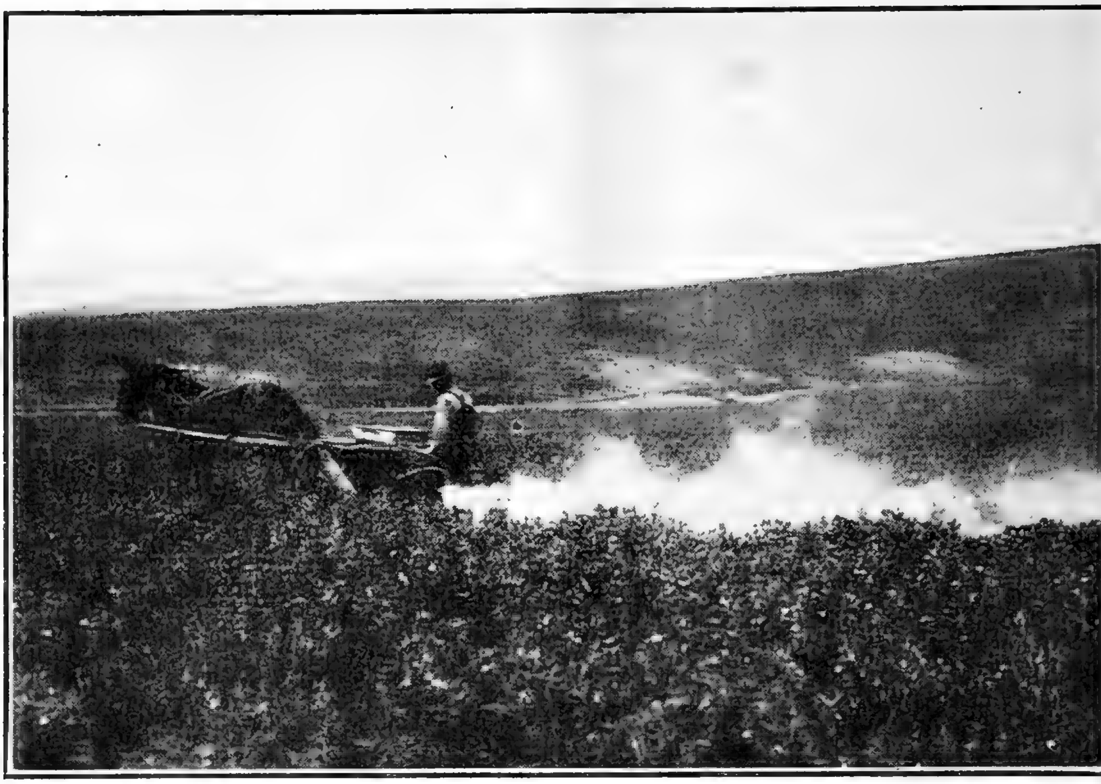

FIG. 7.—Treating a pea field infested by pea aphis with a one-horse duster.

FIG. 8.—One-horse type of duster in use against pea aphis.

Because of the present high cost of the dust and the fact that a high percentage of nicotine is required to effect control, dusting for the pea aphis can only be applied to especially valuable crops.

such as high-priced market peas or sweet peas, and will probably prove too expensive for cannery or low-priced market peas.

FIG. 9.—One-horse duster in use against pea aphis.

THE ONION THRIPS.[7]

The onion thrips, also an insect of wide distribution, is the cause of enormous damage to onions practically wherever the latter are grown. It is also very destructive to cauliflower, cabbage, cucumber, and melons, and various other vegetables. Spraying is efficient in controlling it from the standpoint of the percentage killed, but

FIG. 10.—Power-operated duster with single discharge pipe, used in field of sweet peas when plants are too large to permit driving down the rows.

[7] *Thrips tabaci* Lind.

some growers object to it because of damage to closely planted rows from horse-drawn vehicles, the necessity of often going some distance for water, the inconvenience and delay of heating the soap, and because of the weight of the water which must be transported across the field. The use of nicotine dust also gives a satisfactory killing of the onion thrips, but its application involves none of the objectionable features of liquid spraying.

The hand-operated dusters (Fig. 11) will cover from 2½ to 3 acres a day, using from 30 to 50 pounds of dust per acre. A small power-operated duster, treating six rows at a time, was capable of covering 10 to 12 acres a day.

Fig. 11.—Dusting onions infested by onion thrips with hand-operated bellows duster.

One grower, anticipating the need of control measures, planted a large field of onions in triplicate rows, i. e., in sets of three rows 4 inches apart, with every two such sets 30 inches apart. This arrangement not only permits the use of the desired machinery for controlling the thrips, but actually makes it possible to grow about one-third more onions to the acre. A power outfit was placed on a wagon or truck, with a set of eight discharge pipes at the back, covering as many triplicate rows, or sets, with a pipe to each set of three rows. Figures 12 and 13 show the duster in action. With this it was possible to cover as much as 4 acres per hour. The most satisfactory control was obtained by using the 5 per cent strength, and up to 40 pounds per acre for the larger onions. When the air is quiet, and the dust does not drift away quickly, a smaller amount is sufficient.

CUCUMBER BEETLES.[8]

Cucumber beetles cause considerable damage each season, not only to cucumber, squash, melons, and other cucurbits, but also to a variety of plants. Although biting insects of a type ordinarily best controlled by a stomach poison, they are easily overcome by the fumes of nicotine dust, especially when they attack young cucumber or squash plants. Using the hand-operated bellows duster (Fig. 14, at right) with a liberal feed, one or two puffs of dust are sufficient to cover a hill. Since the beetles are apt to fly when disturbed, the first blast of dust must be sufficiently liberal to coat the beetles thoroughly, otherwise they may escape.

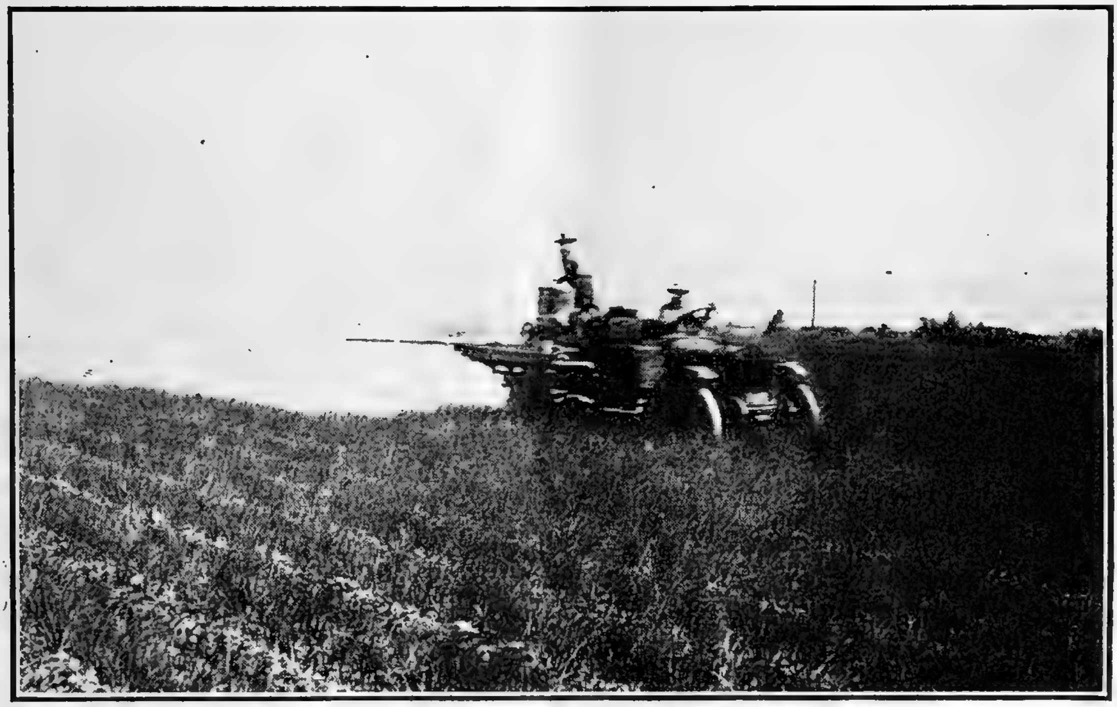

FIG. 12.—Dusting onions for onion thrips with a power duster mounted on a truck; front view.

Not less than a 6 per cent strength should be used, and many growers prefer the 10 per cent mixture, as it is much more sure to overcome the beetles with the first puff of dust.

On small cucumbers, 1 pound of dust will cover from 200 to 300 hills, at the rate of nearly 1,000 hills per hour. On larger plants, the applications are similar to those for the melon aphis, except that it is not necessary to make the application so that the underside of all the leaves is reached.

It has been found advisable when applying this dust to small plants for cucumber beetles to add to the carrier 10 per cent of powdered

[8] *Diabrotica* spp. The nicotine-dust treatment has been used by the writer against the western twelve-spotted cucumber beetle (*Diabrotica soror* Lec.) and the western striped cucumber beetle (*D. trivittata* Mannh.) in California, and by W. H. White, Bureau of Entomology, against the striped cucumber beetle (*D. vittata* Fab.) in the East. (See Department Circular 154, U. S. Dept. Agr., 1921, and Department Circular 224, U. S. Dept. Agr., 1922.)

arsenate of lead. This will take care of any beetles which may infest the plants after the nicotine has lost its effectiveness.

OTHER INSECTS.

Other insects against which this dust has proved entirely satisfactory on a small scale, but against which no extensive work has been done, are the bean aphis,[9] the artichoke aphis,[10] the rose aphis,[11] the false chinch bug,[12] the bean thrips,[13] young or immature grasshoppers, and several kinds of hairy caterpillars in their earlier stages.

FIG. 13.—Large power-operated duster for applying dust to combat onion thrips; rear view.

Very recent tests of this dust against the spotted garden slug[14] killed 100 per cent, even when they were only lightly dusted.

DISADVANTAGES OF NICOTINE DUST.

Nicotine dust is by no means a perfect insecticide, being subject to the following disadvantages:

Its volatility causes it to lose strength rapidly, so that unless put up in air-tight containers it must be used promptly after manufacture.

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[9] *Aphis rumicis* L.
[10] *Myzus braggii* Gillette.
[11] *Macrosiphum rosae* L. and *Aphis rosarum* Walk.
[12] *Nysius ericae* Schill.
[13] *Heliothrips fasciatus* Perg.
[14] *Limax maximus* L.

The dust is sometimes disagreeable to the operator, especially if the latter is inexperienced in applying it.

It can not be combined with Bordeaux mixture, except when the latter is dry.

It can not be applied satisfactorily in windy or cold weather.

Its present cost[15] per pound is high.

FIG. 14.—Two types of hand-operated dusters used in an infested pea field: At left, fan type; at right, bellows type.

SUMMARY.

For controlling certain truck-crop insects nicotine dust has several advantages over a liquid spray of nicotine sulphate. Dusting requires much less weight of material per acre, and may be done in a much shorter time with a lighter and less expensive machine, and in most cases at less cost. The tiny particles of dust reach many insects inaccessible to sprays.

Nicotine dust is nicotine-sulphate solution mixed in correct proportion with a dust carrier. Lime alone is ordinarily used for the carrier, but the addition of sulphur to the lime makes the material more effective against most insects.

Nicotine dust kills the insects by paralyzing the nervous system almost immediately. The application should be thorough in order that the dust may come in contact with as many insects as possible.

Dust may be applied with hand dusters for small acreages, horse-drawn outfits for larger acreages, and power-operated outfits for extensive acreages.

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[15] In the year 1922.

Nicotine dust is most effective at temperatures above 65° F., and when the air is still.

For ordinary uses, a dust containing 2 per cent of nicotine is the most satisfactory.

Among the insects satisfactorily controlled with this dust are the melon aphis, the cabbage aphis, the pea aphis, the onion thrips, and cucumber beetles.

Certain diseases, as well as certain insects of truck crops, can be controlled by adding a proportion of powdered sulphur to the nicotine dust used against the insects.

Certain chewing insects attacking truck crops can be controlled by adding 10 per cent of powdered lead arsenate to the nicotine dust used against aphids or thrips, and this combination treatment is advisable when dusting small plants for cucumber beetles.

Several applications may be necessary. These should be made early, i. e., when the insects first appear, before any damage is done.

Nicotine dust loses strength if held for any length of time, or if not put up in air-tight containers. It is likely to be ineffective if applied on a windy or cold day.

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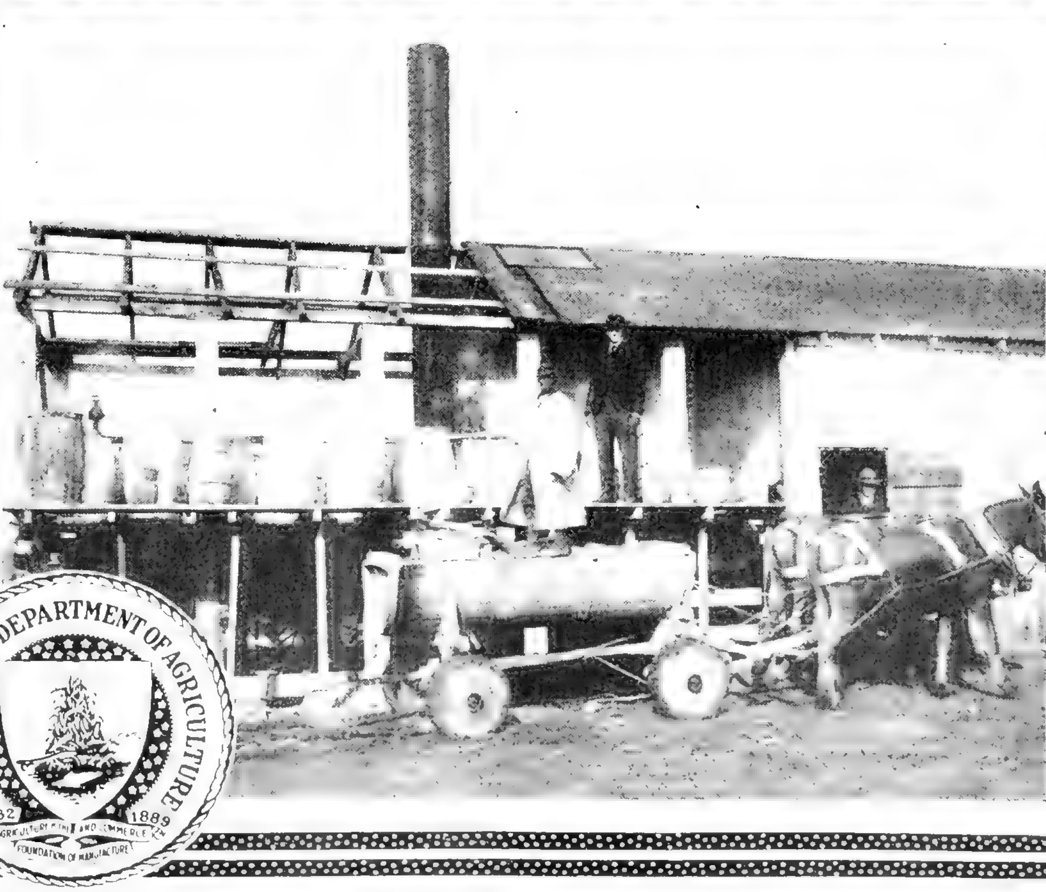
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1285

LIME-SULPHUR CONCENTRATE

Preparation, Uses, and Designs for Plants



UNITED STATES DEPARTMENT OF AGRICULTURE
1862 1889

ANY FRUIT GROWER who is equipped with the proper apparatus can readily prepare lime-sulphur solution for spraying. The equipment need not be elaborate or expensive where small quantities are to be made, since a first-class concentrate can be produced in an ordinary iron kettle suspended over a wood fire. In the first part of this bulletin will be found formulas and suggestions for the making, storing, and diluting of lime-sulphur concentrate. In the latter part suggestions are given on the building of several types of cookers of different sizes, ranging from a very simple 25-gallon kettle to steam plants in which 800 gallons of the concentrate can be prepared in one cooking.

Washington, D. C. December, 1922

LIME-SULPHUR CONCENTRATE.

Preparation, Uses, and Designs for Plants.

E. H. SIEGLER, *Entomologist, Fruit Insect Investigations, Bureau of Entomology*, and A. M. DANIELS, *Mechanical Engineer, Division of Agricultural Engineering, Bureau of Public Roads.*

CONTENTS.

A VALUABLE SPRAY, EASILY PREPARED.

LIME-SULPHUR solution[1] has deservedly won a high place among our present-day orchard spray materials, and is probably used more extensively than any other compound, since it is both an insecticide and a fungicide, effective against certain insects and diseases. It is used during both the dormant and growing seasons. Moreover, lime-sulphur is comparatively cheap, and fortunately can be combined with many other compounds, such as arsenate of lead and nicotine, for the simultaneous control of chewing and sucking insects and certain fungous diseases. Its chief disadvantage is that it is disagreeable to use, owing to its causticity. As the name indicates, it is composed of lime and sulphur, and it is made by boiling these materials together in the presence of water. The chemical changes that take place during the operation are somewhat involved, but the actual process of making the concentrate is comparatively simple.

[1] Lime-sulphur solution described in this bulletin should not be confused with the so-called self-boiled lime-sulphur, which is extensively used in summer spraying of peach trees. The self-boiled lime-sulphur is a mechanical mixture of lime and sulphur, whereas lime-sulphur solution is a chemical combination.

USES OF LIME-SULPHUR.

DORMANT SPRAY.

During the winter or dormant period of deciduous fruit trees lime-sulphur is widely used by fruit growers for the control of the San Jose scale and pear-leaf blister-mite. It is also of value against the oyster-shell scale and the scurfy scale. As a fungicide the dormant application of lime-sulphur is very effective in preventing peach leaf-curl.

DELAYED-DORMANT SPRAY.

Many fruit growers do not apply the dormant spray until the apple-bud tips show green. At this time many of the aphids have hatched and have clustered on the tips (Fig. 1) where they may be killed if nicotine is added to the lime-sulphur solution. Thus the orchardist controls both the scale insects and aphids in the one application instead of making two separate treatments. Care should be taken, however, to complete the spraying by the time the leaf tips begin to separate, since the aphids crawl to the base of the leaves as they unfold and are thus more or less protected from the spray; also, if the delayed-dormant treatment is made too late, the lime-sulphur is likely to burn the expanding foliage. In large orchards and where scale insects are serious, it is not always expedient to delay the dormant treatment until this time, since unfavorable weather conditions may interfere with the complete covering of the orchard within the prescribed period.

FIG. 1.—Aphids clustered on expanding apple bud; proper time to make delayed-dormant spray. Considerably enlarged. (Quaintance and Siegler.)

SUMMER SPRAY.

When trees are in foliage lime-sulphur, at appropriate summer strengths, may be used on all pome fruits, and is of value chiefly as a fungicide for certain diseases, notably apple scab. Its use in the summer also aids in reducing the San Jose scale. For the prevention of leaf-spot of the sour cherry the same strength as that used on the apple should be applied, but on the sweet cherry a weaker spray should be used. (See dilution table, p. 11.) Lime-sulphur solution should never be used on peaches or Japanese plums when the trees are in foliage.

HOMEMADE VERSUS COMMERCIAL CONCENTRATES.

GENERAL COMPARISON.

The chief difference between the homemade product and that sold commercially is in the density of the solutions. The commercial concentrates are usually of a uniform density, testing from about 32° to 33° Baumé, whereas in the homemade solutions the density may vary from 23° to 34° Baumé, depending upon the formula used, the purity of the lime and sulphur, and the care with which it is made. From this it should not be inferred that the homemade product is inferior to the commercial, but if of a weaker strength more of it must be used to compensate for its lower sulphur content. The commercial concentrate is usually a clear, cherry-red liquid, its clarity being due to its having been drawn from settling tanks and carefully strained or filtered. The homemade concentrate is not usually so clear, owing to the presence of a dark greenish, cloudlike sediment, which, however, is so finely divided that it is nowise objectionable.

MAKING LIME-SULPHUR ON THE FARM.

It is impossible to state definitely the conditions under which it is profitable to make lime-sulphur concentrate on the farm. Some orchardists contend that for the average owner there is no economy in doing so. Exceptions to this opinion, however, are manifested by the comparatively large number of home plants that may be found in orchard sections. Unless a grower lives near a commercial plant or factory where this solution is manufactured, it may often be cheaper for him to make it than to purchase it, especially where a nonrefundable charge is made for the barrel container.

The owner of an orchard of 30 to 40 acres or more, in which lime-sulphur is regularly used for spraying purposes, will find it advisable to consider building a simple plant on his farm for the purpose of preparing his own mixture; or it may be mutually advantageous for two or more fruit growers to unite in the construction of a plant, thus effecting a saving over the cost of purchasing the lime-sulphur concentrate. Community plants built on a still larger scale and operated on a cooperative basis have often proved profitable. For description of plants see pages 11 to 41.

MATERIALS FOR MAKING.

The only raw materials required for the manufacture of lime-sulphur concentrates are lime, sulphur, and water.

LIME.

It is essential to use a high-grade, freshly burned[2] stone lime (CaO), known also as lump lime or quicklime, containing at least 90 per cent of calcium oxid and having as low a magnesium content (preferably not to exceed 5 per cent) as can be secured. The presence of magnesium oxid in the lime is very undesirable, since it forms insoluble compounds, thereby increasing the amount of sediment. Before purchasing lime the fruit grower should ascertain its analysis either from the producer or from the State agricultural experiment station.

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[2] Stone lime should also be thoroughly burned, otherwise it will contain carbonates of calcium and magnesium, which will not go into solution.

Different limes behave differently with water, and hence it is often advisable to test a sample before proceeding with the actual cooking operation. This will enable one to ascertain the character of the lime, whether it is quick, medium, or slow in slaking. Limes have been classified by the American Society for Testing Materials as (*a*) quick-slaking, (*b*) medium-slaking, and (*c*) slow-slaking, and it gives the following method for allocating a particular lot: Two or three lumps about the size of a man's fist should be put into a bucket and enough water added barely to cover the lime. If slaking begins in less than 5 minutes the lime is quick-slaking; in from 5 to 30 minutes, medium-slaking; and after 30 minutes, slow-slaking. Slaking is considered to have begun when pieces split off from the lumps or when the lumps begin to crumble. Quick-slaking lime is much to be preferred, since by its use time is saved and there is likewise a greater concentration of heat which aids in the cooking. The use of hot water in slaking the lime, as advocated in this bulletin, will greatly accelerate the action. With slow-slaking lime care should be taken not to use too much water at the start in order to avoid the possibility of drowning the lime. With this type the lime should be placed in a cooker and just enough hot water added to moisten it until there is evidence of slaking, after which additional hot water should be added cautiously from time to time to maintain the action and, at the same time, prevent the mass from burning dry. Medium-slaking lime should be treated in a similar way except that more water may be added without undue danger of drowning the material. When quick-slaking lime is employed the lime may be added to the hot water, a sufficient quantity of the latter being used to cover the lime. During the slaking care should be taken to have a ready supply of additional water on hand to prevent burning.

If preferred high-grade hydrated lime may be substituted for the stone lime, but it will be necessary to use about one-third more of this by weight than is given in the formulas for stone lime. Air-slaked lime should never be used, since this has absorbed carbon dioxid (CO_2) from the air and has thus partly reverted to the original rock or limestone, calcium carbonate ($CaCO_3$).

SULPHUR.

Sulphur has long been recognized as a useful element, and was early employed for medicinal purposes by the ancient Greeks and Romans. At the present time sulphur and its compounds are widely used against insects and plant diseases. It is found upon the market as stick sulphur or brimstone, flowers of sulphur, and commercial ground sulphur, the latter also being known as flour of sulphur. The flowers of sulphur is produced by heating crude sulphur or brimstone until it vaporizes. The vapor is then passed into a cooling chamber, where it is condensed and deposited as a very fine powder on the walls. The commercial, ground material is cheaper than the flowers of sulphur, and if finely pulverized is equally as satisfactory in all respects for the manufacture of lime-sulphur concentrates. It should be about 98 to 99 per cent pure, and this grade is readily obtainable.

CHEMICAL REACTIONS IN THE MAKING OF LIME-SULPHUR CONCENTRATE.

In making lime-sulphur concentrate the first step is to slake the lime (CaO) with water. The union of lime and water produces intense heat and results in the formation of calcium hydroxid ($Ca(OH)_2$). The sulphur is next added, as is also more water, and the entire mass is then thoroughly boiled and agitated until the lime and sulphur have gone into solution. In the course of the boiling several chemical compounds are formed, the more important being calcium pentasulphid (CaS_5) and calcium tetrasulphid (CaS_4), both of which are soluble and are regarded as the most valuable of the lime-sulphur compounds for spray purposes. Another soluble compound, calcium thiosulphate (CaS_2O_3) is also formed, although it is more or less decomposed into free sulphur (S) and calcium sulphite ($CaSO_3$). The latter is insoluble and constitutes the major part of the coarse sediment. As previously mentioned, the magnesium that may be present in the lime forms insoluble compounds, thereby increasing the amount of sediment or "sludge."

FORMULAS FOR MAKING LIME-SULPHUR CONCENTRATE.

In selecting a formula for the making of lime-sulphur concentrate the orchardist will naturally desire to use the one that will produce the best results at the minimum cost. Although it is impossible in the present bulletin to recommend a formula that will best meet the requirements of the individual or community plant, it is hoped that the suggestions given herein will be of value in this connection.

Chemical and field tests have shown that lime and sulphur when boiled in the proper amount of water will go into solution best in the proportion of 1 part of the former to from 2 to 2¼ parts of the latter, provided the chemicals are pure. In most formulas the lime and sulphur are used in the foregoing proportions. Three formulas extensively and successfully used at the present time are here given along with the chief advantages and disadvantages of each.

Formula 1.

Stone lime	pounds	80
Sulphur (commercial ground)	do	160
Water to make finished product	gallons	50

Owing to the relatively large amount of lime and sulphur in comparison with the volume of the finished product, the use of this formula results in a highly concentrated material testing 32° to 34° Baumé. On account of the comparatively small amount of water used, the principal disadvantage of this formula is that there will be some waste of materials by the formation of insoluble compounds, such as calcium sulphite ($CaSO_3$) or uncombined lime and sulphur. If, however, the raw materials are not too expensive, then this loss is not serious, since the cost of labor and fuel in producing a high-test concentrate is no more than in making a product of lower density. By referring to the table of dilutions (p. 11), it will be noted that the high-test concentrate will make more diluted spray solution than a concentrate of lower density. The high-test concentrate will also require less storage space, which is something of an item if large quantities of spray are needed.

Formula 2.

Stone lime	pounds	50
Sulphur (commercial ground)	do	100
Water to make finished product	gallons	50

This formula is perhaps the most popular among those who make their own solution on the farm, since by its use a reasonably high-test concentrate can be made and, at the same time, the proportion of residue or sediment is not unduly large. In cooking experiments with this formula, the Bureau of Entomology has produced solutions testing from 27° to 28° Baumé.

Formula 3.

Stone lime	pounds	50
Sulphur (commercial ground)	do	100
Water to make finished product	gallons	65

In this formula it will be noted that considerably more water is used, resulting in a less dense finished product. With good materials, however, the resulting concentrate should test from 23° to 24° Baumé. The proportion of sediment is less in this than in Formulas 1 and 2; in other words, a larger proportion of the lime and sulphur go into solution, due to the more complete utilization of the raw materials.

PREPARATION OF LIME-SULPHUR CONCENTRATE.

SOURCES OF HEAT.

As is noted elsewhere, lime-sulphur may be cooked over a wood fire in open vessels, such as an iron caldron or kettle, or it may be made by the use of live steam or steam in closed coils. The method of preparation is essentially the same regardless of the source of heat, although if the cooking is done over a fire or by means of closed steam coils, it will be necessary to add extra water to replace that which is lost through evaporation. In the case of live steam no extra water will be required since there is usually sufficient condensation of the steam during the boiling process to equal the water lost through evaporation.

AGITATION.

During the course of the cooking it is essential to keep the materials well stirred. With small cookers this is usually accomplished by the use of a wooden paddle, while in large plants the stirring is usually done by a mechanical agitator operated by power from a gasoline or steam engine. It is very important to agitate thoroughly, especially during the early stages of the cooking and while the concentrate is being drawn from the cooking tank, to provide an even distribution of the sediment. Agitation is also sometimes secured by the issuance of live steam from perforated steam pipes in the bottom of the cooker (Fig. 14).

MAKING THE CONCENTRATE.

PRELIMINARY STEPS.

As previously stated, the materials needed for the manufacture of lime-sulphur concentrate are lime, sulphur, and water. In order to facilitate the making of the concentrate certain preliminary preparations should be made before the actual process of cooking is begun. The usual procedure is to weigh out accurately the desired amount of sulphur and to mix it with water until it is of a smooth, pasty consistency, taking care to break up all the lumps. This will require considerable time and patience if done by hand, but with the aid of a mixing machine, as shown in Figure 6, the work of making sulphur paste is greatly lessened. If a mixing machine is employed, water may be drawn from the water storage tank, a sufficient amount being used to make a paste that is not too thick to flow freely. Sulphur paste may be conducted from the mixing machine to the cooking tank by means of a trough. Although often desirable, it is not absolutely necessary to make a paste of the sulphur, since the latter may be used in dry form, provided the lumps are first removed by screening. The important consideration is to break up the sulphur lumps as completely as possible. Sulphur should never be dumped into the cooking vessel in large bulk, but should be sprinkled gradually or poured so that a homogeneous mixture will result.

In order to expedite the slaking of the lime, it is desirable to use hot or boiling water. Sufficient water to slake the lime may be heated while the sulphur is being prepared. As described in this bulletin, this is automatically provided for in the larger plants which have a water storage tank heated by either furnace flues or steam coils. Assuming that there is sufficient hot water in the cooking vessel and that the sulphur is free from lumps, the next step is to place the requisite quantity of lime into the cooker and begin the slaking. More water should be added from time to time to prevent burning of the lime. Sulphur should preferably be added when the slaking is well under way or promptly at the conclusion of the slaking. As soon as this has been done, the full quantity of water (preferably hot) should then be added so as to bring the contents up to the volume called for in the formula and an additional amount should be used to equalize that which is expected to be lost through evaporation. If desired, the sulphur may first be placed in the cooking vessel with a little water and the lime added later. After the lime is slaked additional water is added to bring the contents up to the required volume, as described above.

MEASURING GAUGES.

It will be convenient to have a graduated measuring device to enable the operator at any time to ascertain readily the volume of the solution in the cooking vessel, since best results are obtained by not allowing the contents to fall below the volume of the finished product. In small cooking plants an ordinary measuring stick will serve this purpose. This can be made from a wooden strip with notches cut in the edges to indicate the contents. Thus, if a 50-gallon

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batch of the concentrate is to be made over an open fire, it will be well to start with about 60 gallons to allow for the evaporation. The measuring stick in this instance should have at least two notches, one representing 50 gallons, or the volume of the finished product,[3] and the other 60 gallons, or the volume at the start. In the instance of larger plants the cooking tanks can be readily marked or a float gauge installed to indicate the volume.

COOKING.

The cooking is done by actively boiling the lime and sulphur together until they have practically gone into complete solution or, in other words, until the sulphur granules have all dissolved.[4] Abundant experience has shown that this will require about 50 minutes of vigorous and continuous boiling, with a latitude of about 5 minutes either way. Agitation should be thorough throughout the operation, and particularly at the start. Very often the orchardist does not fully appreciate the importance of accurately timing the boiling, and so produces an underboiled or overboiled concentrate. In either case, the amount of sediment is increased. Strict adherence to the proper boiling period is important if the best results are to be obtained and, as previously noted, care should also be taken not to allow the volume of the boiling mass to drop below that given for the finished product.

Care required in making and handling.—During the cooking the mixture should be watched and any sulphur lumps or globules formed should be broken up by means of a paddle. When working over open kettles or vats, care should be taken to protect the eyes from the injurious fumes and sulphur particles that may pass off. For this purpose the operator may wear goggles. Lime-sulphur solution is also very caustic and injurious to the skin so that care should be exercised when handling it. The use of leather gloves well oiled or greased on the inside and outside is advised. If gloves are not worn it is well to protect the hands and wrists with an application of vaseline.

STRAINING THE PRODUCT.

As soon as the cooking has been completed the lime-sulphur concentrate should be drawn off (see also page 24), strained, and run into a settling tank, if one is used, or directly into the storage receptacles. A strainer (brass or tinned iron, *never copper*) of 20 meshes to the inch will remove the coarser particles so that the material passing through will be satisfactory for spraying purposes. Very often, however, a still finer screen, 30 to 50 mesh, is used to remove the finer sediment, or, in some instances, the material is passed through two strainers, the first a 20-mesh to remove the coarser particles, and the second a 30 to 50 mesh. In some commercial and community plants the concentrate is run through a filter press which removes both the fine and coarse sediment.

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[3] Hot liquids contract on cooling, the rate of contraction of water being approximately 4 per cent on cooling from the boiling point to 60° F. Thus it will be found that 50 gallons of lime-sulphur concentrate at the close of the cooking will have a volume of about 48 gallons after it has cooled to 60° F.

[4] To determine when the sulphur granules have gone into solution, dip out some of the material and slowly pour it from one container into another, observing whether or not the granules are present.

CLEANING THE COOKING TANK.

The cooking tank should be cleaned after each cooking by using a liberal supply of hot water and washing out any deposits that adhere to the tank before they cool sufficiently to become hard and caked. By so doing, a better subsequent batch is assured.

SEDIMENT OR SLUDGE.

The coarse sediment is of no use for spraying purposes, but if it should contain considerable uncombined sulphur it may be recooked with the next batch, thereby utilizing that which would otherwise be discarded. However, in well prepared solutions the amount of uncombined sulphur is so small as not to affect to any appreciable extent the subsequent batch. If for any reason the quantity of sludge-sulphur is large and is employed in the next cooking, the effect is merely to produce a higher-test concentrate. The fine siltlike sediment which ordinarily passes through a 20-mesh screen is not objectionable for spraying purposes and need not be removed from the concentrate.

SETTLING TANKS.

In commercial plants a clear concentrate of cherry-red color free from sediment is sometimes obtained by the use of settling tanks into which the material is drawn immediately after boiling. The sediment works to the bottom of the tank, leaving the clear solution above.

TESTING THE CONCENTRATE.

As soon as the lime-sulphur concentrate has cooled the clear solution should be tested with a hydrometer, as described on page 10. The density of the solution should then be recorded or plainly marked on the storage container. Most hydrometers are graduated to test accurately when the solution is at 60° F.

STORING THE CONCENTRATE.

Most orchardists will find that storage of the concentrate in 50-gallon wooden barrels will best meet their requirements. Care should be taken to use only clean barrels free from acids,[5] strong alkalies, or soap, since these materials tend to break down the lime-sulphur. The barrels should be in good condition with hoops well driven, since there will be trouble with leakage unless the barrels are tight. If considerable quantities are stored, as in commercial or community plants, iron tanks are preferable.

In storing lime-sulphur concentrate it should be protected from the air, since exposure causes crystals and a crust formation.[6] The barrels in which it is stored should be completely filled and tightly corked, or, if the concentrate is kept in open containers, a thin layer of medium to heavy oil should be poured on as a protective covering. If the lime-sulphur is to be dipped out of these containers, it will be necessary at first to skim off the oil, but if the

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[5] If vinegar barrels are to be used, they must be thoroughly cleaned to remove all traces of acid.

[6] If crystals are formed they may be dissolved in hot wate.

container is provided with a valve at the bottom the concentrate can be readily drawn off without disturbing the oil.

Storage temperature.—No special care in storage is necessary, except that it is well not to expose the concentrate to low temperatures on account of the danger of freezing and consequent breaking of the containers. If the lime-sulphur is stored in buildings during the winter, it is not likely to freeze, since a solution testing 32° Baumé does not freeze until the temperature reaches 5° F. A solution of lesser density will freeze at a higher temperature, while one of greater density has a still lower freezing point.

Using old lime-sulphur.—Concentrated lime-sulphur is not impaired either by freezing or standing in storage except in so far as it may be converted into crusts or crystals as a result of leakage or undue exposure to the air. (See footnote on p. 9.)

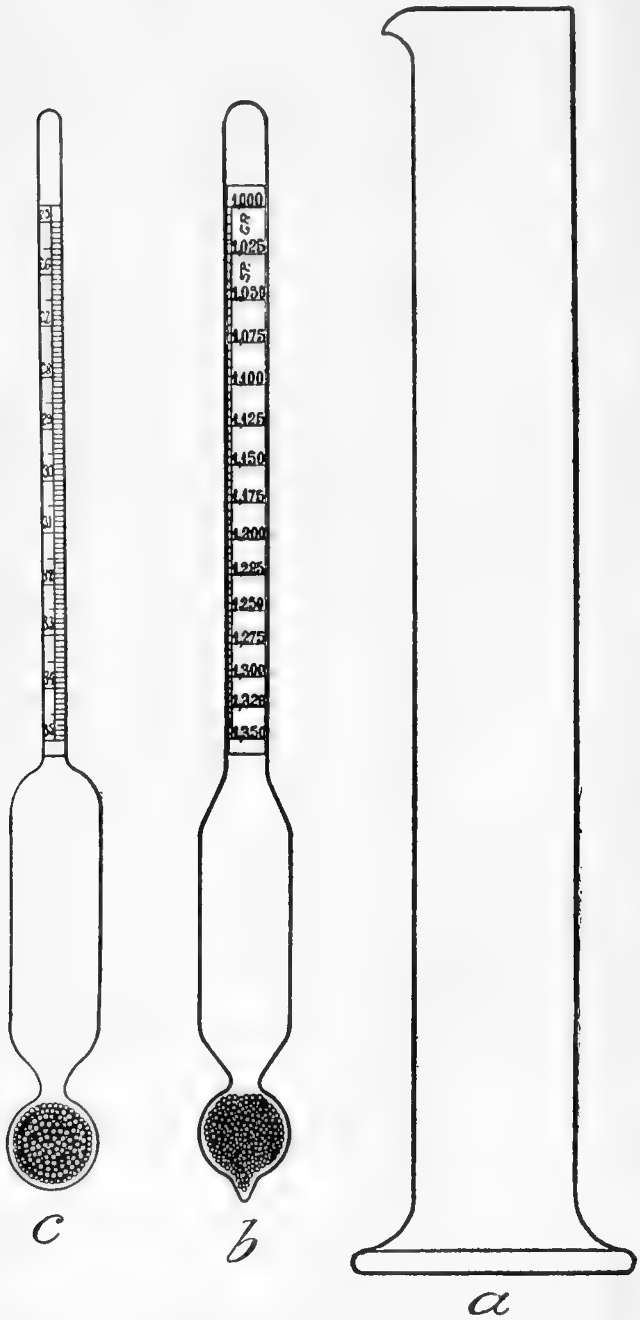

Fig. 2.—Hydrometer outfit for determining specific gravity of lime-sulphur concentrate: *a*, Cylinder for liquid to be tested; *b*, specific gravity spindle; *c*, Baumé spindle. (Quaintance and Siegler.)

DILUTING FOR SPRAYING PURPOSES.

Hydrometer outfit.—A hydrometer outfit (Fig. 2) consists of a hydrometer and a tall glass cylinder in which the liquid may be tested. Such an outfit is not expensive and may be purchased from dealers in chemical supplies, laboratory apparatus, or orchard supplies. For the testing of lime-sulphur concentrate the instrument should be suitable for testing liquids heavier than water. The hydrometer consists of a glass spindle weighted at the lower end. The upper part of the instrument is provided with a graduated scale on which the density of the solution is indicated. Some instruments are equipped with the specific gravity scale, others have the Baumé scale, and some have both scales. In testing use only the clear liquid which, preferably, should be at a temperature of about 60° F. After the density of the concentrate is known, the proper rate of dilution for spraying purposes is ascertained by referring to a table of dilutions,[7] as shown in Table 1.

TABLE 1.—*Dilution table for concentrated lime-sulphur solutions.*

Degrees Baumé.	Specific gravity.	Number gallons concentrated lime-sulphur to make 50 gallons spray solution.			Degrees Baumé.	Specific gravity.	Number gallons concentrated lime-sulphur to make 50 gallons spray solution.		
		Summer or foliage strength.	Winter or dormant strength.				Summer or foliage strength.	Winter or dormant strength.	
			San Jose scale.	Blister mite.				San Jose scale.	Blister mite.
36	1.330	1¼	5½	4¾	27	1.229	2	8	6¾
35	1.318	1¼	5¾	5	26	1.218	2	8½	7¼
34	1.306	1½	6	5	25	1.208	2	8¾	7½
33	1.295	1½	6¼	5¼	24	1.198	2¼	9¼	8
32	1.283	1½	6½	5½	23	1.188	2¼	9¾	8¼
31	1.272	1½	6¾	5¾	22	1.179	2¼	10¼	8¾
30	1.261	1¾	7	6	21	1.169	2½	11	9¼
29	1.250	1¾	7¼	6¼	20	1.160	2½	11½	9¾
28	1.239	1¾	7½	6½					

LIME-SULPHUR PLANTS.

SIZE OF PLANTS.

The size of plants depends largely upon requirements and whether the owner intends to make the concentrate only for his own use or also to sell it to his neighbors. Another factor that influences the size of plant is the time when the work will be done. If the concentrate is to be made only as needed, the plant should be large enough to turn out concentrate in sufficient quantity to avoid any interference with the spraying work in the field. On the other hand, if a large storage tank is provided and the solution is properly protected, a smaller plant may be installed, batches made up during slack periods, and time conserved when spraying operations begin. Then, again, there is an advantage in having a stock always on hand for summer spraying and to supply neighbors who may wish to purchase small quantities at times when other work would have to be stopped in order to put the plant in operation.

Lime-sulphur cooking plants may be grouped under two general heads, (1) small orchard plants and (2) large orchard or community plants.

SMALL ORCHARD PLANTS.

Small orchard plants may have capacities as low as 25 gallons of concentrate at a cooking, although 40 to 50 gallons are more usual.

KETTLE PLANTS.

The simplest plant consists of an old-fashioned caldron or kettle such as was once used for soap making or for scalding hogs. The modern form of stock-feed cooker can be adapted to lime-sulphur cooking. If used it is well to surround it with a 6-inch wall of reinforced concrete, except where the door openings occur. If this is

[7] On foliage of sweet cherry use one-third less of the concentrate than that given in the table of dilutions.

not done, the iron jacket surrounding the kettle and stove is likely to rust out rapidly when used for making lime-sulphur concentrate. Wood is used as fuel for cooking in these simple plants.

Figures 3 and 4 show a somewhat improved kettle type of cooker. In these plants the kettle has been permanently set in masonry with

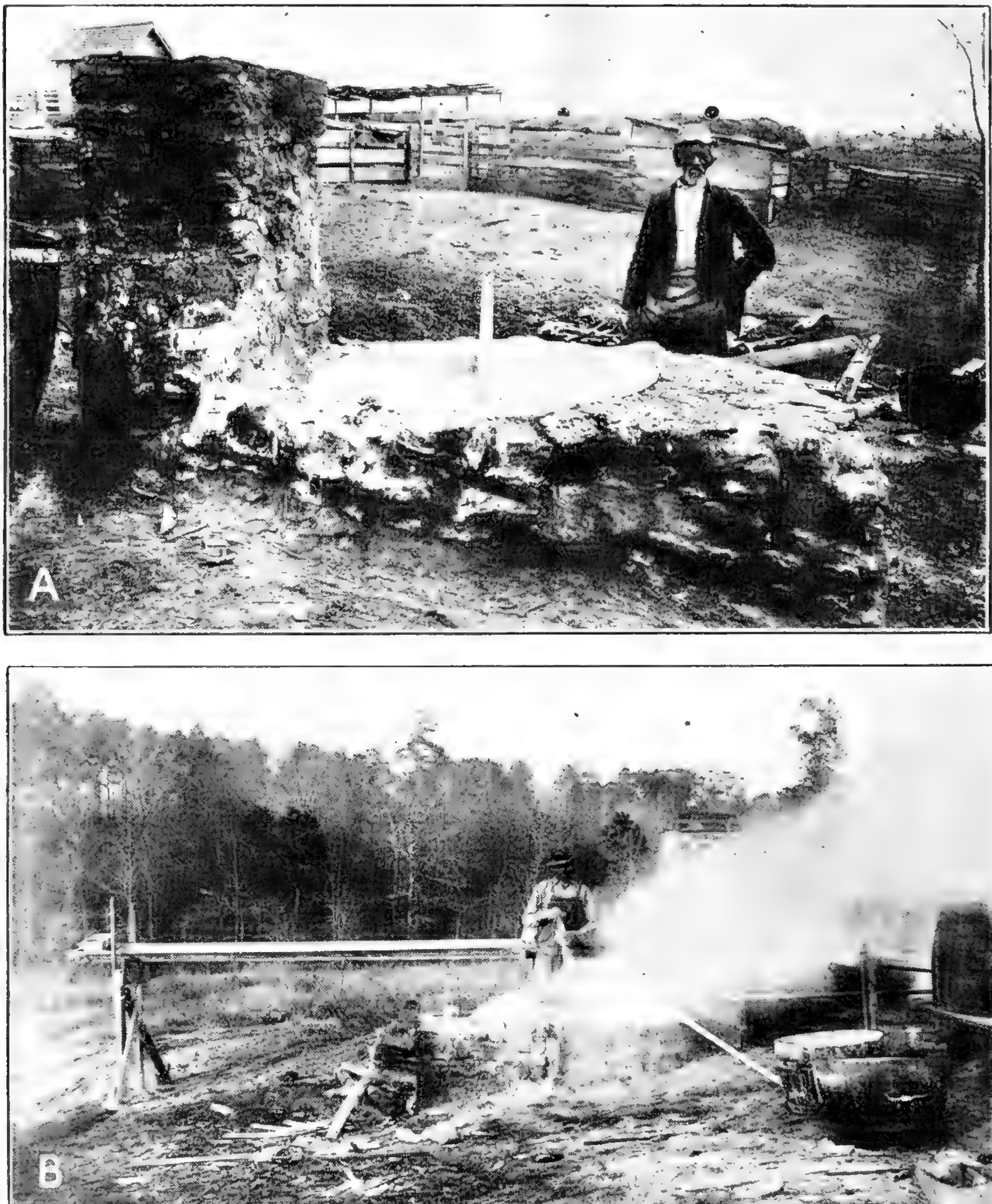

FIG. 3.—Simple types of lime-sulphur cooking plants. These are relatively inexpensive to build and are well adapted to the making of lime-sulphur concentrate in small quantities. In *A*, all materials and the finished product must be lifted by hand; in *B*, the water is piped to the cooker, and the hillside location and trough facilitate straining and filling.

sufficient space for a fire beneath it. Inclosure of the fire decreases the time required to start boiling and assures more even cooking. The plant shown as *B*, Figure 3, has advantages over the plant indicated as *A*, in that water is piped to the cooker and there is a trough so situated that filling of either barrels or spray tank is facilitated.

The portable strainer box resting upon the end of the trough is held directly under the low end during filling and thus catches and removes the coarser sediment. The undesirable features of such plants are the necessity for dipping out the finished product and their more or less limited capacity.

FURNACE-COOKING PLANTS

Figure 5 shows a simple orchard plant built in a hillside and arranged so that the finished product may be drained by gravity, stored near by, and later run into the spray tank or containers, which may be filled by gravity directly from the storage barrels. The elevation of the storage barrels shown in Figure 5 necessitates the use of a hand pump. This might be eliminated if the topography permitted drawing and straining directly into the barrels. One hundred and fifty gallons at a cooking can be handled conveniently with a plant of this type. If the upper tank for heating water for a subsequent batch is provided, the time interval between cooking is materially reduced.

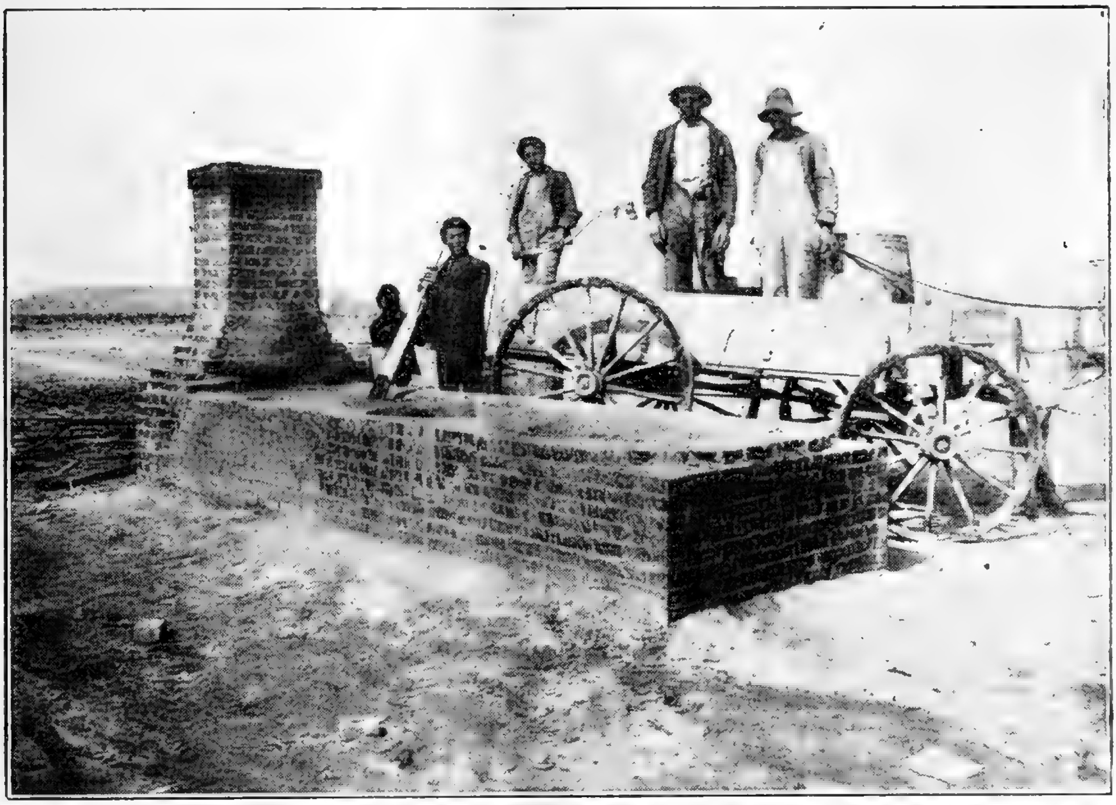

FIG. 4.—A simple form of lime-sulphur cooking plant similar to those shown in Figure 3 but with practically triple the capacity. Three kettles afford means for continuous operation, one being used for heating water and the others for cooking the concentrate. An undesirable feature is that the finished product must be dipped out.

Figure 6 shows a popular type of farm plant in which wood is used as fuel. Figures 7, 8, and 9 show, in plan and elevation, the details of the plant and Figures 10 and 11 show two arrangements of all equipment and indicate the sequence of operations in connection with this single-cooker furnace-type plant. In Figure 10 a level location is assumed with driveways leading to door openings *A*, *B*, and *C*. Figure 11 shows the same plant arranged for either hillside or level ground location. In this plant there are two tanks, one for heating water preparatory to making a batch of concentrate, and the other for cooking the solution. The water tank is located at the rear of the cooking tank with its bottom higher than the elevation of the mixture in the cooking tank. This allows better control of the hot water supply. Directly under the cooking tank is a brick furnace fitted with a grate having an ash pit below. The flue from the combustion chamber to the smoke pipe is carried under and in contact with the bottom of the water heating tank so that while one batch is cooking,

FIG. 5.—Hillside furnace type of lime-sulphur cooking plant.

the water for the next mix is being heated. A sulphur paste mixer consisting of a barrel mounted on bearings is supported on a frame above the platform. The barrel can be filled through an opening in its side and revolved either by hand or motor power so as thoroughly to mix the sulphur paste. If the barrel is in a fixed position a portable trough is used to lead the paste from the barrel into the cooking tank. The cooking vat is fitted with a revolving agitator described on page 40 which is mounted on a steel shaft extending through the tank and wall and fitted with a pulley. The agitator is revolved by means of a belt and gasoline engine. Two outlets are provided in the front end of the cooking tank, one located so that the bottom of the hole is 3 inches from the bottom of the tank and the other in the bottom as near the end as possible. The bottom outlet is used in thoroughly cleaning the tank. The concentrate is drawn off through the upper outlet into a filter tank alongside of the furnace. The filter tank is fitted with three removable strainer boxes which remove the heavy sediment or sludge. These strainer boxes may be of any convenient size and should have bottoms of brass or tinned iron wire, 30 to 50 meshes to the inch. The use of 3 boxes permits a more rapid flow of solution. The boxes may be slid along in rotation under the outlet pipe so that as soon as the one directly under the outlet contains an appreciable deposit of sludge it may be pushed along to the end position, removed, and emptied. Meantime the next box has come into position without interrupting the flow. The cleaned box is then replaced in the first position. Barrels are filled from the filter tank, a short piece of rubber hose being used to direct the flow. Old automobile inner tubes serve the purpose.

A small gasoline engine of 1½ to 2½ horsepower will drive the agitator, but if motor power is not available the stirring may be done by hand with a long-handled wooden hoe.

The operation of this plant, if arranged as in Figure 10, is as follows: The materials are delivered in wagon lots at door A and are stored in bins as indicated. The size of the storage bins will depend upon the quantity of the materials to be purchased at one time. In some of the smaller plants storage space is not provided, lime and sulphur being purchased only as needed and used, but the availability of storage space may mean a saving in time and expense since the materials may then be hauled in as return loads in advance of the spraying season and thus be on hand when needed.

When operation commences, sulphur and lime are taken from bins as indicated by lines *D–F*, and *E–G*, and weighed on scales located conveniently to the working platform. After weighing the materials are raised to the working platform, the sulphur being carried to the mixer, line *I–J*, while the lime goes directly to the cooking tank as indicated by line *K–L*. Hot water, line *T*, for slaking the lime is drawn from the hot water tank while that required for making the sulphur paste is supplied from the same source by bucket or hose, along line *N*. The sulphur paste is run into the cooking tank as indicated by line *O*. The cooked concentrate is drawn off by line *Q* and run into the filter tank from which the strained solution is drawn as indicated by line *R* and barreled or by means of a long hose connection supplied directly by gravity or pump to a spray tank backed up to door *C*. Line *S* indicates the course of concentrate intended for immediate use while the course of that barreled and stored for future delivery to trucks or wagons through door *B* is as indicated. Lines *U* and *V*, terminating at *W*, show the convenient disposal point for the sludge and waste. Fuel would be brought in through door *X*. This arrangement provides for the movement of materials up one side of the building, through the cooking and straining apparatus, and down the other side, thus avoiding all interference between operations. The floor space required, not including any for raw materials or finished product, is approximately 24 by 26 feet.

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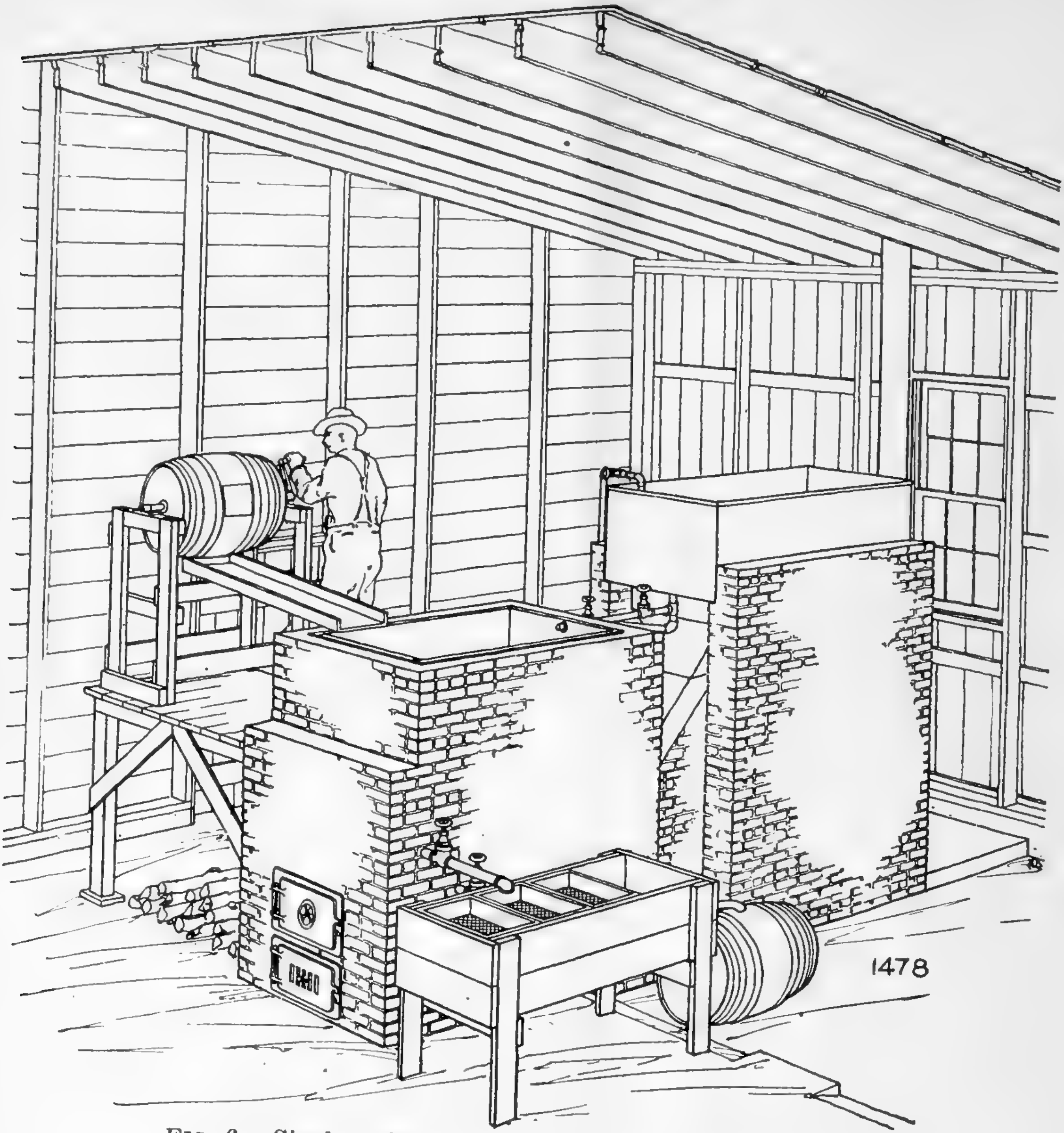


FIG. 6.—Single-cooker furnace type of lime-sulphur plant.

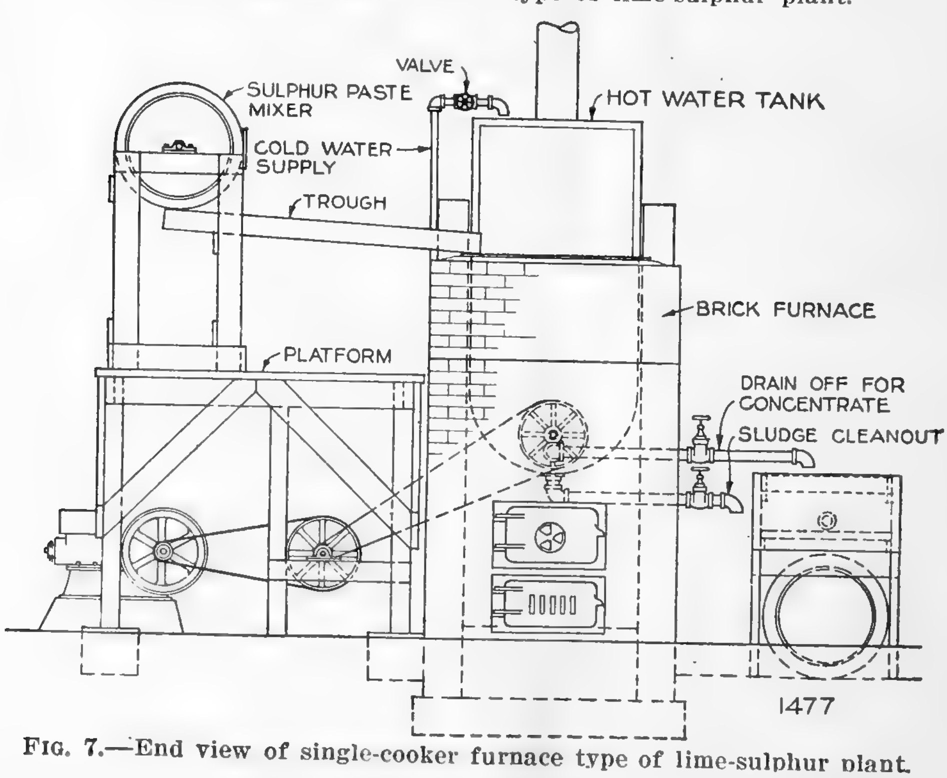


FIG. 7.—End view of single-cooker furnace type of lime-sulphur plant.

In a plant arranged as shown in Figure 11 the materials are delivered at and stored in the bins. From the bins they are carried to the scales and weighed, and thence to the sulphur mixer and cooking

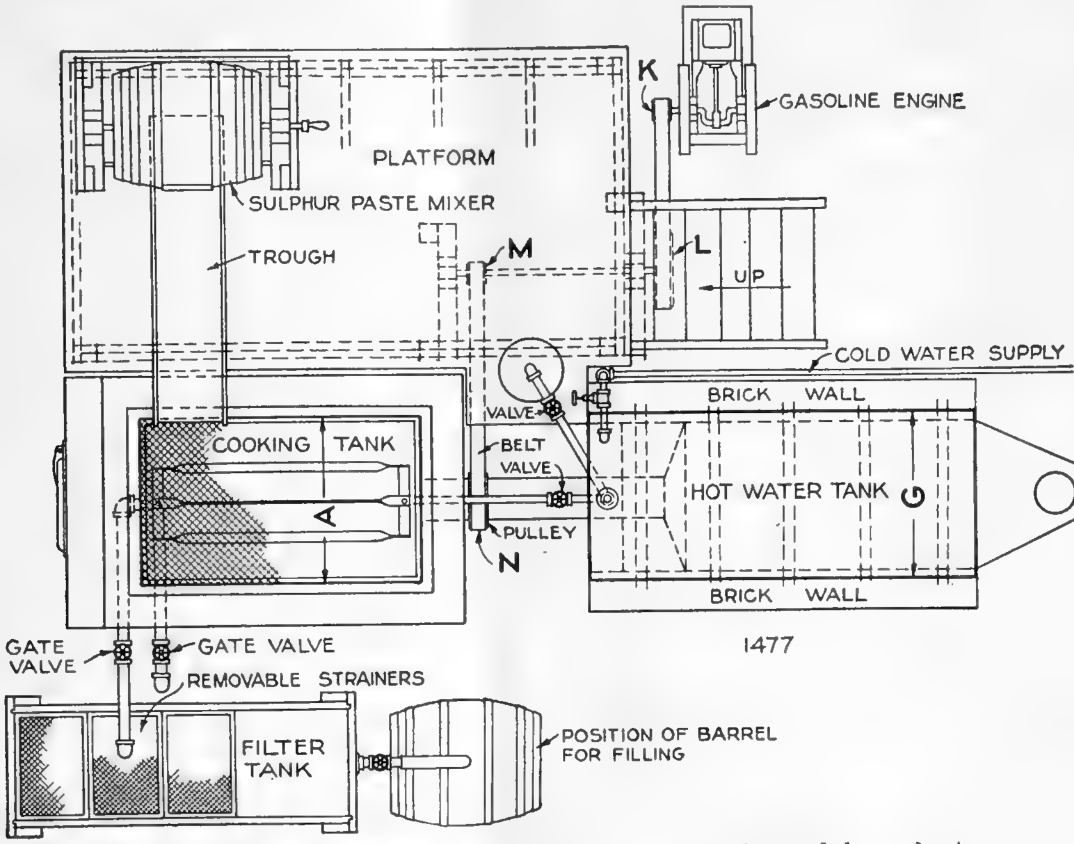


Fig. 8.—Plan of single-cooker furnace type of lime-sulphur plant.

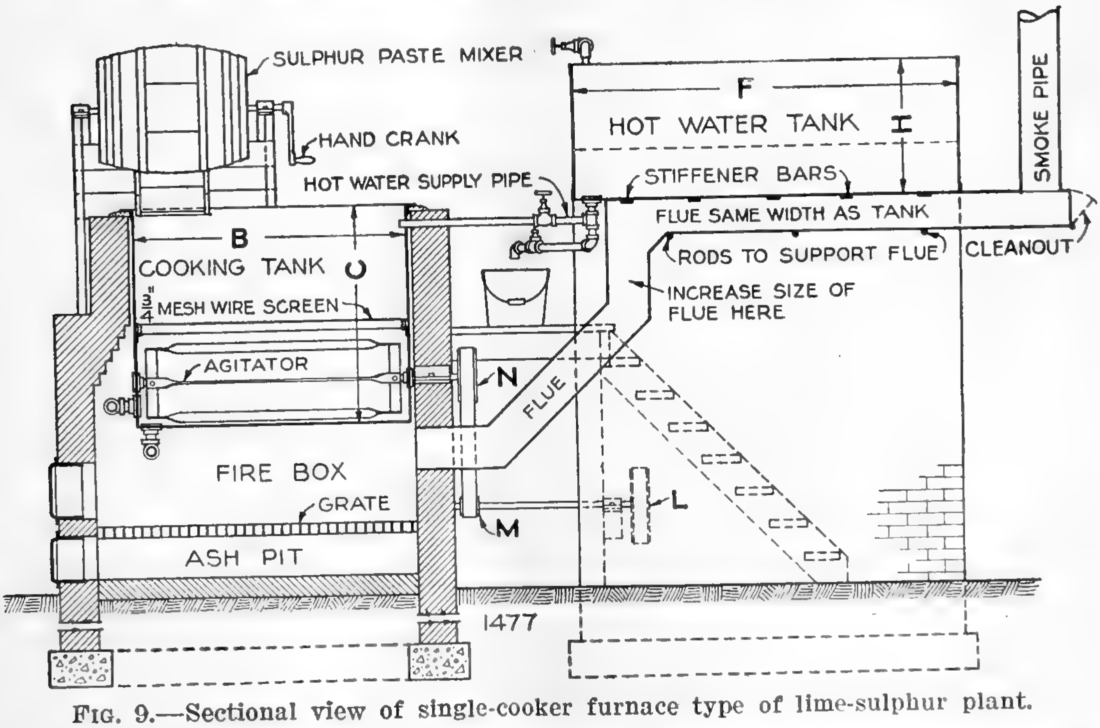


Fig. 9.—Sectional view of single-cooker furnace type of lime-sulphur plant.

tank. If the site is on a hillside, and the storage floor is at or near the level of the working platform, the materials may be handled to better advantage. The working platform may be extended to the wall of the storage room, the scales being placed on the platform or,

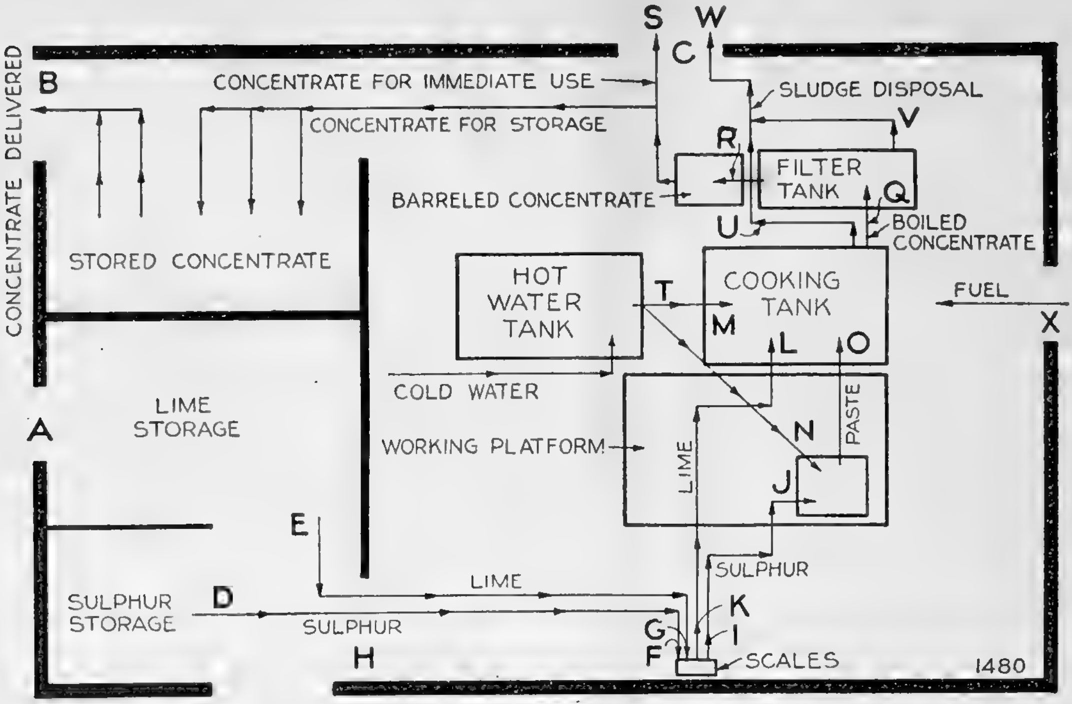


FIG. 10.—Routing diagram for single-cooker furnace type of lime-sulphur plant.

if the levels are slightly different, the scales may be placed in the storage room and a runway erected between the storage room and platform. The boiled product is drawn off, strained, and barreled or piped as in the arrangement illustrated in Figure 10. Thus storage and immediate delivery of the barreled product are provided for at one end of the building instead of at separate points as in Figure 10. All routing is indicated by marked lines with arrows. The floor space required, not including any for raw materials or the offset space marked stored concentrate, is approximately 25 by 24 feet. Additional concentrate storage may be had by extending the small shed as required.

Dimensions, capacity, and detailed data for this plant (Figs. 6, 7, 8, and 9) are given in Tables 2 and 3.

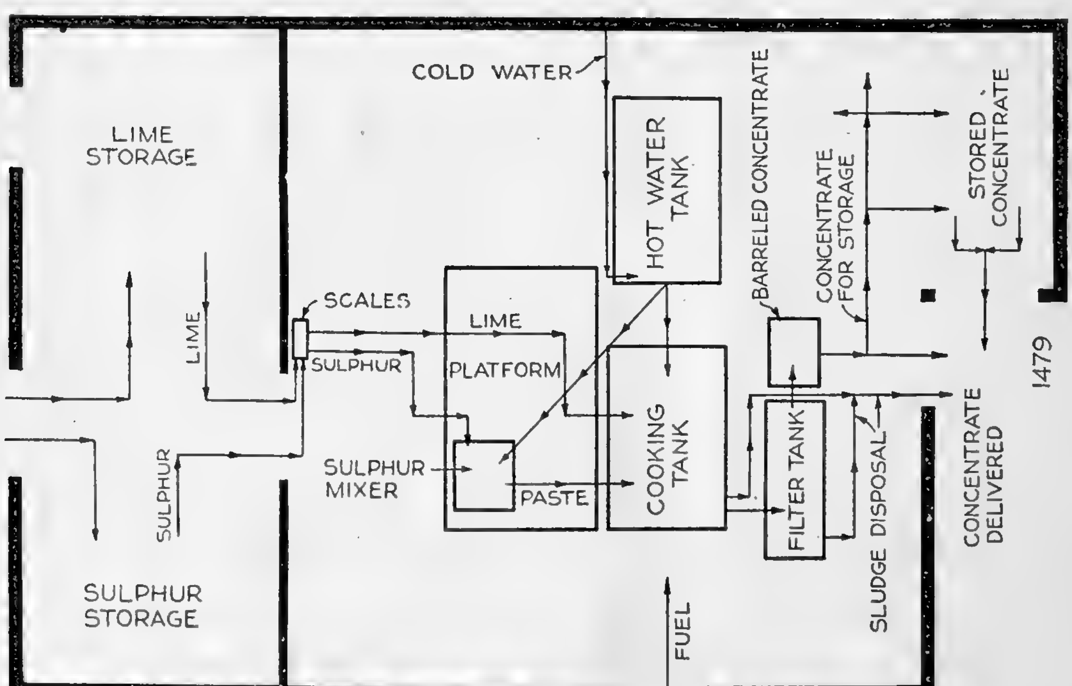


FIG. 11.—Alternate routing diagram for single-cooker furnace type of lime-sulphur plant.

TABLE 2.—*Furnace and steam plants for lime-sulphur.*

Capacity of plant, each cooking.		Cooking tank.						Water-heating tank.				Agitator (each tank).								Supports under water tank.			Agitator drive.					
		Dimensions (see Fig. 12).						Rectangular.				Arms (cast-iron pulleys).			Shaft.		Paddles.		Center agitator shaft from bottom tank.				Gasoline engine.		Diameter of pulleys.			
Gallons.	Barrels, 50 gallons.	A	B	C	D	E	Gross volume.	Length F.	Width G.	Depth H.	Gross volume.	Number.	Diameter.	Width.	Diameter.	Length.	Number.	Size.		Number.	Spacing.	Description.	Horsepower.	Revolutions per minute.	K	L	M	N
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
		Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Cu. ft.*	*Ins.*	*Ins.*	*Ins.*	*Cu. ft.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ft. in.*		*Ins.*	*Ins.*									
150	3	24	48	48	36	12	30	84	24	24	28	2	10	2	1 1/4	5 4	4	3/8 by 2 1/2	6	5	(a)	(b)	1 1/2–2 1/2	550	4	12	4	12
300	6	36	60	48	30	18	55	84	36	30	52	2	15	2	1 1/4	6 4	4	1/2 by 2 1/2	8 1/2	5	(a)	(b)	1 1/2–2 1/2	500	4	12	4	10
400	8	48	72	48	24	24	86	84	48	30	70	3	20	2	1 1/2	7 4	4	1/2 by 2 1/2	11	5	(a)	(b)	1 1/2–2 1/2	450	6	12	4	15
600	12	36	c60	c48	c30	18	110	84	54	42	110	2	15	2	1 1/2	6 4	4	1/2 by 2 1/2	8 1/2	5	(a)	(b)	2 1/2–5	400	6	12	4	12
800	16	48	c72	c48	c24	24	172	84	66	48	154	3	20	2	1 1/2	7 4	4	1/2 by 2 1/2	11	5	(a)	(b)	2 1/2–5	350	8	12	4	15

[a] Equal.
[b] 3-inch I beams or old iron strong enough to support tank and resist sagging.
[c] Two tanks.

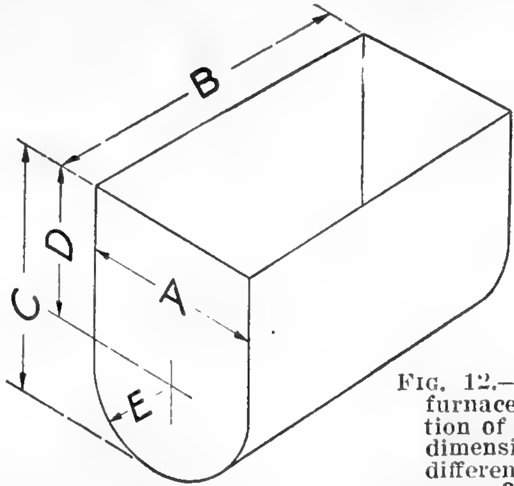


FIG. 12.—Diagram of cooking tank for furnace and steam plants for preparation of lime-sulphur concentrate. (For dimensions of tanks for plants of different capacities, see Table 2, Columns 3 to 7.)

TABLE 3.—*Brick furnace plants.*

Capacity of plant.	Space requirements, not including storage space for materials or concentrate.			Ash pit.			Furnace.			Flue dimensions.		Smoke pipe.
	Length.	Width.	Height.	Length.	Width.	Height to underside grate.	Length.	Width.	Height grate to tank.	At breeching.	Under water tank.	
	1	2	3	4	5	6	7	8	9	10	11	12
Galls.	*Feet.*	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*	*In.*	*Ft. In.*	*Ft. In.*	*In.*	*In.*	*In.*	*In.*
150	24	22	12	4 9	2 1	9	4 9	2 1	21	9 by 9	20 by 7	9
300	26	24	12	5 9	3 1	9	5 9	3 1	21	9 by 9	32 by 7	9
400	28	26	12	6 9	4 1	9	6 9	4 1	21	10 by 10	44 by 10	10
600	25	20	19	5 9	3 1	9	5 9	3 1	21	10 by 10	48 by 10	10
800	26	23	20	6 9	4 1	9	6 9	4 1	21	10 by 10	58 by 10	11

STEAM-COOKING PLANTS.

Steam is preferable to a wood fire in cooking lime-sulphur concentrate as it affords better control of the heat, but it is doubtful whether it would be economical to install a steam-cooking plant having a capacity of less than 400 gallons per cooking.

Steam may be introduced into the mixture through either a perforated or a closed pipe coil placed in the cooking tank and slightly above the bottom. It is generally preferable to cook by live steam admitted through a perforated pipe, since in cooking there is a cer-

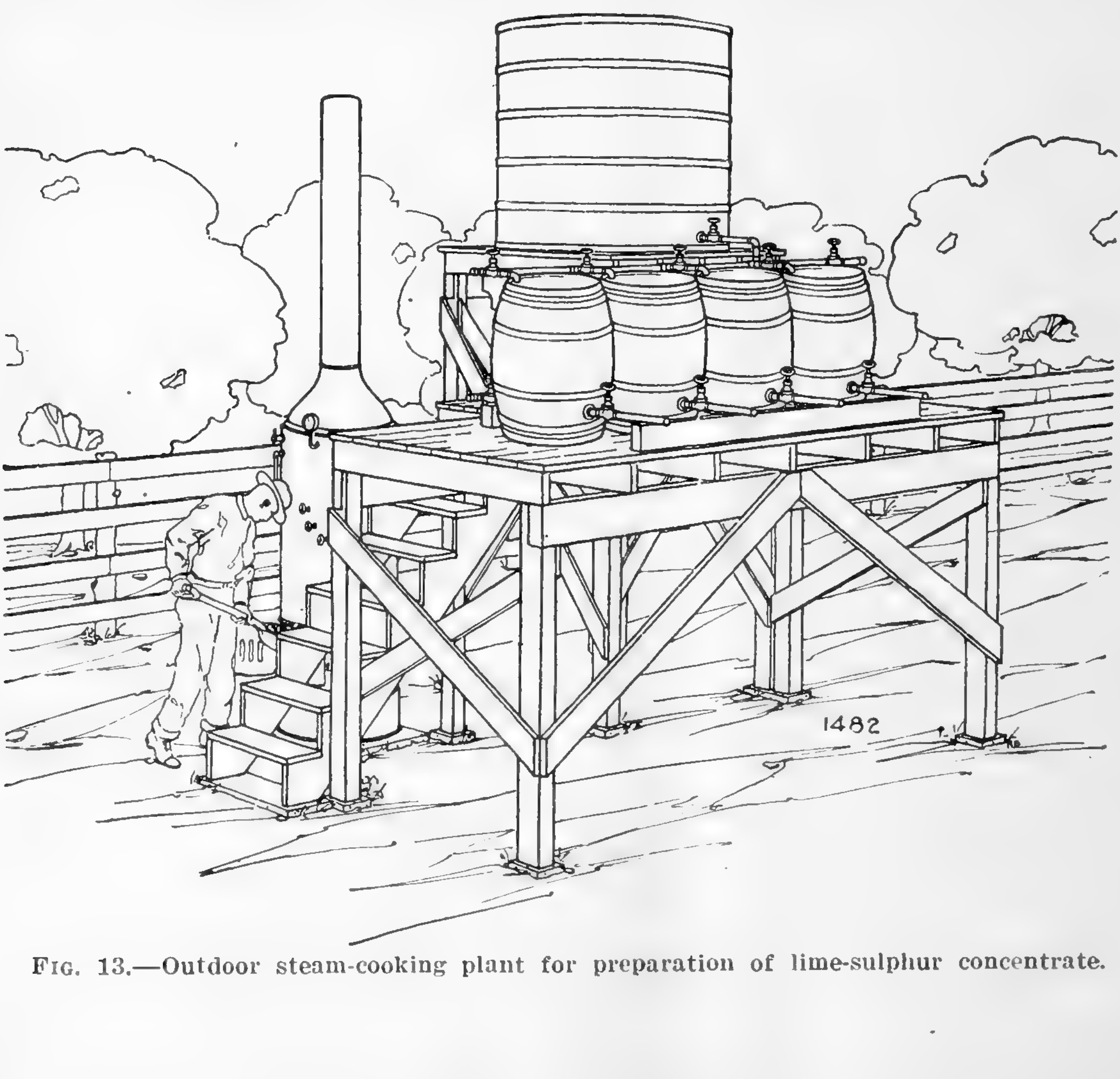
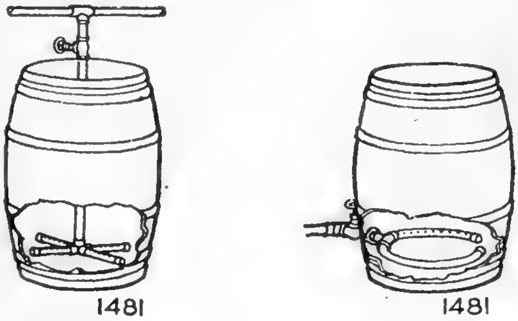


FIG. 13.—Outdoor steam-cooking plant for preparation of lime-sulphur concentrate.

tain loss due to evaporation, and the live steam not only serves to keep the liquid at the boiling point but supplies the necessary "make-up" at the same temperature. If a closed coil is used, much more pipe is required in the cooking tank.

Inexpensive steam lime-sulphur orchard cooking plants are quite common and exist in a variety of forms. Figure 13 shows an inexpensive and usual arrangement involving the use of a steam boiler. Two forms of steam jet pipes for an installation of this type are shown in Figure 14. The type shown in *B* is preferable because there is no piping in the upper part of the barrel to interfere with hand stirring or agitation. In some plants of this type the outlets of the several barrels are connected into one main pipe (Fig. 15) running along the front. Separate outlets are preferable to avoid clogging of the main pipe with sludge.



A *B*

FIG. 14.—Two forms of steam jet pipes for cooking lime-sulphur in barrels. The steam connection for *B* is preferable to that of *A*.

Figure 16 shows another orchard plant of this type. The condition of this plant indicates frequent boiling over of the concentrate with a consequent loss which in the aggregate is quite appreciable. With plants of this type the concentrate must be dipped out of the barrels, a procedure that should be avoided if possible. A platform, as shown in Figures 13 and 15, high enough to permit filling the spray tank directly from the boiling vessel adds greatly to the efficient operation

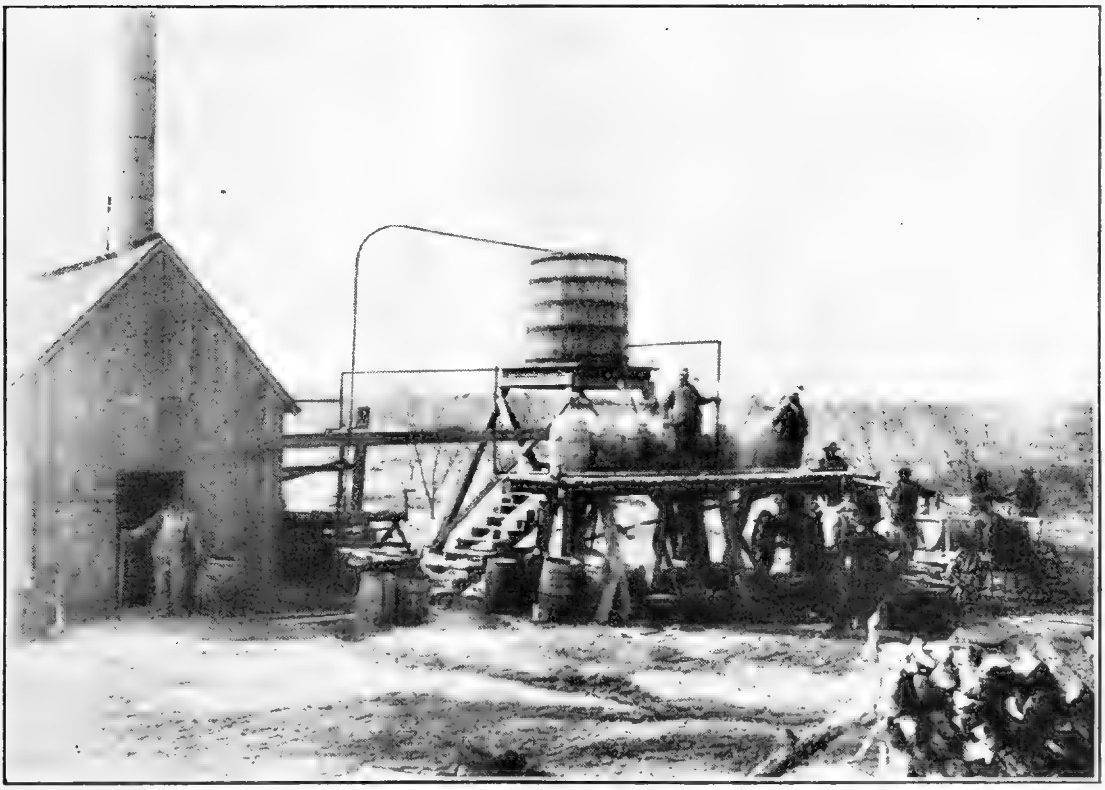


FIG. 15.—This lime-sulphur cooking plant is of the type shown in Figure 13. The boiling must be carefully watched but otherwise it is a very good arrangmeent. It differs from the plant shown in Figure 13 chiefly in that the barrels all empty into one main line with an outlet at the end of the platform.

FIG. 16.—With this steam-cooking lime-sulphur plant the waste due to boiling over and dipping out may be quite appreciable and makes undesirable working conditions under foot.

of the plant. Figures 17 and 18 show other examples of temporary or makeshift steam-cooking plants. They serve, in a way, the purpose for which they are intended, but are not to be recommended.

FIG. 17.—It is undesirable to use lime-sulphur cooking vessels of different sizes. Such an arrangement necessitates the weighing of different amounts of materials for each container.

The arrangement of a simple, permanent, home-built plant which has been in service several years is shown in Figure 19. In this plant there are two units, each consisting of two tanks which may be built of concrete, wood, or metal. One tank of each unit is equipped with steam jets for cooking the mixture. When it has boiled sufficiently, the solution is dipped out of the cooking tank and poured into the adjoining tank, where it is diluted with the proper proportion of water. Agitation during cooking and stirring during dilution are done with a long-handled wooden paddle. As soon as the boiled concentrate is diluted and thoroughly mixed with water, it is drawn from the bottom of the tank through a pipe line and delivered at a convenient point for filling the spray tank. Each cooking tank

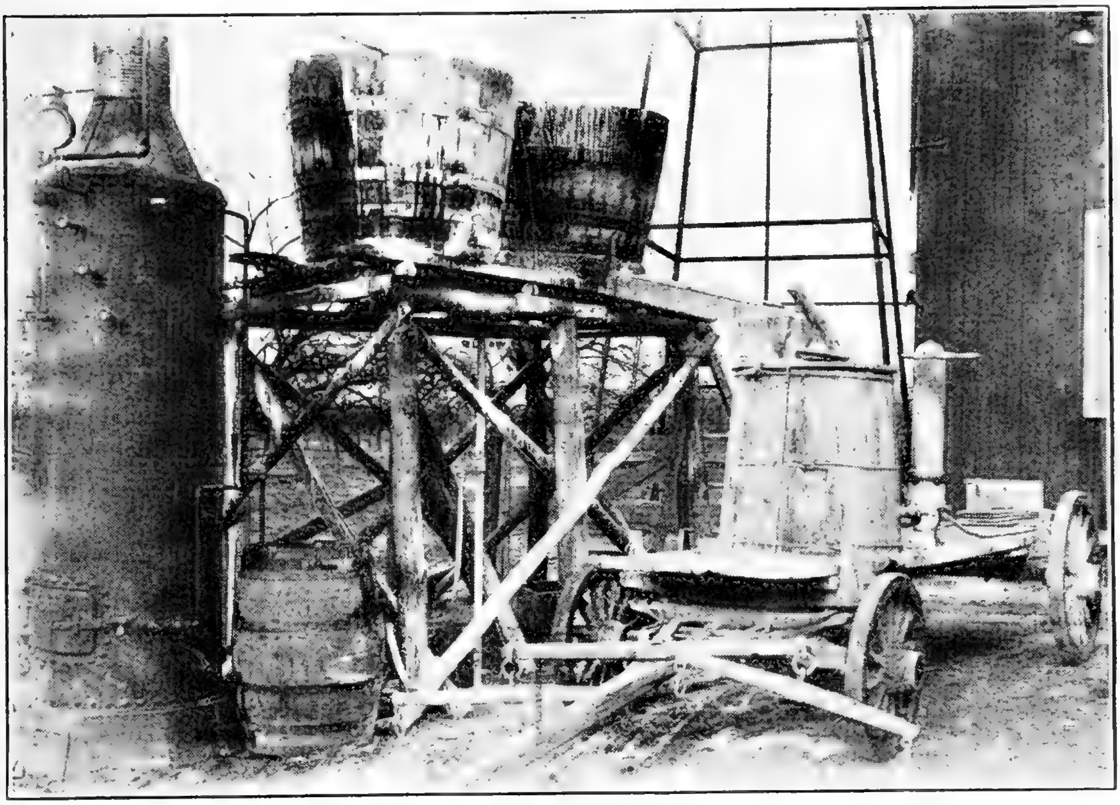


FIG. 18.—A lime-sulphur cooking plant somewhat similar to that shown in Figure 17. With this arrangement, however, it is unnecessary to dip out the finished product by hand.

is provided with a sludge outlet which is plugged during the cooking process. Water is supplied under pressure from a storage tank on top of a hill back of the plant. The water line runs along the floor in front of the tanks with valved outlets into each tank and a connection for supplying water to the boiler. A portable or stationary boiler may be used. The steam line properly supported is carried overhead with valve-controlled drops to the steam jets. A wooden shed with open front and an extended roof protects stored lime and sulphur from the weather. If the cooking tank is made not larger than about 36 inches square by 40 inches deep, one man at the tanks may be able to make concentrate fast enough to supply two spray-tank wagons. This outlay does not include a convenient means for straining the concentrate, nor does it contemplate preparation except as needed for immediate use. It requires a hillside location.

The layout of a somewhat more elaborate home-built steam-cooking plant is shown in Figure 20. This might properly be called a concrete lime-sulphur plant, although parts of it could as well have been built of wood or metal and, like the one just described, requires a hillside location. Its arrangement, however, includes a storage tank beneath the working floor. It is thus possible to prepare concentrate during spare time. The driveway directly in front of the lower side of the house permits filling the spray tank directly from the outlet pipe. Rain water from the roof of a near-by barn is stored in a tank located at an elevation higher than the cooking tank and is

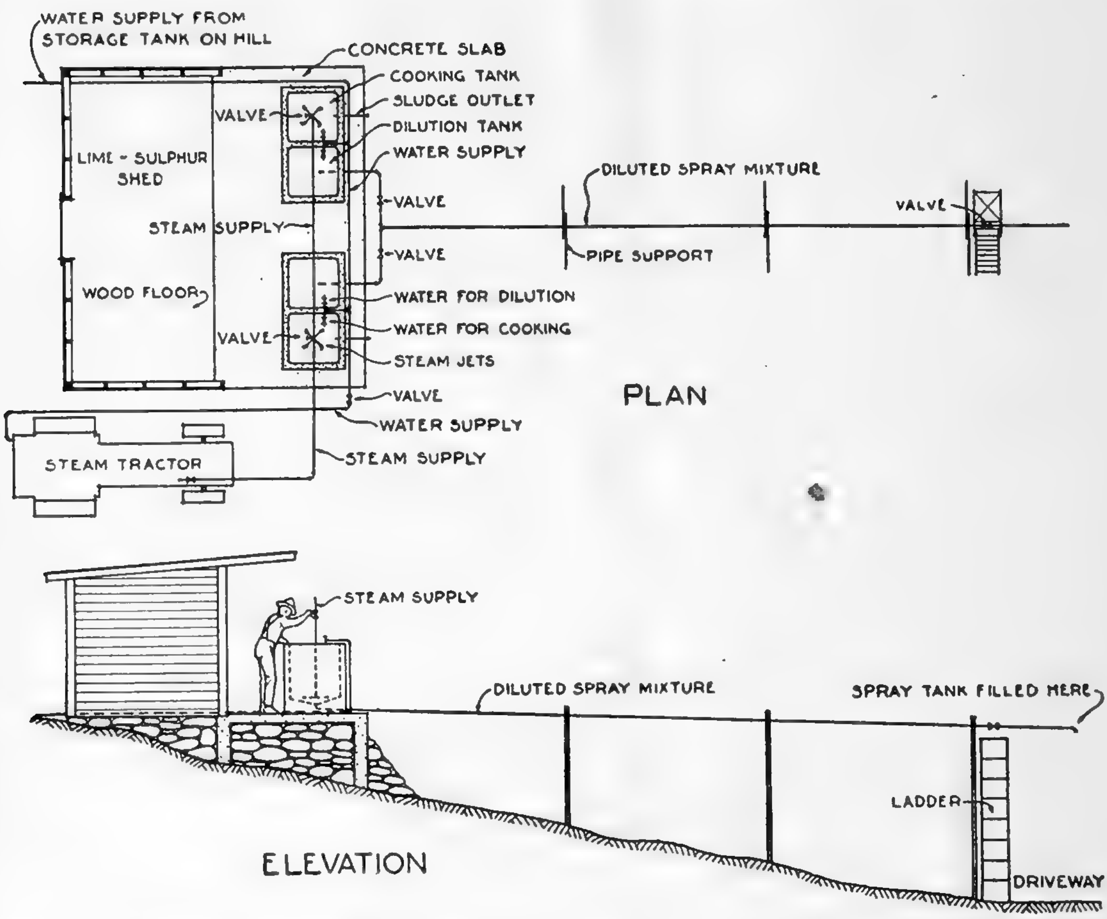


FIG. 19.—A simple, permanent, home-built lime-sulphur steam-cooking plant which has been in service for several years.

the source of the water supply. Steam for cooking is supplied by a boiler permanently placed in the cooking house and is introduced into a mixture through steam jets. When cooking is completed the solution is drawn off from the bottom of the cooking tank into the bottom of a filter tank adjoining it and is strained upwards through removable screens that rest upon a ledge just below the bottom of the outlet pipe that conveys the filtered solution into the storage tank. A hose connection is provided so that the lime may be slaked in a portable slaking box before it is introduced into the cooking tank. Sludge is removed through a pipe in the bottom of the filter tank, which extends through the side of the building. The concentrate is diluted in the spray tank and if water supply stations are provided at several points in the orchard, the weight that must be hauled from the plant is materially reduced.

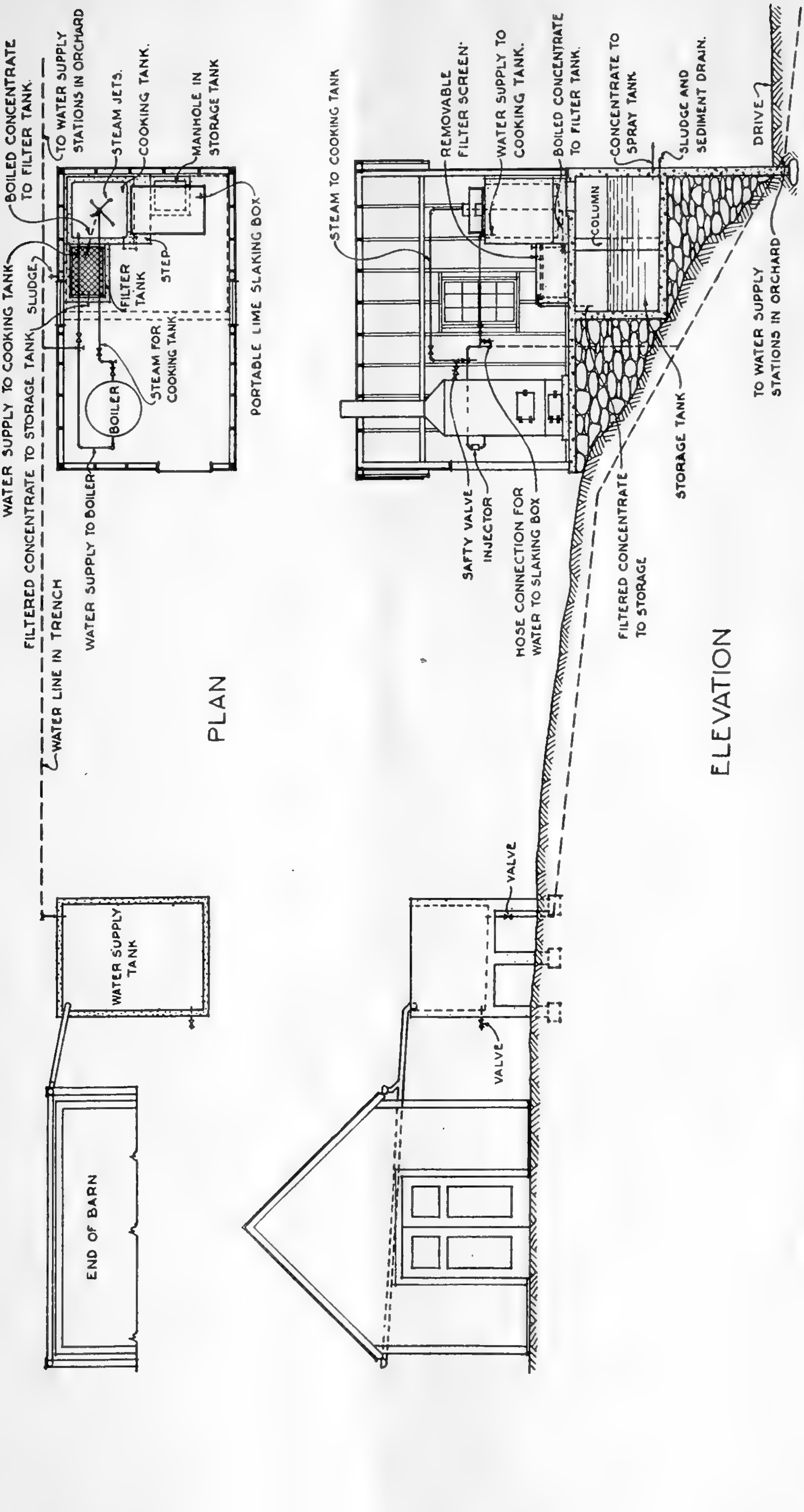


FIG. 20.--A somewhat more elaborate home-built, steam-cooking lime-sulphur plant than that shown in Figure 19.

In Figure 21 is shown a plant similar to that illustrated in Figure 6 except that steam is used for cooking instead of a wood fire under

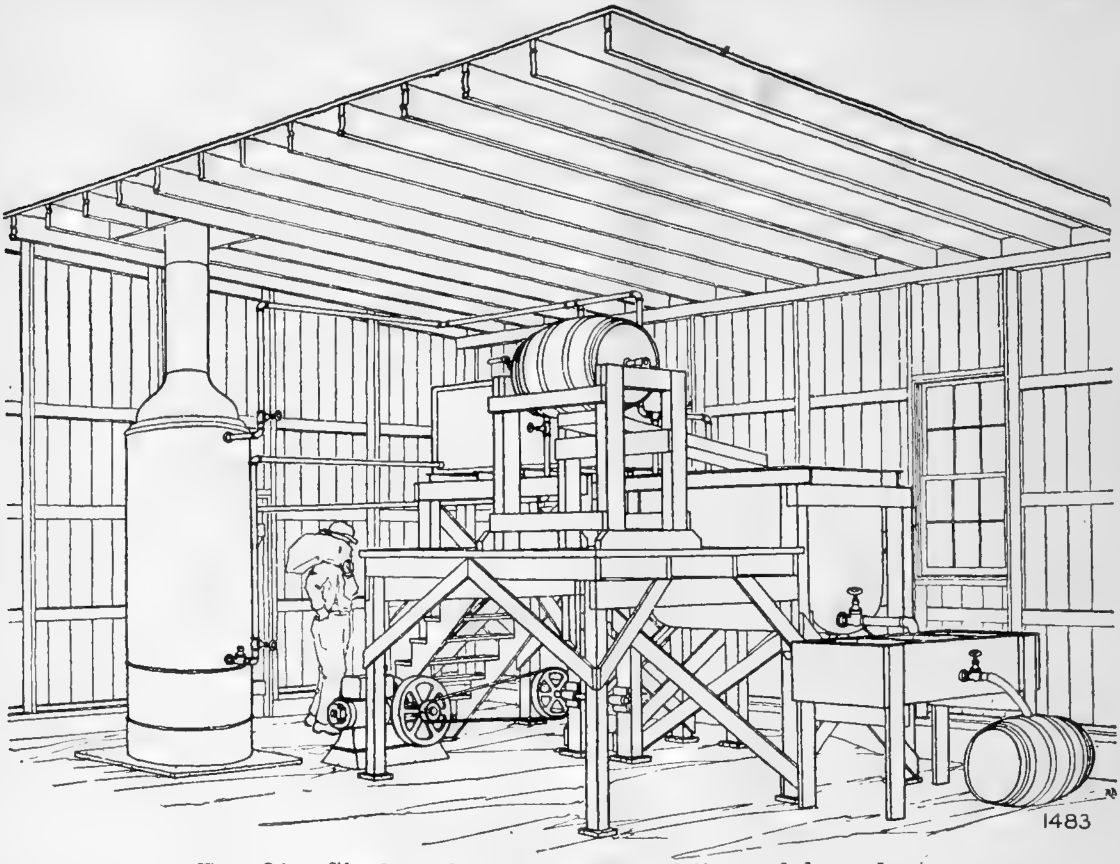


FIG. 21.—Single-cooker steam type of lime-sulphur plant.

the tank. The time required for raising the temperature of the water from 60° to 180° F. depends upon the length, size, and kind of pipe

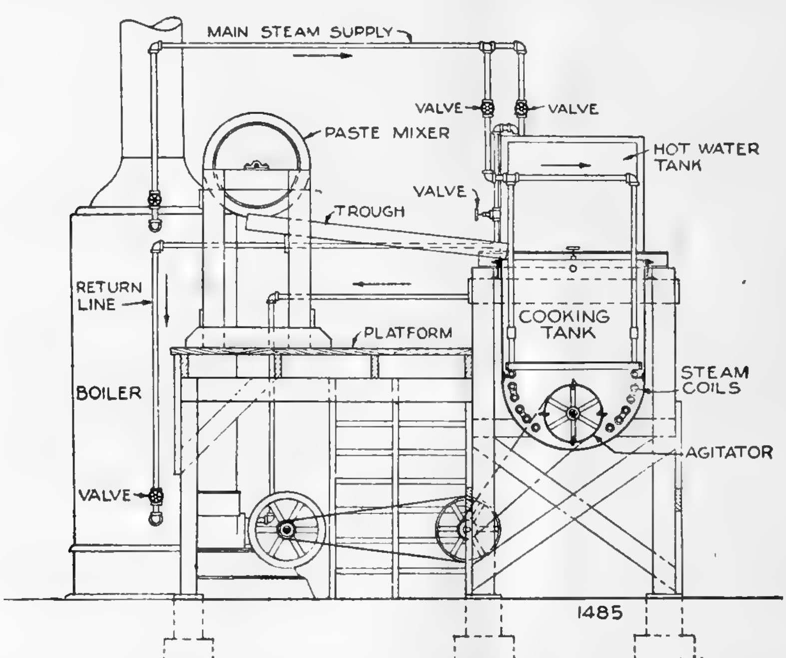


FIG. 22.—End view of lime-sulphur cooking plant shown in Figure 21.

or tubing used in the steam coils and the temperature of the steam, which in turn depends upon its pressure. The data given in Table 4 for the steam coils of this plant are based on the heating of the amount of water necessary for one batch in 40 minutes with steam at 5 pounds per square-inch pressure. If steam is used at higher pressure both the quantity of pipe and the time required for water

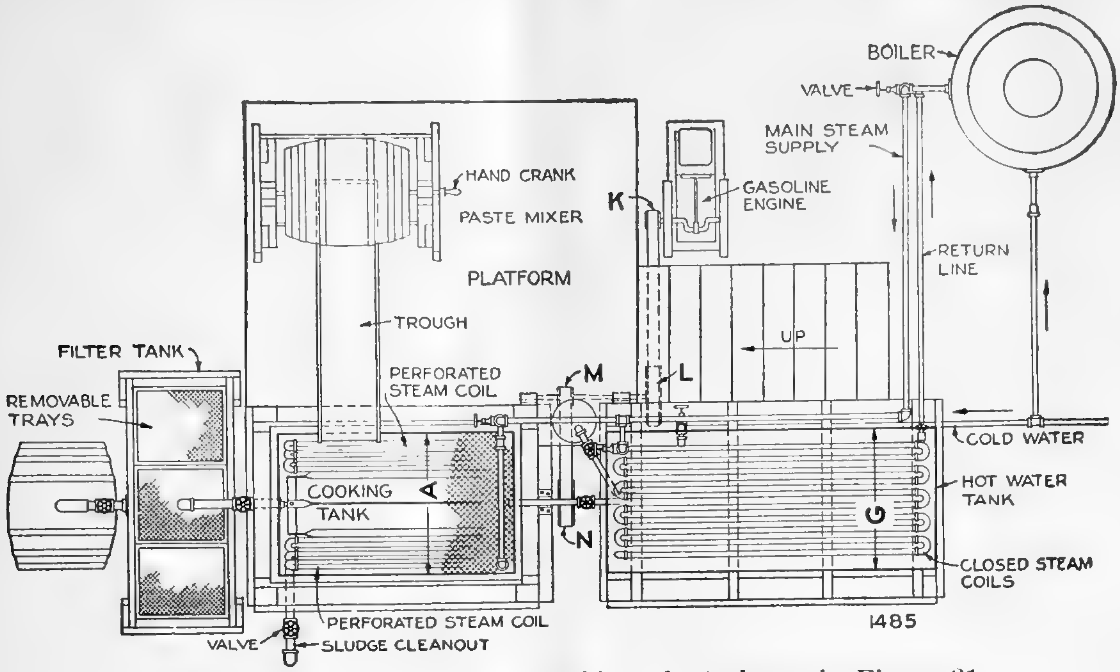


FIG. 23.—Plan of lime-sulphur cooking plant shown in Figure 21.

heating will differ from that given above and in Table 4.[8] This design is based on the use of iron pipe, and the linear feet of pipe installed in the water tank should not be less than as given under

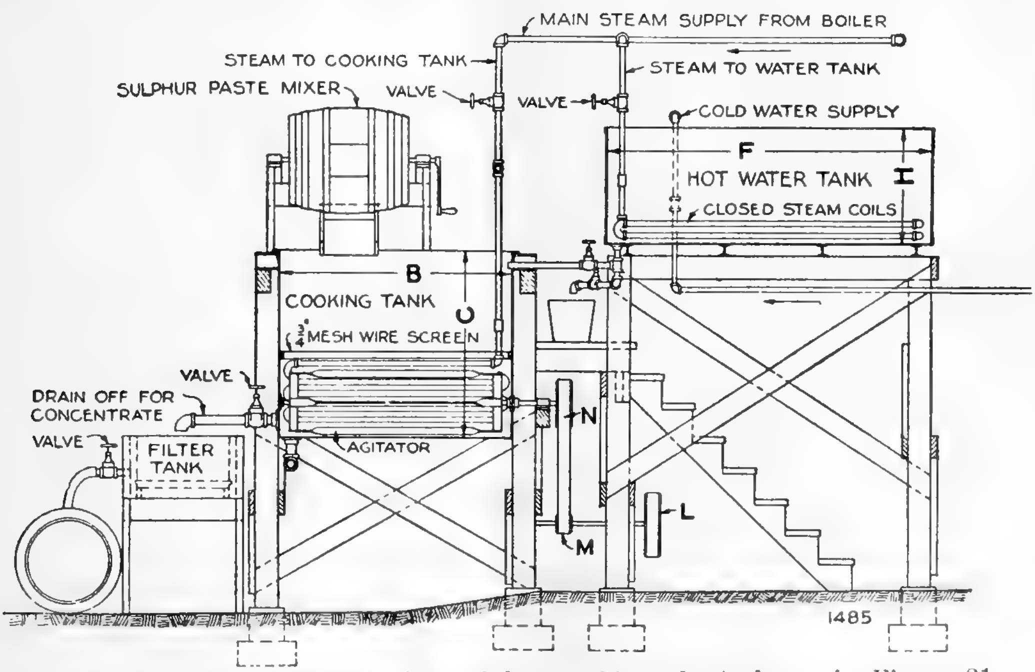


FIG. 24.—Sectional view of lime-sulphur cooking plant shown in Figure 21.

columns 5 to 8 of Table 4. The length of pipe in the cooking tank should be such as to assure the introduction of sufficient live steam to heat the mixture uniformly. Figures 22, 23 and 24 show

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[8] Upon request the Division of Agricultural Engineering, Bureau of Public Roads, United States Department of Agriculture, will advise concerning this point in connection with particular installations.

this plant in plan and elevations. Dimension data for plants of 150, 300, and 400 gallons capacity are given in Tables 2 and 4. The piping in the cooking tank is perforated with $\frac{3}{16}$ to $\frac{1}{4}$ inch holes spaced 6 inches apart but not in line so that when the steam is admitted into the coils it will enter the mixture at different angles and so be uniformly distributed.

TABLE 4.—*Steam plants for lime-sulphur.*

Capacity of plant (gallons).	Space requirements, not including storage space for materials or concentrate.			Pipe required in water tank.				Recommended boiler capacity (horsepower).[a]
	Length.	Width.	Height.	Area.	Linear feet for— 1-inch.	1¼-inch.	1½-inch.	
1	2	3	4	5	6	7	8	9
	Feet.	*Feet.*	*Feet.*	*Square feet.*				
150	23	18	12	18	51	40	35	18
300	25	20	13	35	102	80	70	35
400	27	22	13	46	133	106	92	46
600	26	30	14	73	212	168	146	72
800	27	33	14	102	296	235	205	100

[a] Based on steam at 5 pounds per square inch pressure.

Figures 25 and 26 show two arrangements of all equipment and indicate the sequence of operations in connection with the single-cooker steam-type plant. In the arrangement illustrated in Figure 25 materials are delivered at the indicated door and stored in bins. Lines beginning at the storage room indicate the course of material from

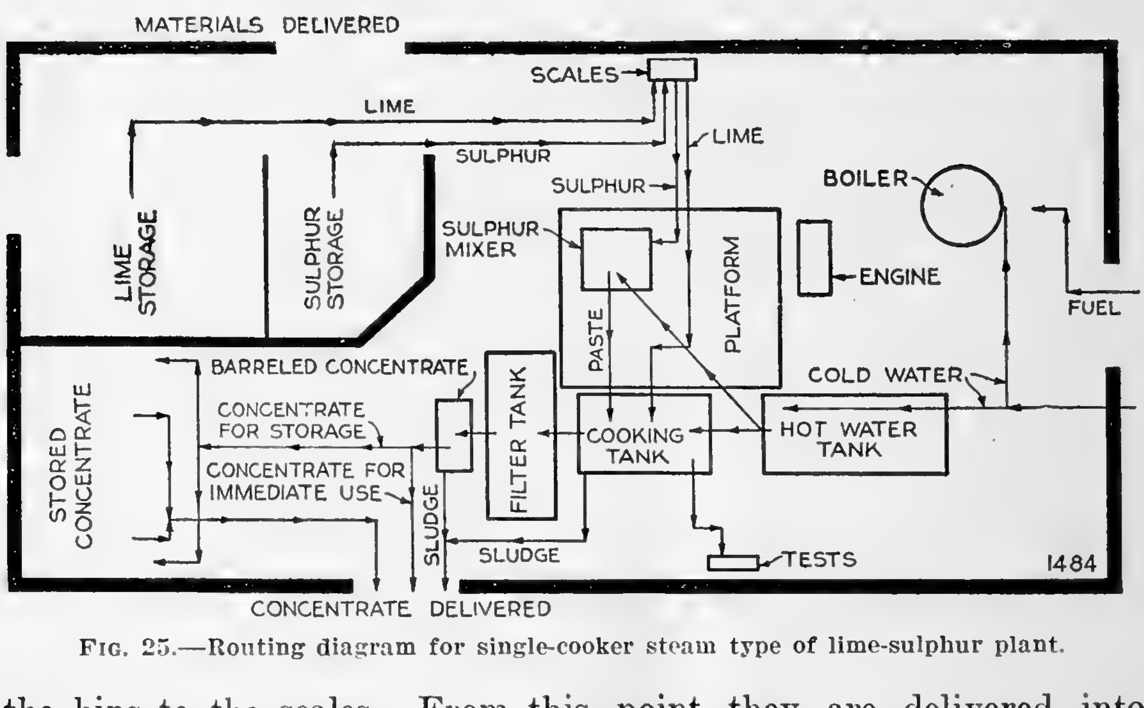

FIG. 25.—Routing diagram for single-cooker steam type of lime-sulphur plant.

the bins to the scales. From this point they are delivered into the cooking tank as in the plant shown in Figures 10 and 11. The passage of the concentrate through the filter tank is as indicated by the lines and arrows. The delivery door is located conveniently for loading the barreled product or piping the strained material directly into the spray tank. The floor space required, not including any for raw materials or finished product, is approximately 20 by 28 feet. Figure 26 shows an alternate arrangement of the same plant requiring a floor space approximately 20 by 27 feet. The routing of the operation, as in the layouts illustrated in preceding figures, is indicated by lines and arrows.

LARGE ORCHARD OR COMMUNITY PLANTS.

Community plants, that is, those supplying concentrate to a number of orchards and those capable of meeting the requirements of large individual growers, are of greater capacity than the installations previously described. Two designs for plants of larger capacity are shown in Figures 27 to 30 and 33 to 36, both inclusive.

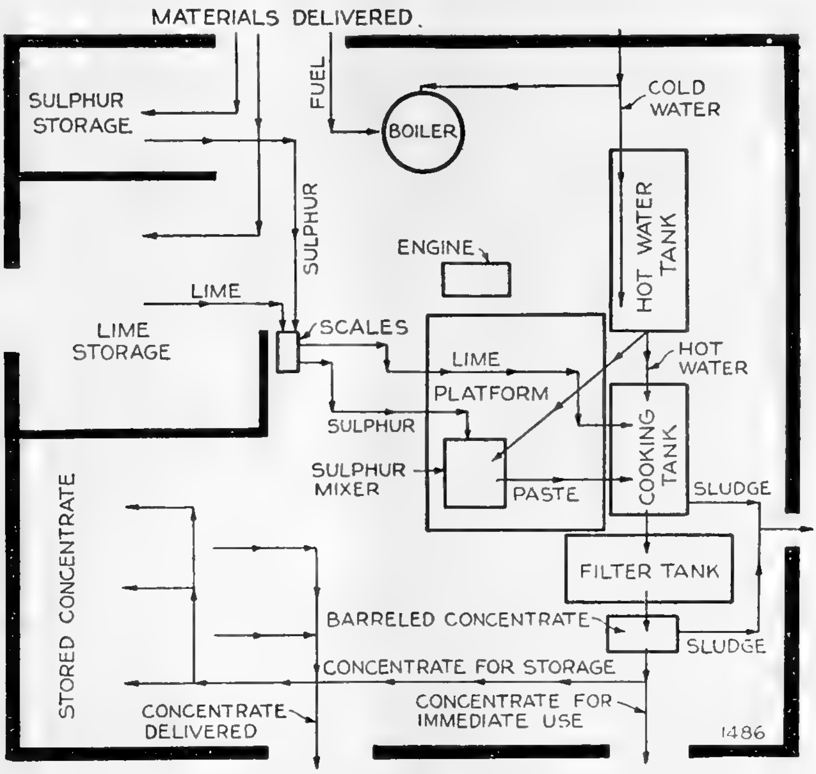

FIG. 26.—Alternate routing diagram for single-cooker steam type of lime-sulphur plant.

Figures 27, 28, 29 and 30 show a furnace-type plant so designed that either cooker can be operated separately or both may be run at the same time, or, if the work is properly laid out and managed, practically continuous operation can be secured with the same crew required for a single-cooker plant. Dimension data for plants of 600 and 800 gallons capacity are given in Tables 2, 3, and 4.

For continuous operation it is necessary that a program or schedule of operations be followed so that none of the work connected with one batch will interfere with any operation in connection with the other tank. A schedule that will afford practically continuous operation for five hours is given in Table 5. During this time four batches can be prepared and handled. A boiling period of 50 minutes allows time for the preparation of a subsequent batch. Precaution must be taken, however, not to introduce the second batch too soon. It should be introduced 5 minutes before the first batch has finished cooking in order that the third and fourth batches may be prepared and cooked as indicated in the schedule (Table 5).

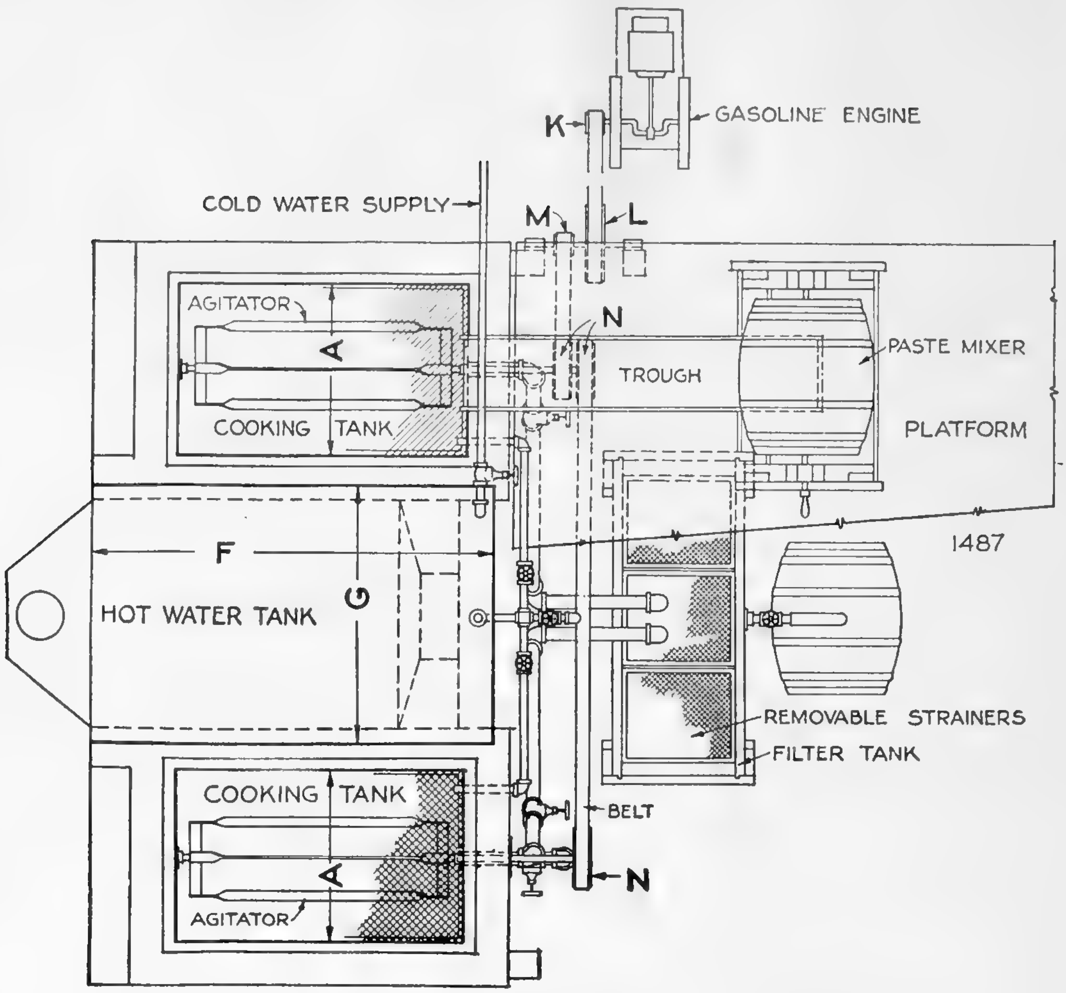

Fig. 27.—Plan of double-cooker furnace type of lime-sulphur plant.

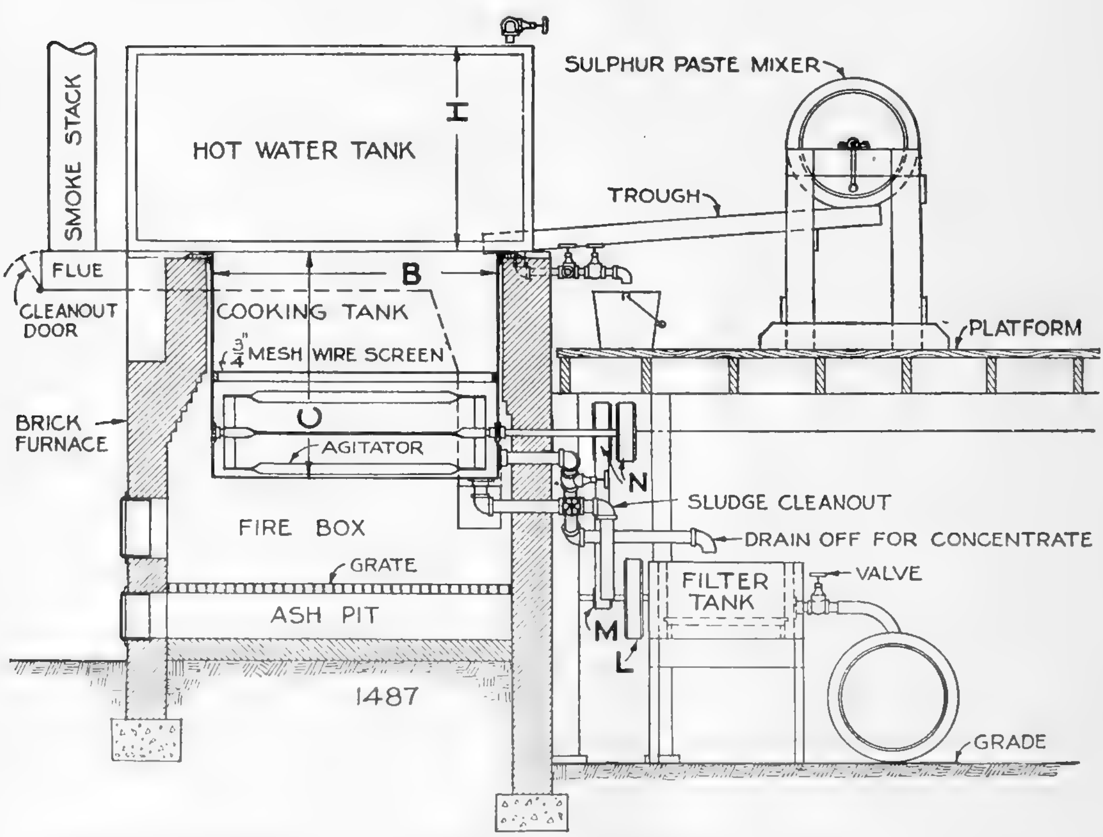

Fig. 28.—Sectional view of double-cooker furnace type of lime-sulphur plant.

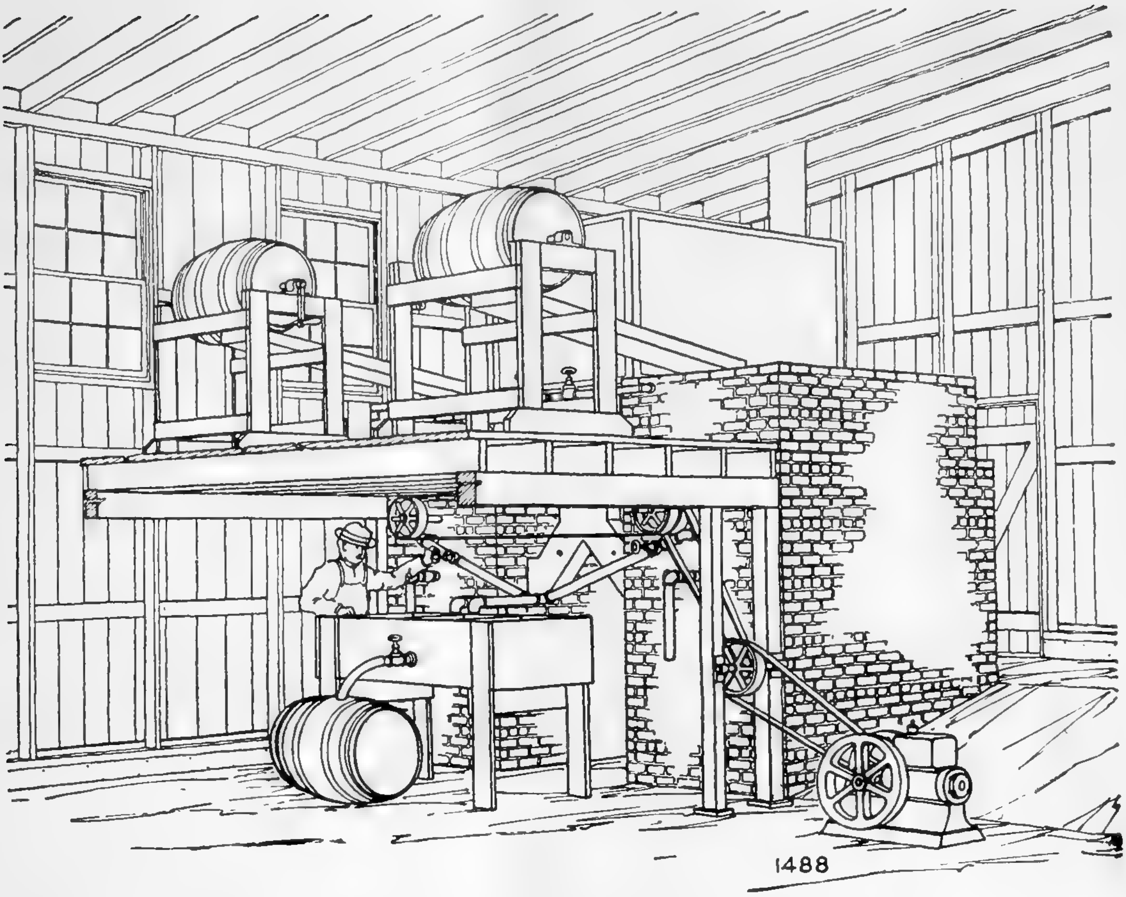

FIG. 29.—Double-cooker furnace type of lime-sulphur plant.

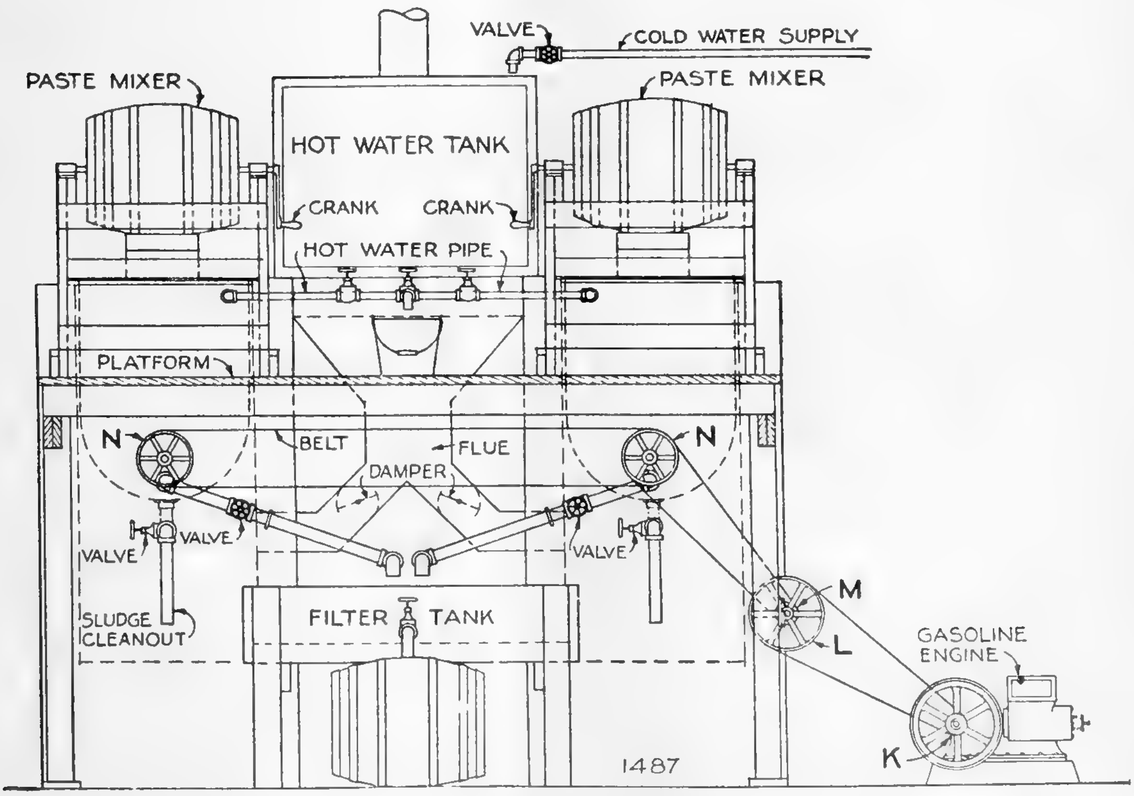

FIG. 30.—End view of double-cooker furnace type of lime-sulphur plant.

TABLE 5.—*Program for operating a double-cooker lime-sulphur plant with one group of workers.*

Batch No. 1.		Batch No. 2.		Batch No. 3.		Batch No. 4.	
Time.	In tank No. 1.	Time.	In tank No. 2.	Time.	In tank No. 1.	Time.	In tank No. 2.
7.00	Prepare materials for batch.						
7.15	Introduce into tank; bring to boiling; prepare to draw off.						
7.30	Begin boiling period.	7.30	Preparations for drawing off.				
		7.45	Prepare materials for batch.				
		8.00	Spare time.				
		8.15	Introduce into tank; bring to boiling.				
8.20	Draw off and barrel.						
		8.30	Begin boiling period.				
8.35	Clean tank.						
8.50				8.50	Prepare materials for batch.		
				9.05	Introduce into tank; prepare to draw off.		
		9.20	Draw off and barrel.	9.20	Begin boiling period.		
		9.35	Clean tank.				
		9.50				9.50	Prepare materials for batch.
						10.05	Introduce into tank; bring to boiling.
				10.10	Draw off and barrel.		
						10.20	Begin boiling period.
				10.25	Clean tank.		
						10.35	
				10.40			
						10.50	Prepare for draining off.
						11.10	Draw off and barrel.
						11.25	Clean tank.
						11.40	General clean-up; prepare for afternoon work.
						12.00	

It is likely that different owners will find it advisable to make changes in the suggested program because of the difference in the efficiency of the workers. This is to be expected, but care must be taken not to start the cooking of a batch at such a time that it can not be handled promptly when it is ready. It might be found advisable, when operating a plant in this manner, to have one man act as supervisor so as to avoid delay, duplication of effort, or interference with operations. If the contents of each tank are to be cooked at the same time and consequently drawn at the same time, more workers will be required, and it might be possible to reduce the periods other than the cooking period enough to permit preparation of six instead of four batches during 5 hours' operation.

Figures 31 and 32 explain the arrangement, operation, and routing of the large orchard or community double-cooker furnace-type plant shown in Figures 27 to 30. In this layout a side-hill location is assumed with delivery of the raw materials at the uphill door, as indicated in Figure 31, which is a plan at a level above the working platform. Figure 32 shows the arrangement and routing below the platform level and hence does not show the raw material storage space.

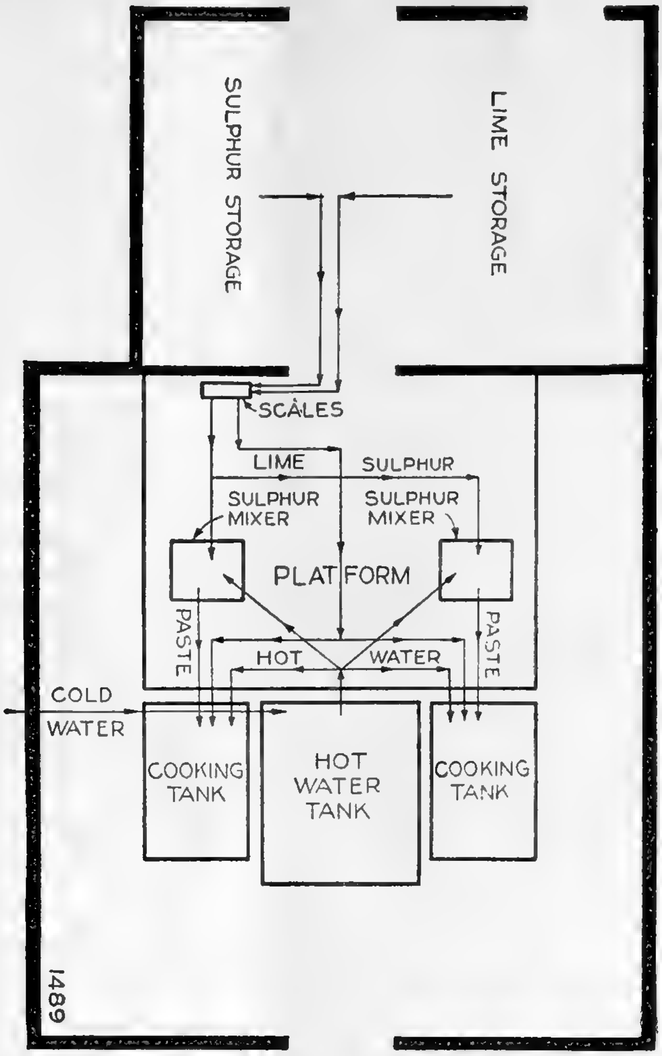

Fig. 31.—Routing diagram for double-cooker furnace type of lime-sulphur plant at upper level.

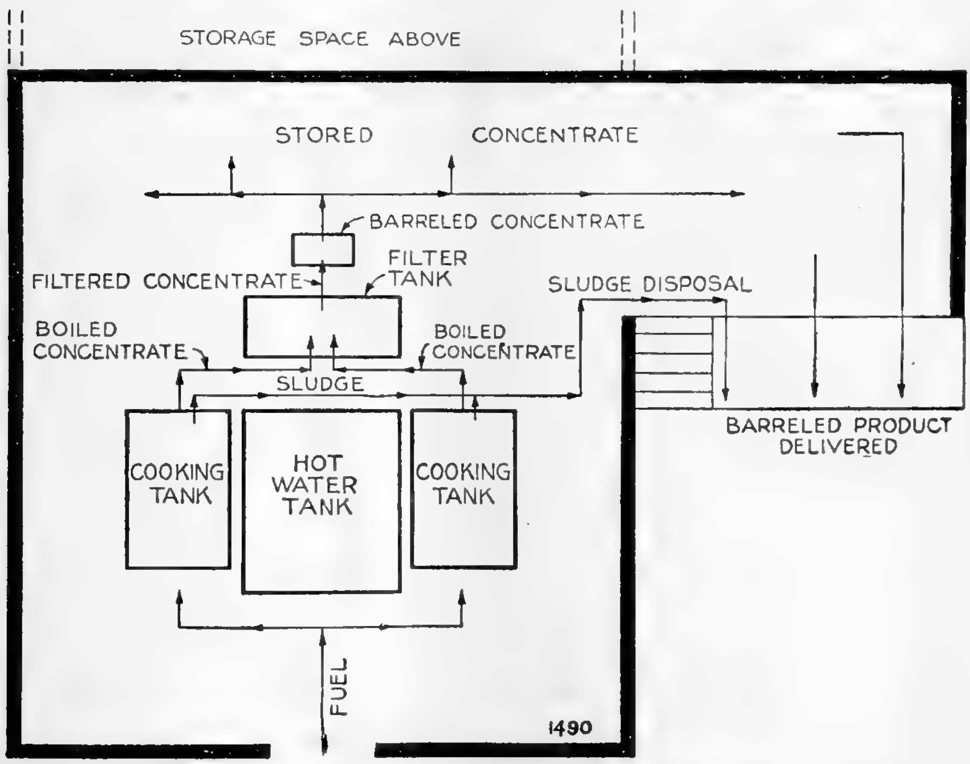

Fig. 32.—Routing diagram for double-cooker furnace type of lime-sulphur plant at lower level.

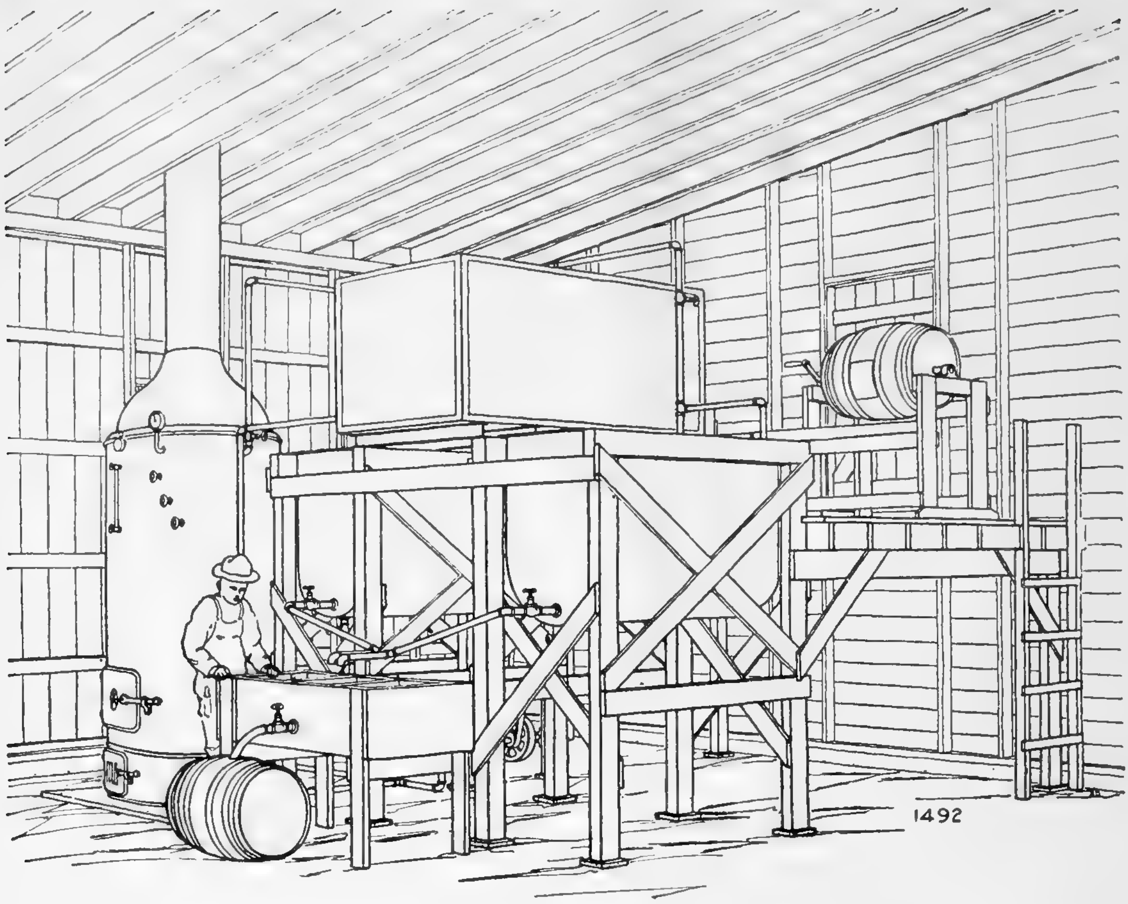

FIG. 33.—Double-cooker steam type of lime-sulphur plant.

Figure 31 may be superimposed over Figure 32, the wall back of the space for stored concentrate in Figure 32 coinciding with the dividing wall in Figure 31. As the floor level of the storage space corresponds to that of the working platform, the materials may be conveyed to

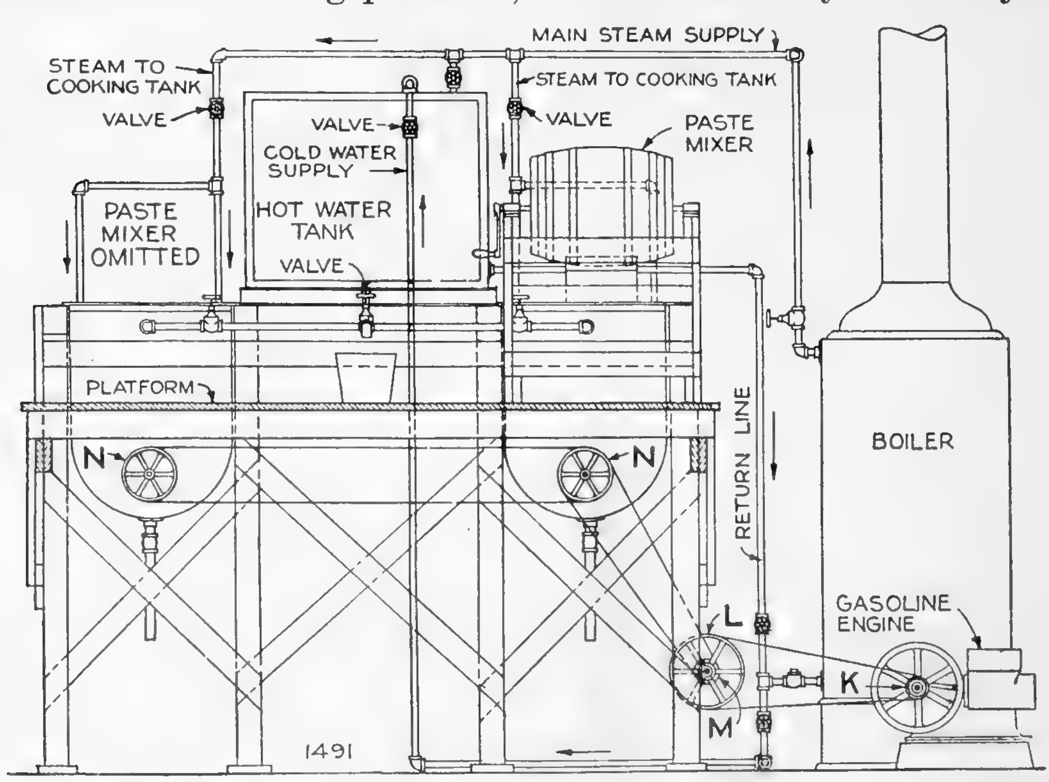

FIG. 34.—End view of double-cooker steam type of lime-sulphur plant.

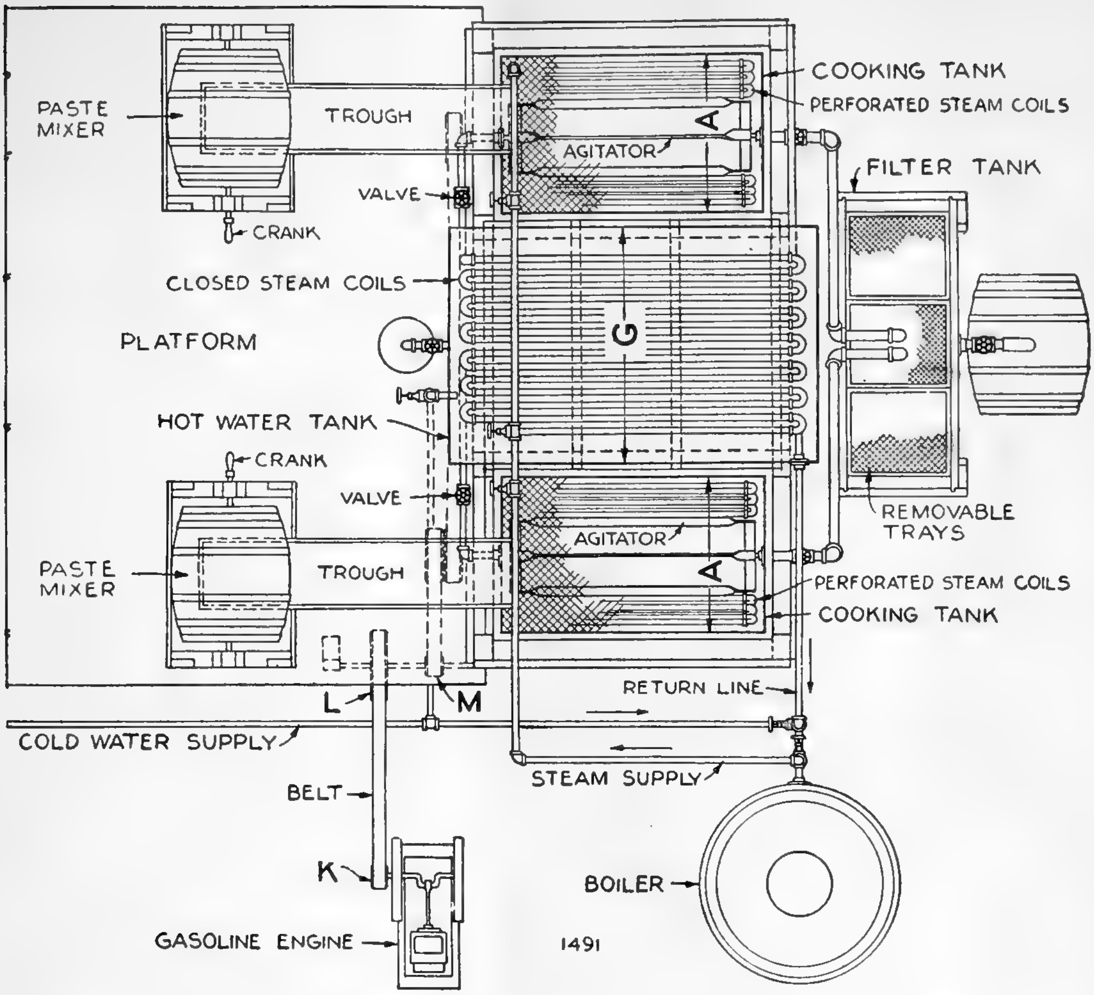

Fig. 35.—Plan of double-cooker steam type of lime-sulphur plant.

the cooking tanks and mixers without having to be elevated by hand. The drawing-off, barreling, etc., is done at the lower level directly under the working platform as indicated by the marked lines and

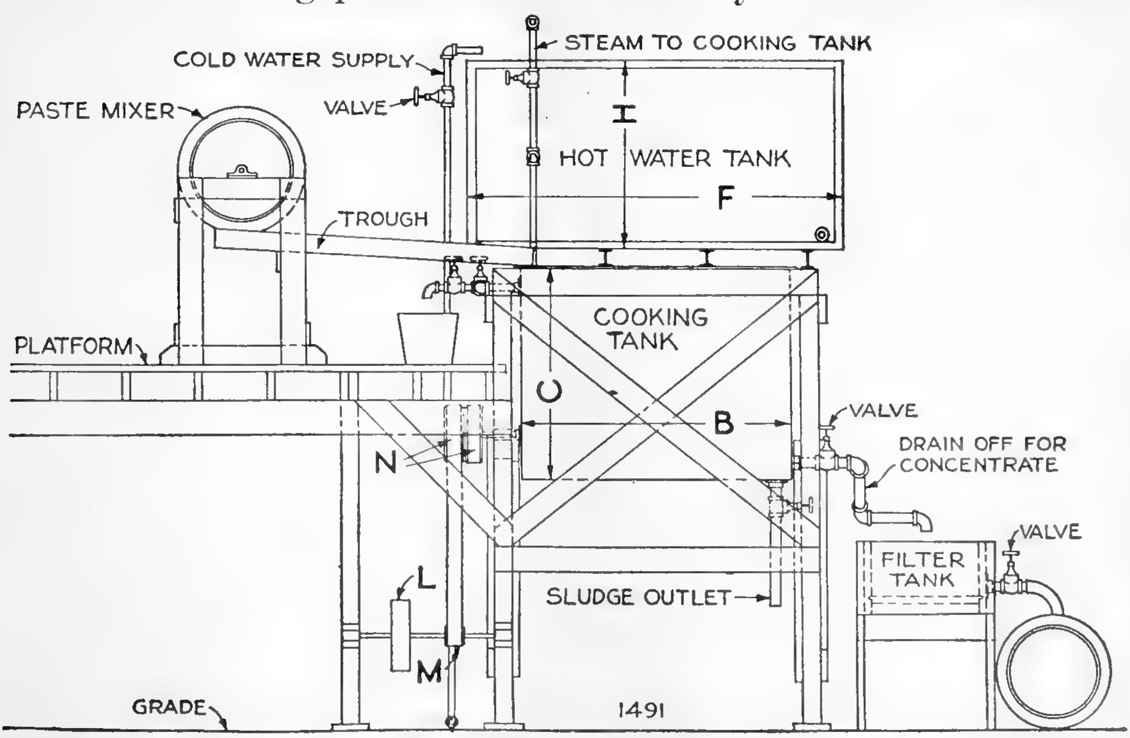

Fig. 36.—Sectional view of double-cooker steam type of lime-sulphur plant.

arrows. If a hillside location is not available the same routing diagram will apply, but the materials will have to be lifted to the working platform. The space required, not including that for storage of materials or finished product except that under the platform, is approximately 23 by 26 feet.

A steam double-cooker plant is shown in Figures 33 to 36, inclusive. Dimension data for plants of 600 and 800 gallons capacity are given in Tables 2 and 4. Sizes and lengths of pipes for transmitting heat are based on steam pressure at 5 pounds per square inch and provide sufficient surface to heat the water from 60° to 180° F. in 40 minutes and to bring the mixture to the boiling point in 15 minutes. It is

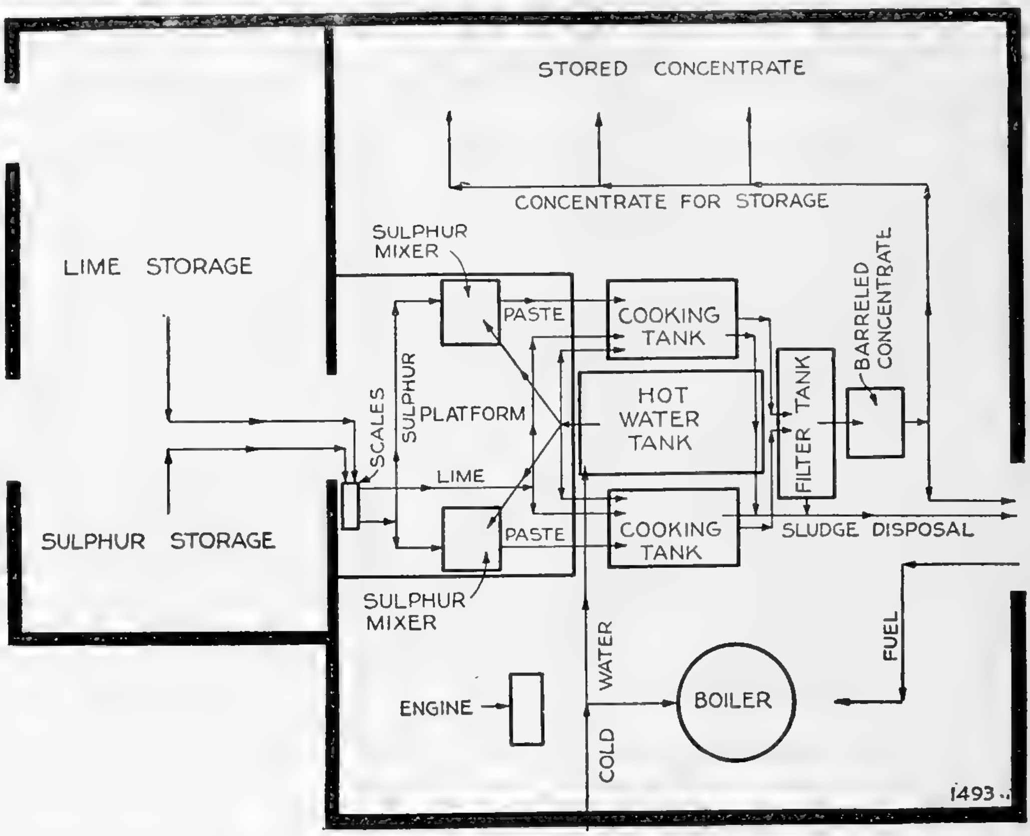

FIG. 37.—Routing diagram for double-cooker steam type of lime-sulphur plant.

assumed that water under pressure sufficient to force it into the boiler is available. When this is not the case a feed pump or injector must be used. The size and capacity of pump required depend upon the conditions.[9]

Figure 37 shows an arrangement of the community or large orchard double-cooker steam plant illustrated in Figures 33 to 36 inclusive, and located on a level site. The routing differs from that shown in Figures 31 and 32 in that the finished product is handled from the opposite end of the cooking tank, the movement of the materials through the plant being as indicated by lines and arrows. The space required, not including that for storage, is approximately 24 by 26 feet.

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[9] Upon request the Division of Agricultural Engineering, Bureau of Public Roads, United States Department of Agriculture, will advise concerning this point in connection with particular installations.

CHARACTERISTICS OF EQUIPMENT.

COOKING TANK.

Cooking tanks are built of wood, iron, or steel, or they may be of concrete.

Wooden tanks are suitable only when steam is used for cooking, although there are instances of wooden tanks with iron bottoms that extend far enough up the sides to protect the wooden part from damage through direct contact with the open fire. Wooden tanks have one advantage over those of metal in that, wood being a poor conductor of heat, boiling will probably occur more quickly in a wooden tank than in a metal tank of equal capacity and surface. Wood tanks should be made of material not less than $1\frac{1}{2}$ inches thick. Tongued and grooved material is preferable because of the tight seams that can be made. It is advisable to strip the seams and to fill all joints with white lead paste so as to minimize the danger of leakage.

Sheet or galvanized iron tanks should be of material not less than $\frac{1}{16}$ inch thick and if the under side is to be in direct contact with fire a greater thickness is recommended. Tanks of cylindrical, cubical, or oblong shape can often be obtained through local orchard supply houses or hardware dealers. The type shown in Figures 8, 9, 21, and 23 will probably have to be specially built, but since the round bottom has a decided advantage over the flat bottom it is considered a good investment.

Concrete cooking tanks are in use in small lime-sulphur installations. Those that have been inspected by the authors seem to show no ill effects, but no investigation has been made to determine definitely the desirability of using concrete for this purpose. Figure 19 is a diagrammatic layout of a plant in which the cooking and dilution tanks are of concrete. This particular plant has been in service several years. The plant illustrated in Figure 20, with the exception of the walls and roof of the house, is constructed entirely of concrete. If concrete is used for this purpose, it is advisable to employ a comparatively rich mixture, not leaner than 1:2:4 mix, and to use no aggregate larger than $\frac{1}{2}$ inch. The walls and bottom of the tank should be reinforced in both directions in order to provide against cracks due to temperature variations. During cooking the upper part of the walls will be cool as compared to the lower part and bottom. A thickness of not less than 6 inches is advised.

Cooking tanks should have two outlets, one in the end nearest the filter tank and so placed that the bottom of the opening will be 3 inches above the bottom of the tank and the other in the bottom as near as possible to the upper outlet. The upper outlet is used in withdrawing the concentrate, while the bottom outlet is used in completely draining and cleaning the tank with hot water after each cooking. Neither opening should be less than $2\frac{1}{2}$ inches in diameter and each should be equipped with either a gate or quick-opening valve. A globe valve should not be used.

The capacity of the cooking tank should be one and one-half times the volume of the mixture to be cooked, otherwise there is a likelihood of the solution boiling over and producting a dirty and sloppy condition about the plant. In Table 2, columns 8 and 12, are given the gross volumes of tanks recommended for the respective batch volumes given in column 1. These volumes include the extra space allowed for boiling.

The cooking tanks of most farm plants are not provided with covers. Although the temperature of the solution may be raised to the boiling point more quickly in a covered tank, the use of this type of tank is of doubtful advantage. Practically all commercial cooking is done in uncovered tanks. If covers are employed they should be made of metal or wood and should fit loosely over and rest upon the top edge of the cooking tank. They should be supported from above by ropes or light steel wire cables passing over pulleys to a counterweight so that they may be raised and lowered readily. Several holes should be provided in the top to permit steam and gases to pass off.

Cooking tanks may be cylindrical, cubical, or oblong in shape with either flat or round bottom. The rectangular tank is usually easier to install and the round bottom can be cleaned with less difficulty than can a flat bottom with square corners. Moreover, the rounded shape of the bottom insures thorough mixing of the entire mass with an agitator like that shown in Figures 9 and 24.

On the inside of the cooking tank, just above the agitator, supports should be provided for a three-fourths-inch mesh heavy wire screen. This screen prevents the lime and sulphur coming in contact with the agitator until the lime is properly slaked. If the screen is not provided lumps of lime may clog the agitator and, in the furnace type, become burned through contact with the bottom of the tank before it is slaked.

HOT-WATER TANK.

The hot water tank may be built of either metal or wood if the water is heated by steam. If the hot gases of the smoke flue of a furnace are utilized in heating the water a metal tank with flat bottom is necessary. Concrete tanks may be employed where steam is used for heating. The capacity should be sufficiently greater than the volume required for one cooking that there will be ample hot water available for cleaning the cooking tank or tanks after a cooking and for the next batch. Sizes and volumes of tanks suitable for plants of various capacities and like those shown in Figures 6 and 21 are given in columns 3 to 12 in Table 2. Metal water tanks should be of material not less than one-twentieth of an inch thick. If the tanks are elevated, as in the designs illustrated, the bottoms should be reinforced with iron bars, old rails, channels, or other suitable metal supports.

The water tank may be filled from a cold water supply pipe fixed in position over the tank or from a hose line. Discharge from the tank should be out of the bottom through a $1\frac{1}{4}$ or $1\frac{1}{2}$ inch pipe, preferably the larger size. The discharge line should be equipped with two outlets, one to the cooking tank and the other for drawing hot water for use in the sulphur-paste mixer. Each outlet should be controlled by means of a cut-off valve or cock. A measuring stick or gauge graduated so as to read gallons and parts of gallons according to the height of water in the tank will assist materially in drawing off a given quantity. The gauge may be portable or it may be permanently fixed on the inside of the tank.

STORAGE TANKS.

Storage tanks for the cold water and for the prepared concentrate may be of concrete, wood, or metal.

The water-supply tank may be above, level with, or below the ground surface. The elevated tank has the advantage of gravity drainage, but on the other hand it requires that substantial supports be provided. Cylindrical wooden tanks are often used for the water supply. These are usually elevated and supported on wooden posts. Elevated concrete tanks require properly designed walls or reinforced columns, the number and size depending upon the capacity and dimensions of the tank. The tank, too, should be reinforced and the walls should have a minimum thickness of 6 inches.

Storage tanks for concentrate are frequently built of concrete. They are usually placed below ground so that they may be supplied from the filter tank by gravity. Concrete underground storage tanks are used because they are comparatively easy to construct. The bottom and walls should be poured at one time so that there will be no joint through which leakage might occur. Such tanks, especially if of large size, should be reinforced to prevent cracks due to settlement or earth pressures. The top may be of concrete or of wood. The floor of the house of the plant shown in Figure 20 forms the top of the storage tank, access to the inside being through a manhole. Concrete work of this kind requires careful design and placement of the reinforcement, and provision must be made for additional support for superimposed loads such as the cooking and filter tank in Figure 20.

FURNACE AND FLUE.

Brick is perhaps the best material of which to construct the furnace, which should be equipped with a cast-iron grate and cast-iron fire and ash-pit doors. The use of fire and ash-pit doors is, of course, not absolutely necessary, but they afford far better regulation of the fire and make for more efficient operation. If the air supply necessary to combustion is controlled, economy in fuel consumption is possible. The top of the grate should be about 15 inches below the lowest part of the bottom of the cooking tank, and the ash pit should have a depth of about 9 inches. It is well to extend the furnace about 12 inches beyond the front end of the cooking vat. This aids cooking by bringing the fire nearer the front end so that the entire length of the vat is subjected to the greatest heat of the fire. The furnace construction should be practically air tight to assure a good draft. Lime mortar may be used in laying the brick and in bedding the cooking tank, but cement mortar is preferable.

If the hot gases of the smoke flue are to be utilized in heating the water, as in Figures 9 and 28, the flue should be run under the water tank, and at this point should be as wide as the tank and not less than 6 inches deep. It should be built of not less than 20-gauge galvanized iron and should be covered with insulating material to prevent or lessen the radiation of heat. The top of the flue should be omitted under the water tank so as to reduce the amount of metal between the gases and the water as much as possible. All wood surfaces that are less than 12 inches from the smoke pipe or flue should be protected with insulating material.

An air-tight cleanout door should be installed at the junction of the flue and the smoke pipe. Care should be taken when connecting the flue with the furnace to see that all joints are air-tight. In plants of the double-cooker furnace type two flues, entering the same smoke pipe, are required and an air-tight damper should be installed in each flue, near the smoke pipe, so that only one furnace can be used, if desired, without draft interference from the other connection.

The diameter of the smoke pipe should be 9 inches, 10 inches, and 11 inches in plants of 150 to 300 gallons, 400 to 600 gallons, and 800 gallons, respectively. The pipe should be rigidly supported and high enough to provide a good draft. It should be equipped with a damper placed in a convenient position.

AGITATORS.

Agitation is considered absolutely necessary, both during cooking and while the concentrate is being drawn from the cooking tank. There is always a tendency of the suspended matter to settle and to form a more or less thick deposit in the bottom of the tank. This should be kept continually in motion, by hand or mechanical means, in order to insure a product of even quality and a minimum amount of sludge. This is especially necessary during the first half of the cooking period.

Agitators vary in design according to the shape and type of tank in which they are to be used. The type shown in Figures 9 and 24 is extremely simple in design. It consists of two or three cast-iron spiders (old pulleys may be used) and four pieces of flat iron. The spiders are mounted on a shaft running longitudinally through the cooking tank. The flat iron paddles are connected to each spider and should be twisted so that, as the agitator revolves, they will cut through the heavy mass at an angle and, in disturbing it, tend to raise it into the less dense portion of the mixture. Suggested sizes of parts for agitators of this type are given in Table 2. There should be a clearance of 1 to 1½ inches between the bottom of the tank and the agitator paddles when in their lowest position.

If a circular cooking tank is used the shaft of the agitator should be installed in a vertical position and the agitator should be of a different design. A suitable one consists of a shaft of square iron to which are bolted several pieces of flat bar iron as paddles. These should be bent slightly and the leading edge sharpened so as to cut the mass at an angle as the shaft revolves.

The agitator should make about 60 revolutions per minute. The speed of a horizontal agitator will be governed by the speed of the engine that drives it, the diameter of the pulley on the engine shaft, and the diameter of the large pulley on the end of the agitator shaft, all of which must be correctly proportioned. If a vertical shaft agitator is used the shaft must be extended far enough upwards through a plank bolted to the top of the tank to allow for the necessary gearing. A bevel gear fitted to the shaft, the pinion engaging it and fitted to the end of a jack shaft, and a large pulley on the other end of the jack shaft must all be correctly proportioned to give the required speed of the paddles.

Power for the agitator may be obtained from a 1½ to 5 horsepower gasoline engine, depending upon the size of the plant, or from a small steam engine if steam is used for cooking. If the concentrate is prepared during slack periods the spray-pump engine may be used.

ENGINE AND PULLEY SIZES.

A 1½-horsepower engine will drive the agitator in the smaller plants, while 2½ to 5 horsepower engines will be needed for the larger plants. The size of the pulleys necessary to obtain 60 revolutions of the agitator per minute will depend upon the speed of the engine. In Table 2 under columns 26 to 29 recommended sizes of pulleys for five different engine speeds are given. The sizes of pulley K, Figure 8, are those usually found on engines operating at the speeds indicated. If the speed and size of pulley K are other than as given in Table 2, then the sizes of pulleys, L, M, and N must be changed accordingly in order to cause the agitator shaft to turn at 60 revolutions per minute.

ARRANGEMENT AND LOCATION.

Temporary or makeshift lime-sulphur cooking plants are sometimes located in the open without shelter for the plant or workers. A shelter, which need not be elaborate or expensive, is an economy in the end as protection from the weather prolongs the life of the equipment, especially that of a steam boiler or an engine, and makes it possible to operate the plant at any time. It is necessary at least to protect the stored supply of lime and sulphur.

If the plant is housed all openings should be of liberal size in order that light and ventilation shall be ample and that fuel, materials, and finished product may be handled easily.

The arrangement of the plant should be planned with a view to labor and time saving. A hillside location, such that the raw materials may be delivered readily at or slightly above the level of the working platform, is very desirable especially if there is available a gravity water supply which will deliver, without pumping, to the water tank and boiler. Such a plant might be termed a gravity installation, since the direction of practically every movement is on a level or downward, and the work can be carried on with a minimum of manual effort.

The plant should be installed so that the different operations may be carried through in a logical sequence, without interruption or interference. Local conditions will determine the relative positions of the several parts of the plant. It is obviously impossible to suggest arrangements applicable to all conditions, but the layouts and routing diagrams shown in connection with the different plants described should assist materially in planning an efficient arrangement.

The fumes from boiling lime-sulphur will discolor lead-and-oil paint and cause it to peel off. The plant, therefore, should be situated far enough away from painted buildings to avoid this.

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WASHINGTON : GOVERNMENT PRINTING OFFICE : 1922

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1286

The RED-NECKED RASPBERRY CANE-BORER

A "FLAT-HEADED," milk-white borer, the larva or young of a small, slender, black beetle with bronze-red head and coppery red or golden thorax ("neck"), causes a reduction in the crops of raspberry, blackberry, and dewberry in the eastern half of the United States by its injury to the canes. The beetle, also, does some injury by feeding on the leaves of the plants.

This insect may be controlled by cutting out the infested canes in the fall or winter, or in early spring before the beetles have emerged from them, and promptly burning the cuttings. Cooperation in the observance of this measure, including the same precautions on wild plants, for successive years, is highly desirable.

Washington, D. C. Issued September, 1922.

THE RED-NECKED RASPBERRY CANE-BORER.[1]

By F. H. Chittenden,

Entomologist in Charge, Truck-Crop Insect Investigations, Bureau of Entomology.

CONTENTS.

INJURIOUS WORK OF THE BORER.

THE young canes of raspberry, blackberry, and dewberry are subject to injury by the larva, or young, of a small, short-horned beetle, known as the red-necked raspberry cane-borer, or raspberry gouty-gall beetle. This larva, or borer, forms irregular swellings, or galls, from 1 to 3 inches in length, consisting of gradual enlargements of the canes and splitting of the bark. The canes so infested either die or become weakened to such an extent that the crop fails to develop.

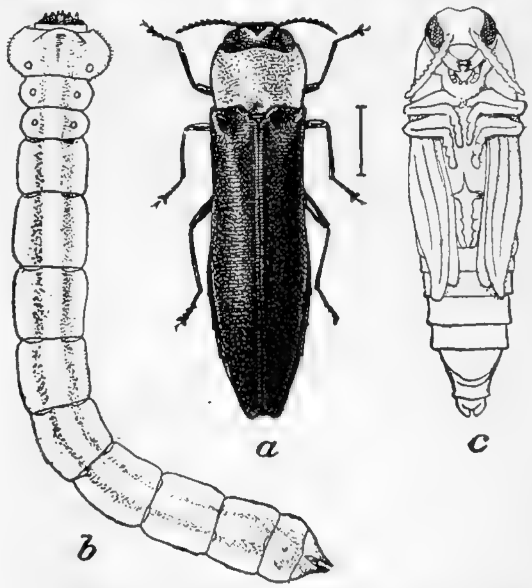

FIG. 1.—Red-necked raspberry cane-borer; *a*, Beetle; *b*, larva, ventral view; *c*, pupa. Magnified about 6 times.

DESCRIPTION OF THE INSECT.

THE BEETLE.

From all related insects the beetle, which produces this borer, can be readily distinguished by its beautiful coppery-red or golden thorax ("neck"), which has given it its name. It is of moderate size, averaging a little more than one-fourth of an inch (5.5 to 7 milli-

[1] *Agrilus ruficollis* Fab.; order Coleoptera, family Buprestidae.

meters) in length. Its elongate-cylindrical form and most characteristic features are shown in the accompanying illustration. (Fig. 1, *a.*) The ground color is dull bronze black on the lower surface, the head is bronze red, and the wing-covers are a beautiful velvety black. The entire upper surface, as seen under a magnifying glass, is finely and beautifully sculptured. The antennæ (feelers) and legs are short and slender, the former saw-toothed and the latter ending in a pair of claws divided at the tips. This species is quite distinct from the two-spotted raspberry cane-borer[2] which belongs to the long-horned borers.[3]

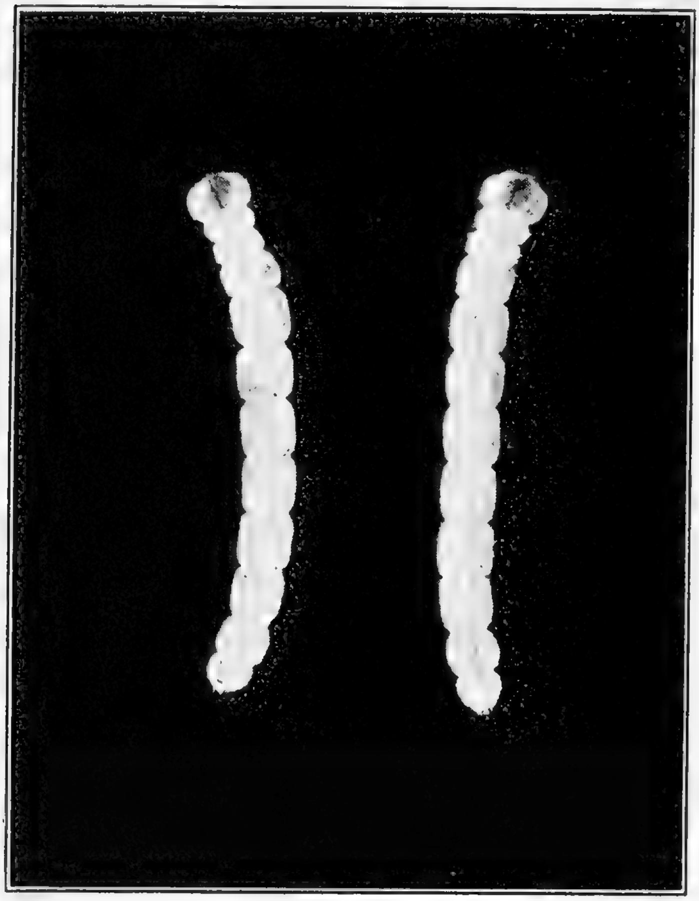

Fig. 2.—Larvæ of the red-necked cane-borer, ventral view. Much enlarged. (Photographed by Gentner.)

THE LARVA.

The larva (fig. 1, *b;* fig. 2) is one of the flat-headed borers and is a singular looking object. The body is elongate and flattened, and the first thoracic segment, which is apt to be mistaken for the head—as the latter can be withdrawn into it—is prominent, being much flattened and widened at the sides, whereas the last segment of the abdomen terminates in a pair of slender, dark brown, toothed, forcepslike processes. The general color is milk white, the first thoracic segment being pale yellow and the mouth parts dark brown turning to black. The illustrations (fig. 1, *b;* fig. 2) show the ventral or lower surface, and it will be noted that there are no legs; hence the dorsal and ventral surfaces are quite similar. The length of the larva is between five-eighths and three-fourths of an inch.

THE PUPA.

The pupa (fig. 1, *c*) is of about the same length as the beetle, and shows in retracted form many of its characters.

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[2] *Oberea bimaculata* Oliv.

[3] Family Cerambycidae.

DISTRIBUTION, FOOD PLANTS, AND EXTENT OF INJURY.

The species is of wide distribution, being found in both warm and cool latitudes from Canada and New England westward to Minnesota and southward to the Gulf States, covering nearly the entire eastern half of the United States. (See fig. 3.)

This cane-borer does not feed, so far as is known, on any plants other than those mentioned, although there are at least three somewhat doubtful reports of its breeding on rose. It attacks practically all varieties of blackberry, raspberry, and dewberry, and when numerous is always injurious, whether occurring on wild or cultivated plants. As an instance of damage, in 1892 hundreds of acres of blackberries about Hammonton, N. J., were so badly injured by this cane-borer that 25 per cent reduction of the crop for 1893 was predicted.

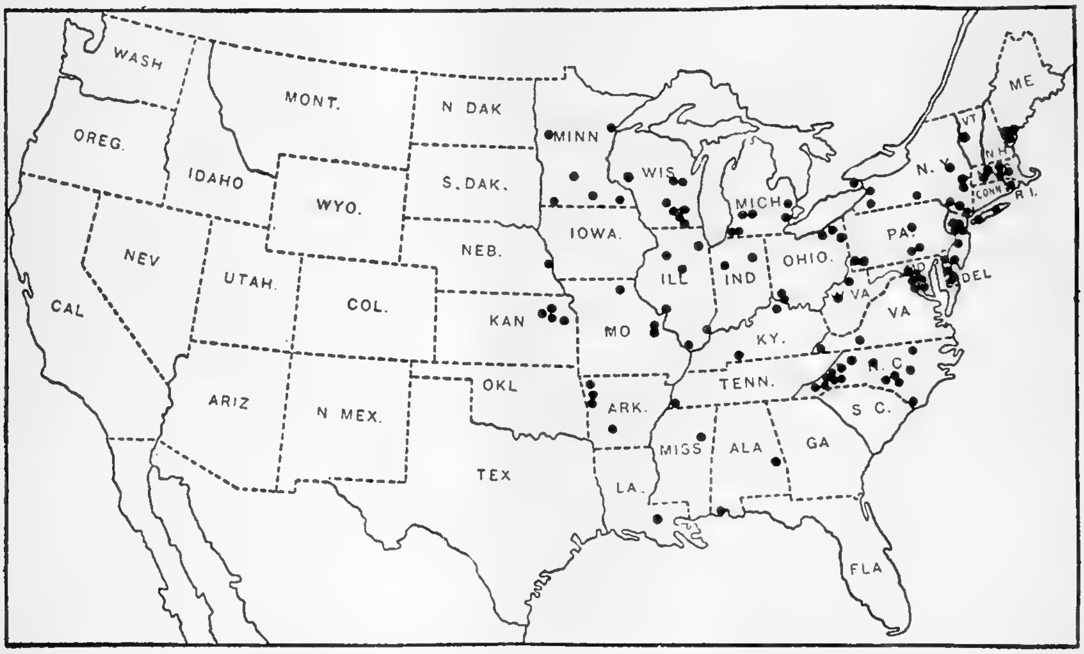

Fig. 3.—Known distribution of red-necked raspberry cane-borer.

INJURY BY THE BEETLE.

While injury is due mainly to the larva boring within the canes, the adults of the cane-borer also do harm by feeding on the leaves. They attack by preference young, bright green foliage, and may either notch the leaves or cut small rounded holes in them. Their work is irregular, but it is unmistakable, as they feed exclusively on the upper surface and leave considerable quantities of excrement upon the leaves. In time the attacked leaves wither and die prematurely. Figure 4 illustrates a leaf some time after the attack of the beetle. The beetles do not appear to be at all particular whether the plants attacked are in sunlight or in shade, in this respect differing from many other species of the same family.

SEASONAL HISTORY AND HABITS.

The beetles make their first appearance in the District of Columbia and vicinity some years as early as the first week in May. In more northern regions they appear some time in June, continuing until August, the time of appearance being coincident with the blooming of the raspberry. They deposit their eggs on young growth, first near the root and later at different points on the main stem and branches. From one to as many as a dozen galls have been observed in a single cane. A favorite place is near the base of a leaf. The eggs hatch and the minute white larvæ feed on the sapwood just under the bark, proceeding spirally upward or downward in the sapwood and around the cane, girdling it and thereby causing its death. Where this girdling takes place the galls are formed. (See fig. 5.) Sometimes larvæ may be present in the stems without the formation of galls. Still later the larvæ bore into the pith, continuing upward or downward. After proceeding from 4 to 8 inches in the canes they form oval pupal cells in the pith near the woody part and in these the larvæ pass the winter. In March they molt, forming shorter, or prepupal, larvæ, and in April molt again and change to pupæ, in this stage remaining inactive for from 7 to 10 days, according to temperature, the beetles developing toward the end of April and issuing in May and until July.

FIG. 4.—Blackberry leaf taken some time after attack by beetles of the red-necked raspberry cane-borer, showing enlargement of original holes made by the beetles in feeding.

The pupal cell may be only a short distance above the ground; it may be a few inches only below the first gall, or in rare cases above the gall.

A single generation is produced annually.

NATURAL ENEMIES.

This species, like most interior feeders, attracts certain parasites, two[4] of which, small four-winged wasplike flies, are common and undoubtedly are material factors in reducing the numbers of the pest.

REMEDY.

The only direct method for the control of the red-necked raspberry cane-borer consists in cutting out the infested canes, which may be detected by the galls or enlargements on them. This may be done in the late fall, in winter, or in spring, or at any time before the latter part of April in most localities where the insect is injurious, and the cuttings should be promptly burned. As the beetles begin to emerge from the canes early in May they are, by the means indicated, destroyed before their emergence. Thus considerable diminution in injury will follow for the season.

FIG. 5.—Section of blackberry cane showing gall or enlargement at middle, caused by larva of red-necked raspberry cane-borer.

To insure thoroughness, however, it is necessary to employ the same means on all of the insect's food plants—blackberry, dewberry, and raspberry—and, where possible, to extend this operation to wild plants of the same kind. Otherwise the wild plants, unless of value for fruit, should be kept down, since it is principally in volunteer growth and neglected berry patches that the insect breeds.

Cooperation in the observance of this measure with neighboring growers of these fruits is highly desirable and should be continued for successive years, or as long as the galls or swellings are to be seen in any number.

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[4] *Microbracon xanthostigmus* Cress. and *Charitopus magnificus* Ashm.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1294

The EUROPEAN CORN BORER *and* ITS CONTROL

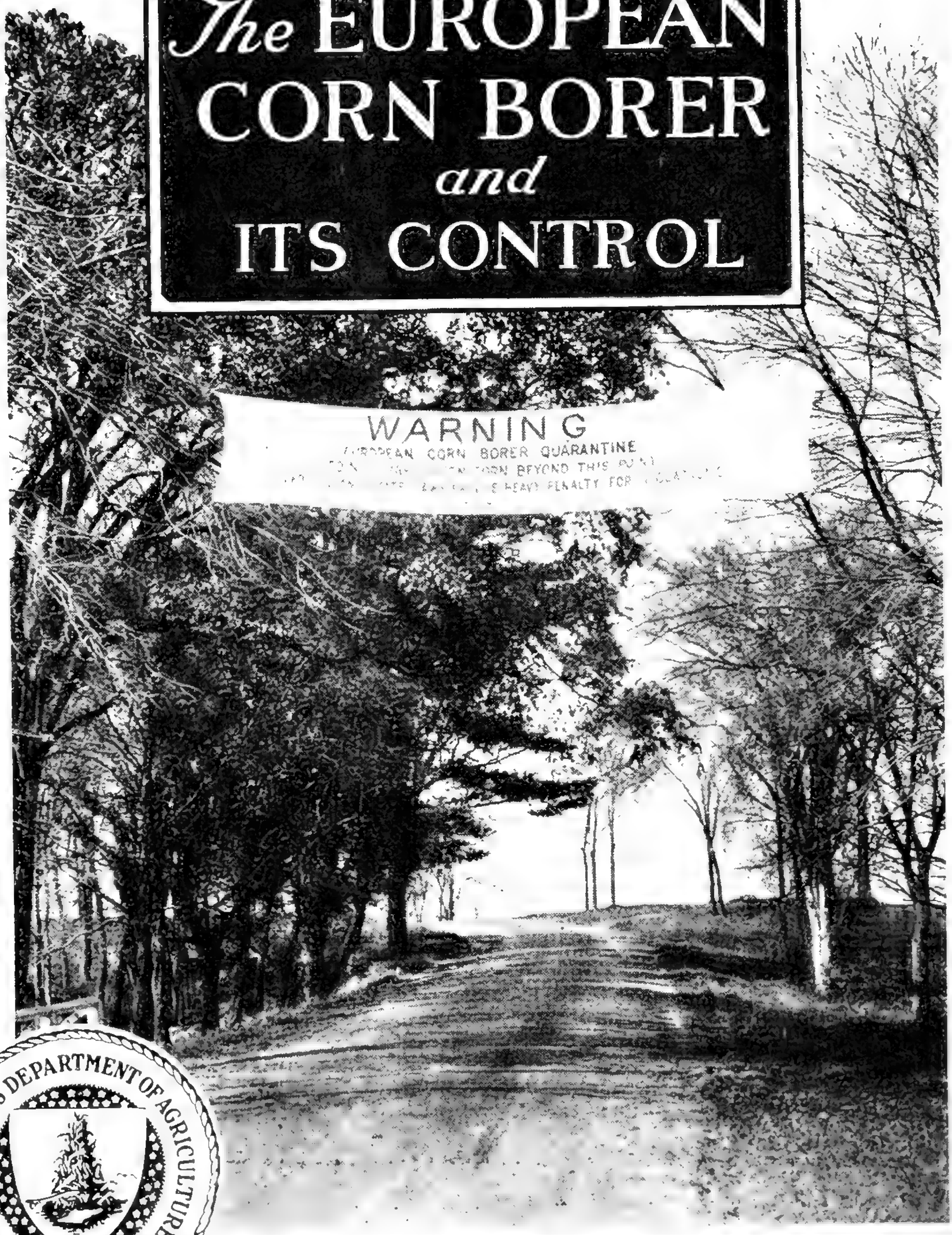

FIGURE 1.—Corn borer injury to various plants. Top at left: Larvæ and pupæ in cornstalks, and young tassel attacked by the insect. Male and female moths drawn on same scale as the corn. Top center: A female moth with cluster of eggs on a section of corn leaf, on a considerably larger scale. Top right: Mature tassel showing typical injuries by caterpillar (the broken tassel stem is often the most noticeable evidence of the presence of the insect during the early summer months). Center: External and internal views of injuries inflicted on two ears of sweet corn. Lower half of the figure: Snap beans, beets, and celery attacked by the borer, cornstalk containing caterpillars, corn stubbles cut away to show how the caterpillars hide themselves in the fall, winter, and early spring months, "smartweed," which is a favorite food at times, "barnyard grass," which in Massachusetts is often heavily infested, and "cocklebur" plant, a weed that often serves as a breeding place for the pest. (Walton.)

THE EUROPEAN CORN BORER[1] AND ITS CONTROL.

D. J. CAFFREY, *Assistant in Charge, Corn-Borer Investigations*, and L. H. WORTHLEY, *Expert in Charge, Corn-Borer Control, Bureau of Entomology.*

CONTENTS.

A PEST OF PRIME IMPORTANCE.

THE EUROPEAN CORN BORER, the injurious stage of which is the young, or caterpillar, of a small moth, has become firmly established in the northeastern United States and in Ontario, probably having gained entrance in 1909 and 1910 in broom corn imported from Hungary and Italy. The results of four years of investigation by the Bureau of Entomology of this department leave no room for doubt that this insect constitutes a corn pest of prime importance. In addition, it attacks a large variety of useful and ornamental plants as well as grasses and weeds, and this increases its destructiveness and adds greatly to the difficulty of controlling it or restricting its spread. The losses resulting from the work of the insect have not as yet been extensive, but a gradual increase annually in such losses has occurred throughout all of the older areas of infestation in this country.

NOTE.—This bulletin is intended to supply practical information regarding the European corn borer to corn growers, corn canners, dealers in green vegetables, and market and home gardeners. Complete technical details regarding the Federal investigations of the corn borer will be supplied in a subsequent publication.

[1] *Pyrausta nubilalis* Hübn.; order Lepidoptera, family Pyralidae, subfamily Pyraustinae.

The discovery, in August, 1921, of a slight but extensive infestation of the pest along the southern shore of Lake Erie in Pennsylvania, Ohio, and Michigan indicates that this insect is about to invade the area of most intensive corn production, and that steps to combat the pest must be taken promptly if future losses from its work are to be prevented or overcome.

HISTORY OF THE INSECT IN THE UNITED STATES.

During the summer of 1917 the European corn borer (Fig. 1) was first reported and identified from the United States.[2] At that time it was found to be causing severe damage to sweet corn in the vicinity of Boston, Mass., and to be present within an area of at least 100 square miles in that section.

In January, 1919, the insect was discovered in the vicinity of Schenectady, N. Y., and in September, 1919, separate infestations were found south of Buffalo, N. Y., and at Girard, Pa.

The summer scouting of 1921 revealed an infestation of the pest on Middle Bass Island in Lake Erie, not far from the Ohio shore. Subsequent investigations showed that a sparse but extensive infestation occurred throughout a narrow strip of territory comprising most of the towns bordering Lake Erie, and adjacent thereto, in the States of Pennsylvania, Ohio, and Michigan.

DISTRIBUTION IN NORTH AMERICA.

UNITED STATES.

To date the European corn borer is known to be present in three separate areas in the United States (Fig. 2) comprising a total area of 7,696 square miles.

The most severely infested area is in New England and contains 2,670 square miles including 140 towns in eastern Massachusetts and 12 towns in southeastern New Hampshire. This area extends along the Atlantic coast and a short distance inland. (Fig. 2, *a*.)

In eastern New York 64 towns and cities, containing 2,203 square miles, are known to be infested. This area is in the section surrounding Schenectady. (Fig. 2, *b*.)

The third and largest area of infestation is in the territory along the American shore of Lake Erie, and probably extends only a short distance inland. This includes 44 towns in western New York, comprising an area of 1,634 square miles, 12 townships and cities in northwestern Pennsylvania, with an area of 347 square miles, 30 townships in northern Ohio, with an area of 757 square miles, and 3 townships in southeastern Michigan with an area of 85 square miles. (Fig. 2, *c*.)

[2] In August, 1916, specimens of dahlia stems infested by caterpillars of some moth were sent to the Massachusetts Agricultural Experiment Station, Amherst, Mass., from three localities near Boston, Mass. Adults were reared from this material, but the fact that they were the European corn borer was not established until after adults had been reared and identified from sweet corn in 1917.

Extensive scouting operations have been carried on during the past three years in the territory surrounding and adjacent to the infested areas of New England, New York, Pennsylvania, Ohio, and Michigan, as well as along the main lines of travel, river valleys, water routes, the vicinity of broom factories, and other susceptible localities in those States. Scouting operations have included field examinations in susceptible localities not only in the territory east of and including the Mississippi River basin States, but also in Texas, New Mexico, and Arizona. Particular attention has been given localities where imported broom corn was known to have been re-

FIG. 2.—Map showing areas of infestation of the European corn borer in North America, as known April 1, 1922: *a*, New England area; *b*, eastern New York area in vicinity of Schenectady and Albany; *c*, western New York area, including Buffalo and Dunkirk, and the spread of 1921 in Pennsylvania, Ohio, and southeastern Michigan; *d*, Canadian areas of infestation.

ceived, as well as to sections producing field corn, sweet corn, and broom corn. Special scrutiny has been given the territory adjacent to ocean and river ports as well as railroad centers, and along the main railroad, highway, and water routes.

DOMINION OF CANADA.

During August, 1920, the Canadian authorities reported an infestation in Welland County, Ontario, bordering the Niagara River from the western New York area of infestation, and another large and heavily infested area extending along the Canadian shore of Lake Erie with its apparent center near St. Thomas, Ontario. (Fig. 2, *d*.)

Recent advices from the Canadian authorities report the European corn borer as present in an area of about 7,690 square miles, comprising most of the southern Ontario peninsula bordering Lake Erie and including Pelee Island. The infested area extends on the north to Goderich on Lake Huron, and on the east to Lake Ontario and the Niagara River. There is also a small isolated infestation on the northern shore of Lake Ontario.

PROBABLE METHOD OF INTRODUCTION.

The exact date and manner in which this European pest gained entrance to the United States is not definitely known, but circumstantial evidence accumulated since its discovery indicates strongly that broom corn imported from Hungary and Italy in 1909 and 1910 was the carrier. Broom factories which received this foreign material were located near the centers of infestation at Everett, Mass., and Amsterdam, N. Y. An apparent confirmation of this probable method of introduction was afforded when two shipments of broom corn, received at the port of New York from northern Italy during February and March, 1920, were found to be infested and shipments received from Hungary during April, 1922, were found to be similarly infested. Broom corn is commonly infested by this insect in Europe.

Raw hemp formerly was believed to be the most likely medium through which the insect gained entrance to this country, but this theory has been abandoned.

From present indications it is believed that the infestations on the islands and along the shore of Lake Erie in Michigan, Ohio, and Pennsylvania may have originated from the badly infested area just across Lake Erie, in the Province of Ontario. The history and intensity of this Canadian infestation indicate that it is probably the oldest colony of the pest in this region. The infestation in western New York may also have originated from the same source, although the origin of this infestation is more obscure. The method of dispersion from Ontario may have been by forced flight of the moths or by the drift of infested plant material in the waters of Lake Erie; at the present writing, however, no traces of such material have been discovered. A study of the wind and water currents in the Lake Erie section, in conjunction with the known habits of the insect, shows the possibility of such dispersion through either of these agencies. Recent experiments have shown the moth to be capable of a flight of nearly 20 miles.

PLANTS ATTACKED BY THE INSECT IN THIS COUNTRY.

Corn is injured by the larvæ, or borers, of the European corn borer to a greater extent than any other cultivated crop attacked by the insect in this country. The borer attacks sweet corn, field corn (both dent and flint), pop corn, and corn planted for fodder or silage. Corn doubtless is the preferred host of the insect in North America, as it is in Europe. In the badly infested area in New England the borers also attack a variety of other plants, including field crops, vegetables, flowers, grasses, and weeds. (Fig. 1.)

The economic plants (other than corn) attacked by the insect in New England may be roughly divided into two groups, according to their susceptibility as recorded at this writing. Only the more important economic plants are listed.

GROUP I.—*Economic plants frequently attacked by the European corn borer.*

Aster.	Chrysanthemum.	Hemp.	Sunflower.
Barley.[3]	Cotton.[3]	Hops.	Swiss chard.
Beans.	Cowpea.[3]	Millet.	Sweet sorghum[3]
Beets.	Dahlia.	Peppers.	
Broom corn.[3]	Gladiolus.	Potato.	
Celery.	Grain sorghums.[3]	Rhubarb.	

GROUP II.—*Economic plants occasionally attacked by the European corn borer.*

Artichoke.	Golden glow.	Okra.[3]	Sweet clover.
Buckwheat.[3]	Hollyhock.	Parsnip.	Timothy.
Calendula.	Johnson grass.[3]	Salvia.	Tobacco.[3]
Canna.	Marigold.	Soy bean.[3]	Tomato.
Cosmos.	Mignonette.	Spinach.	Zinnia.
Geranium.	Oats.	Sudan grass.[3]	

The infestation of these crops, other than corn, is especially likely to occur (1) when corn is growing near by; (2) when the infested crop remnants and weeds from previous crops on the same, or adjacent, areas have not been destroyed; and (3) when susceptible weeds are growing in the same field or in its immediate vicinity.

Many of the thick-stemmed weeds and grasses serve as hosts of the borer in the New England area of infestation, and aid in its multiplication as well as complicating its effective control. Among these plants are included barnyard grass,[4] cocklebur,[5] smartweed,[6] pigweed,[7] ragweed,[8] beggarticks,[9] dock,[10] panic grass,[11] burdock,[12] horseweed,[13] tansy,[14] wormwood,[15] and other similar plants. These susceptible weeds are often very heavily infested in some of the cultivated fields and waste places. Occasionally the borers appear to prefer these plants as hosts rather than corn.

In New York, Pennsylvania, Chio, and Michigan the infestation to date has been confined mostly to corn, with a light infestation in the more susceptible weeds. In western New York a very few borers have also been found in some of the cultivated crops and flowering plants (soy beans, sorghum, millet, dahlia, and cosmos). It is probable that the degree and variety of infestation in susceptible weeds, vegetable crops, field crops, and flowering plants will increase if the insect becomes more numerous in these areas.

To date (January 1, 1922) the European corn borer has been found in 185 species and varieties of plants in the United States. Some of these plants undoubtedly serve primarily as shelter for the borers rather than as food.

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[3] Plants occurring rarely in the infested portion of New England or which were grown only in the experimental fields.

[4] *Echinochloa crus-galli.*
[5] *Xanthium* spp.
[6] *Polygonum* spp.
[7] *Amaranthus retroflexus.*
[8] *Ambrosia* spp.
[9] *Bidens* spp.
[10] *Rumex* spp.
[11] *Panicum* spp.
[12] *Arctium* spp.
[13] *Erigeron canadensis.*
[14] *Tanacetum vulgare.*
[15] *Artemisia* spp.

The egg clusters of the insect have also been found in the field on dandelion,[16] horseradish,[17] lettuce,[18] oxalis,[19] plantain,[20] and rye.[21] Borers have been reared experimentally upon these plants and also upon blue-grass.[22]

CHARACTER OF INJURY TO CORN.

The most serious injury caused by the European corn borer to corn is through the work of the larvæ, or borers, in the ears and stalks. The borers also tunnel within the tassel, the midrib of the leaf, the brace roots, the stubble, and in fact all parts of the corn plant except the fibrous roots. In addition they often feed to a slight

Fig. 3.—Newly developed tassel of corn plant, showing injury by young larvæ of the European corn borer. Note small gnawed areas on leaves at right caused by feeding of newly hatched larvæ.

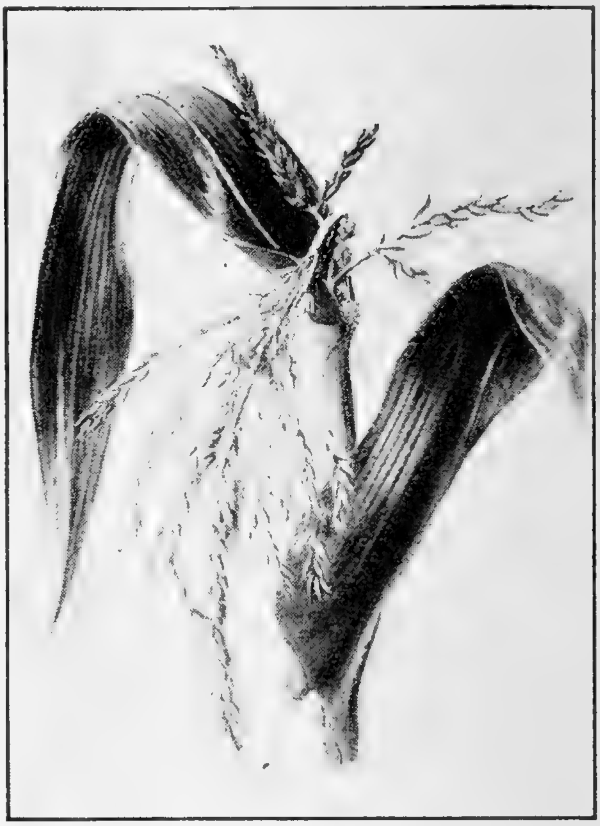

Fig. 4.—Broken corn tassel showing injury caused by larvæ of the European corn borer. (Caffrey.)

extent upon the surface of the plant, particularly upon the leaf blades (Fig. 1), the tassel buds, the husks and silk of the ear, and between the leaf sheath and the stalk.

The character of the injury to corn depends upon the stage of growth of the plant when attacked, and also upon the habits of individual borers. Usually however, the newly hatched borers feed for a short period upon the surface of the plant, near their place of hatching, particularly upon the tender leaf blades (Fig. 3), or upon the green silk and husk of partially developed ears.

[16] *Leontodon* spp.
[17] *Radicula armoracea.*
[18] *Lactuca sativa.*
[19] *Oxalis* spp.
[20] *Plantago* spp.
[21] *Secale cereale.*
[22] *Poa pratensis.*

Within a few hours after hatching many of the borers begin to migrate to various parts of the same plant or to other plants in the

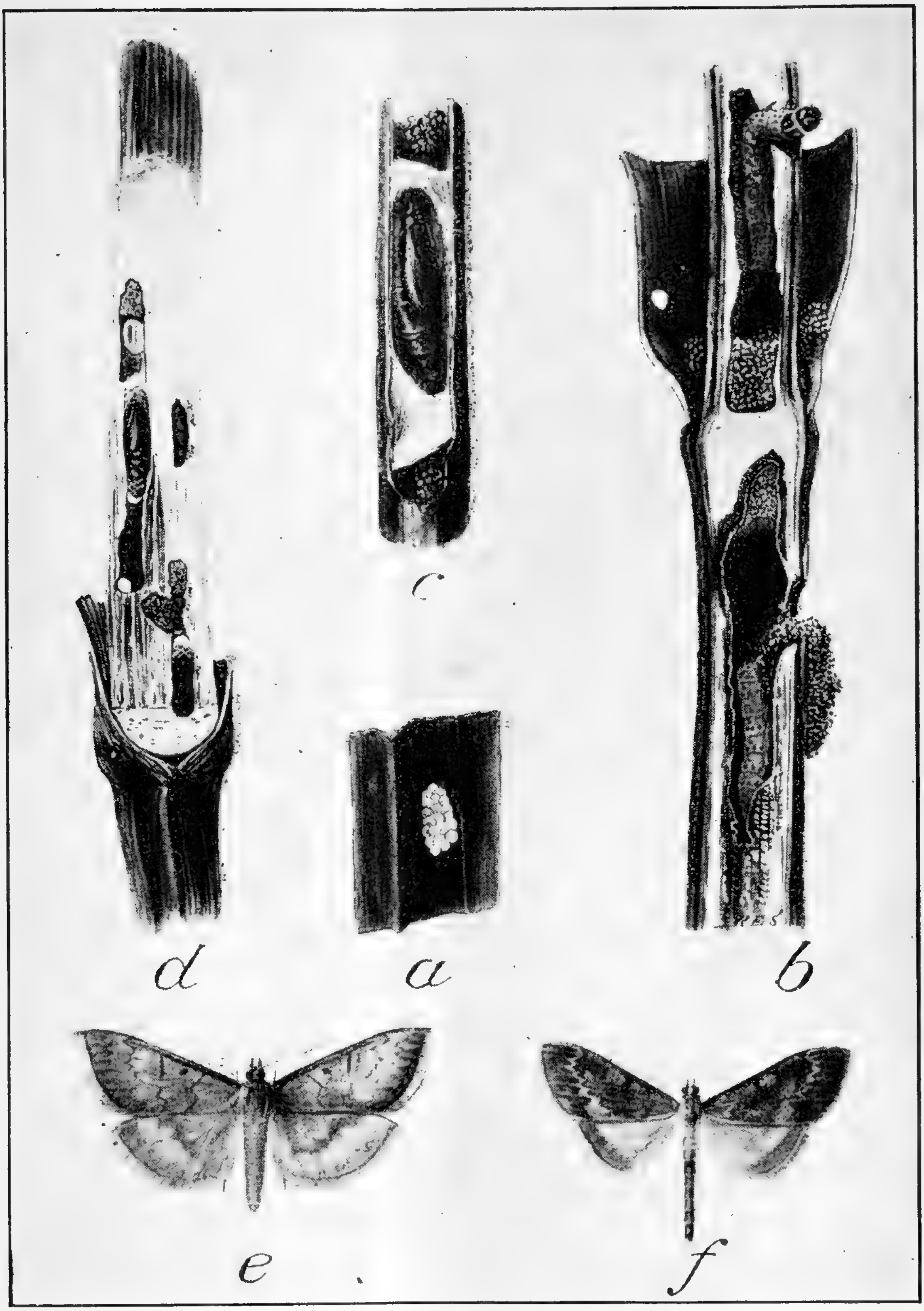

FIG. 5.—The European corn borer: *a*, Eggs; *b*, cornstalk sectioned to show larvæ in their burrows; *c*, cornstalk sectioned to show pupa inclosed within pupal chamber; *d*, cornstalk sectioned to show pupa inclosed within pupal chamber in dry cornstalk; *e*, female moth; *f*, male moth. All somewhat enlarged.

vicinity. If the attacked plant is just developing a tassel, some of the small borers enter the tassel buds and feed within (Fig. 3) while others feed on the surface of the tassel buds and protect themselves with a slight silken web.

As the tassel develops and the feeding borers become larger, they tunnel within the tassel stalk and its branches. This injury so weakens the tassel stalk that it frequently breaks over. Such broken tassels (Fig. 4), with extrusions of frass or sawdust-like material at the breaks, are the most conspicuous signs of infestation in fields of growing corn. Field counts made in badly infested cornfields have shown as high as 80 per cent of such broken tassels. Certain corn plants, especially when attacked during an advanced stage of their growth, do not always exhibit this particular type of injury.

Fig. 6.—Portion of cornstalk showing external evidence of the work of the European corn borer. (Caffrey.)

After working in the tassel stem, the borers may continue tunneling downward into the main stalk (Fig. 5), or they may leave the upper part of the plant and enter it, or neighboring plants, at points lower down (Fig. 5), gradually increasing the size of their tunnels as they develop, and working upward or downward, according to their individual preferences. Small holes in the plant with sawdust-like extrusions (Fig. 6) indicate where the borer is at work.

Instead of feeding upon or within the tassel buds and tassel stalks, some of the newly hatched borers habitually migrate to points lower down on the plant. Under these circumstances they may enter the plant at practically any point, but usually enter between the leaf sheath and stalk (Fig. 6), or between the stalk and the base of the partly developed ear (Fig. 7), in case the plant has advanced to that stage of growth.

Where, as frequently occurs, several or many borers are present within the same stalk, it becomes reduced to a mere shell, filled with

FIG. 7.—External view of ear, showing extruded frass and numerous punctures caused by larvæ of the European corn borer. (Caffrey.)

fragments of the frass or castings of the borers. Such injury may cut off much of the supply of nutriment from the developing ear and greatly weaken the stalk, which eventually collapses and breaks over.

The ears are entered by the borers either directly through the silk and husk, or through the short stem or "shank" by which the ear is attached to the plant (Fig. 8). Here they feed upon the grain and tunnel through all parts of the cob. The "shank" of the ear often is thoroughly tunneled by the borers. Such injury, where extensive and occurring before the ear is well developed, may result in a small or poorly formed ear. This type of injury may cause the ears to break off and fall to the ground before harvest.

In the New England area, during July and August, many of the moths deposit their eggs directly upon, or closely adjacent to, the newly developed ears of late corn. Many of the resulting borers feed at first upon the silk, and then enter the ears directly, where

FIG. 8.—Longitudinal section of ear of sweet corn damaged by European corn borer, showing entrance of larva, the stem, and cob. (Caffrey.)

they feed voraciously upon the grain and cob. It is at this time that the borers do the greatest amount of damage to the ears. As many as 15 full-grown borers, each about an inch long, have been found feeding upon and within a single ear of corn.

The injury to stalks and ears may be further increased by a soft rot which sometimes follows the work of the borers and reduces the interior of infested plants to a decaying, putrid mass. This rot may cause greater loss than is occasioned primarily by the work of the borers.

CHARACTER OF INJURY TO PLANTS OTHER THAN CORN.

The injury to plants other than corn is of the same general character as that to corn, except that in some instances special parts of the plants appear to be preferred as food or shelter.

The stems or stalks of celery, rhubarb, potato, hops, oats, barley, buckwheat, hemp, cotton, dahlia, chrysanthemum, gladiolus, aster, zinnia, cosmos, geranium, and others are entered and tunneled by the borers, and the larvæ are sometimes found in the fruits or flowers of certain plants, notably tomato, pepper, cotton, hemp, dahlia, crysanthemum, and gladiolus.

The stem and leaves of beets, spinach, Swiss chard, and others are preferred by the borers when attacking these plants.

In beans the borers are usually found in the stalks, pods, or green beans.

In addition to the actual loss caused by the work of the borers in these crops, there is also the liability that such products, when distributed through commerce, may contain the insect and thus serve as carriers of the pest to new localities.

Injury to the weeds and wild grasses (Fig. 1) serving as hosts of the European corn borer is not of itself commercially important, but the presence of such weeds and grasses affords abundant opportunity for the multiplication and spread of the pest throughout areas where corn is not grown. In cultivated fields the borers are sometimes so numerous that they are compelled to feed upon these other plants in order to complete their growth. There is also a possibility that some of these wild plants, when used for packing material or as bedding, may contain the borers and thus become a medium for transporting the pests to new localities.

EXTENT OF INJURY TO CORN.

NEW ENGLAND.

In this area the cultivated ground within a radius of about 15 miles of Boston consists very largely of truck and market-garden farms, many of which have been reclaimed from tidal swamps. The soil in many cases is a dark, heavy one, abundantly supplied with humus and moisture. There are in addition some uplands scattered throughout the area where truck crops and corn are grown, but in no case is there any considerable area where field corn is grown on a large scale, as is commonly the case in the Corn Belt, or even throughout the general farming areas of the United States. Thousands of suburban kitchen gardens are also involved in this region.

Because of the damp climate, the excellent growing conditions, and the lush character of the vegetation, this area affords exceptionally favorable conditions for the existence and rapid multiplication of the corn borer. Neglected fields, city lots, and uncultivated areas abound, very often thickly covered with large herbaceous plants and weeds, in which the corn borer is permitted to breed unmolested, and it makes the best of this opportunity. It should be understood also that the infestation of the pest throughout even this old and intensely infested region is not uniform but that the more heavily infested areas occur in spots more or less scattered. No fields of dent corn are grown commercially in this area.

Although a very small amount of flint and no dent corn is grown for grain within that portion of Massachusetts where the corn borer has existed for at least a decade and become well established during that time, both types of corn are readily attacked by the borer, judging from observations made in the few commercial fields of flint corn available and the experimental plats which contained representative varieties of both dent and flint corn. The experimental plats in which this corn was grown were situated in three different sections of this heavily infested region, and it is believed that the results there obtained represent average conditions of infestation and injury which may be expected to occur in similar localities where the insect is fairly abundant and has become well established.

In this heavily infested area it was found that slightly more than four-fifths of the ears of flint corn (Figs. 9, 10) were infested with the borer, with a damage to the grain on these infested ears amounting to approximately one-eighth of the grain produced. Dent corn grown experimentally within this same area was found to be somewhat less injured by the attack of the borer, approximately three-fourths of the ears being infested, while only 2 per cent of the grain was found to be damaged. Sweet corn (Fig. 11) grown in this area and representing average conditions was found to be infested to such an extent that slightly more than half of the ears contained the borer at the time of picking, while in many of the smaller and more intensely infested fields every ear was found to have the borer present. Although the grain on many of the infested sweet-corn ears was only damaged to a slight extent, this slight injury was sufficient to render the majority unfit for market purposes and in consequence of this injury there resulted an average loss of slightly more than one-third of the total value of the crop in 16 of the more heavily infested fields.

The infestation and injury to sweet corn and to early maturing varieties of flint (field) corn in practically all cases have been more severe than in the larger and later maturing varieties of dent (field) corn. In some instances, however, the insect appeared to exhibit an equal preference for sweet, flint, and dent corn. In these cases the choice apparently depended more upon the stage of development of the plant, or upon its proximity to infested weeds or other plant material, than on the type of corn.

During 1921, which was an unusually favorable season for caterpillar enemies of corn, the resulting damage by the corn borer was somewhat increased over the preceding season, more markedly, however, in towns situated at some distance from the center of the infestation, and it may be of interest at this point to illustrate by a specific example the representative conditions which existed in the most heavily infested fields of sweet and field corn. In a very heavily infested 1-acre field of Longfellow flint corn, every stalk of corn in the field contained the borer, with an average of 11 borers to the stalk. The ears were nearly as highly infested as were the stalks, 96 per cent containing borers, with an average of 3 borers to each infested ear.

Outside of this area which has just been discussed, and even in some fields within it, little or no economic damage has occurred to either sweet or field corn, owing to the light character of the infesta-

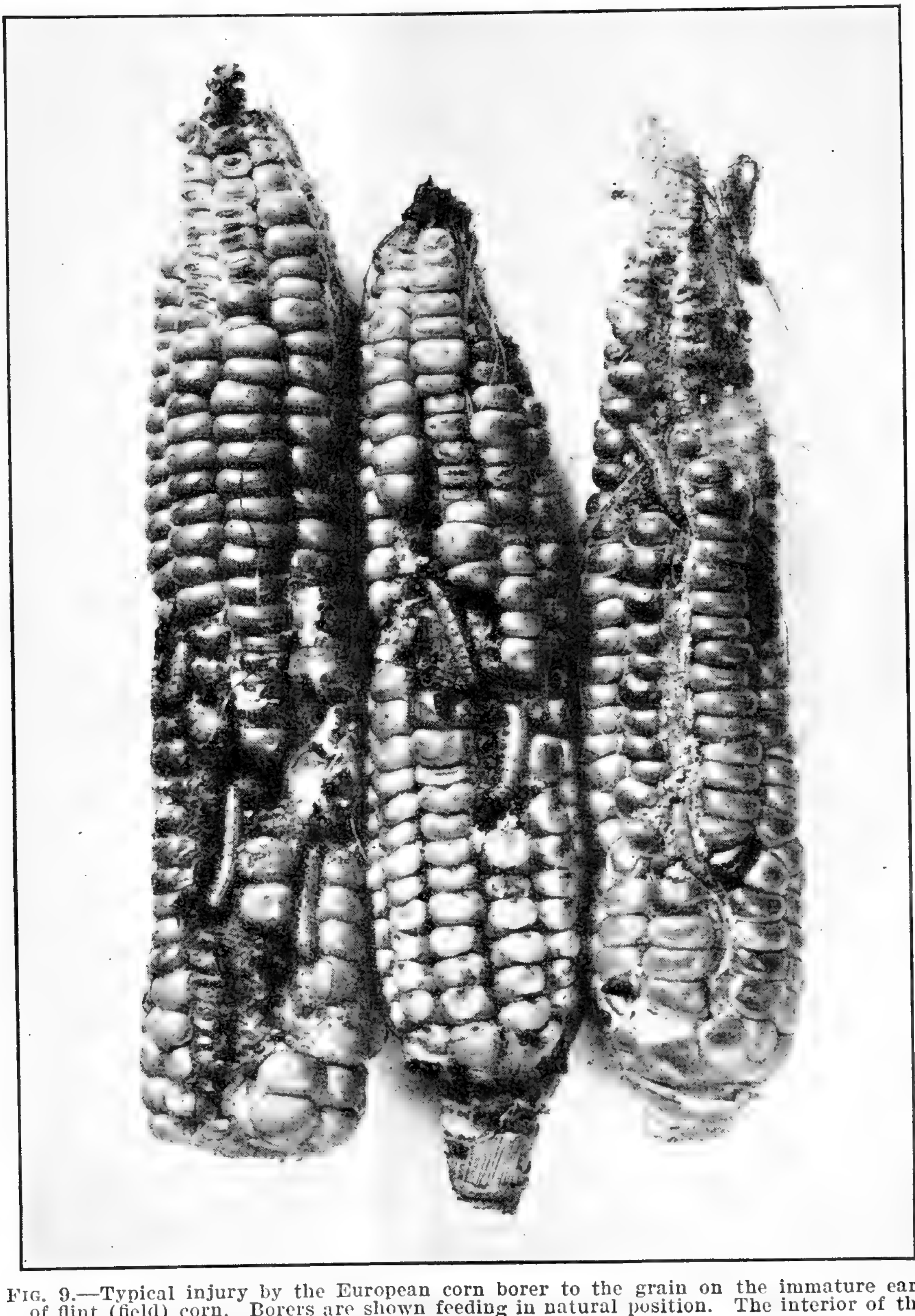

Fig. 9.—Typical injury by the European corn borer to the grain on the immature ears of flint (field) corn. Borers are shown feeding in natural position. The interior of the cobs was also badly tunneled by the borers.

tion and possibly to the clean-up methods which have been employed by the State and Federal authorities, as well as by farmers, gardeners, and other interested persons.

NEW YORK.

In this region of the corn-borer infestation the extent of injury and economic loss caused by the European corn borer to date has been comparatively slight. The injury and loss, as well as the degree of infestation, however, have been greater in the western than in the eastern area of the State. An intensive clean-up campaign in eastern New York by the State authorities soon after this infestation was discovered may also have aided in preventing the increase of the pest which otherwise might have occurred.

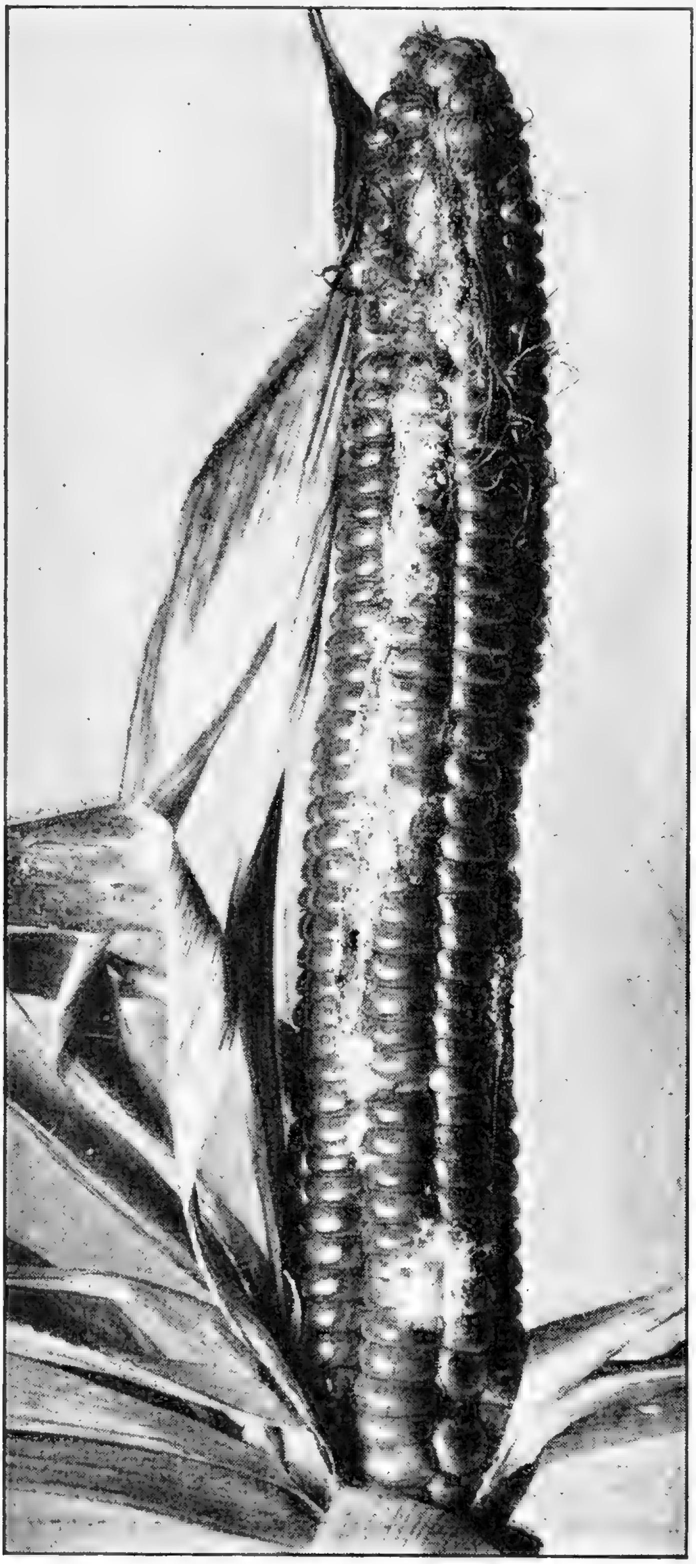

Fig. 10.—Mature ear of flint corn, showing damage by the European corn borer.

In the western area of the infestation, near Lake Erie, sweet corn is infested to a slightly greater degree than are the various varieties of flint and dent corn in the most heavily infested fields, while in sections which represent the average conditions of infestation sweet corn is approximately twice as heavily infested as are the field-corn types (dent or flint). Sweet corn representing average conditions in this area has an average of about one-tenth of the stalks containing the borer, while 3 in each 100 ears are unfit for market. In comparison with this condition, dent corn is found to have an average of 5 per cent of the stalks infested, while but 1 ear in 100 contains the borer. However, in the most heavily infested sections, sweet corn has an average of slightly less than 25 per cent of the stalks infested, with an occasional maximum of approximately 50 per cent. Under these conditions an average of 5 per cent of the ears have been found unmarketable. Dent corn under like conditions averages 18 per cent stalk infestation.

In the eastern New York area the comparative infestation between sweet and field corn is the reverse of that found in the western area, although the difference is very slight. An average of 3 per cent more of the stalks were infested in dent than in sweet corn in this area, considering representative fields in making this statement.

In this area sweet corn contains an average of slightly less than 6 per cent of the stalks and 3 per cent of the ears infested, while dent and flint corn have an average infestation in the stalks amounting to 7 per cent and with only 1 per cent of the ears containing the borer.

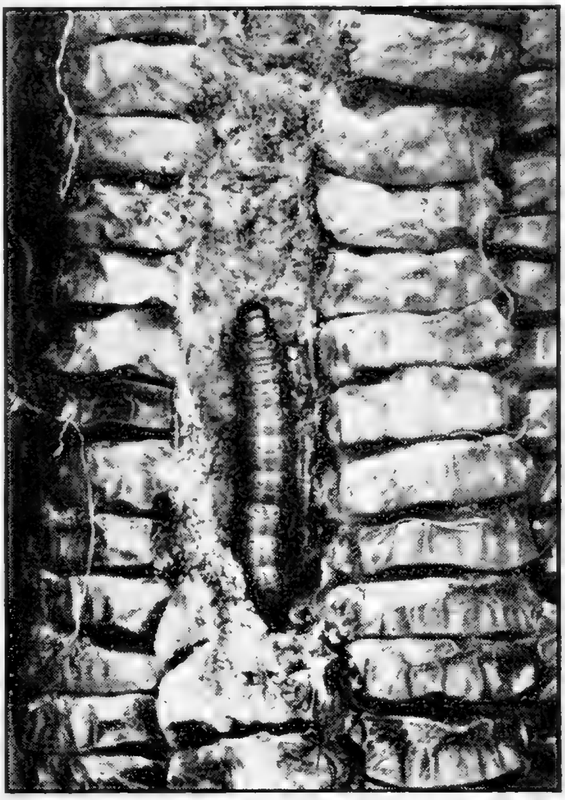

Fig. 11.—European corn borer larva feeding in ear of mature sweet corn. Slightly larger than natural size.

The grain injury by the borer in New York has been slight. In the most heavily infested section of the western area, from 3 to 5 per cent of the grain was damaged, with a few cases where the injury amounted to approximately 16 per cent in sweet corn. In one of the worst infested fields of field corn the damage amounted to 3 per cent of the kernels destroyed. In the eastern area an average of less than 1 per cent of the ears of sweet corn were rendered unmarketable by the borer and the damage to field corn was slightly less. During the favorable season of 1921, however, the grain injury in one case amounted to an average of 7 per cent damaged kernels and in sweet corn an average of 13 per cent was noted.

PENNSYLVANIA, OHIO, AND MICHIGAN.

At the present writing there has been no appreciable damage by the European corn borer in the newly infested cornfields of this section of the infested area, owing to the slight character of the infestation in these recently invaded regions.

INDIRECT INJURY.

The foregoing estimates of injury to the ears and grain refer only to the direct injury through the attack of the borer to the corn ear. In addition to this direct loss there is an indirect loss of grain in badly infested plants caused by the tunneling of the insect in the stalk below the ear and especially in the short stem or shank bearing the ear. This injury (which of course prevents the proper food supply from reaching the developing ear), where severe and occurring before the ear is well developed, frequently results in a small and poorly formed ear. These injuries not only reduce the supply of nourishment for the growing ear, but in many cases weaken the stalk and shank to such an extent that the occurrence of heavy winds or severe rainstorms subsequently results in extensive breaking over of the stalks and ears. The ears thus thrown to the ground may subsequently be injured or destroyed by rots and molds during ensuing wet weather. Severe injury to the stalk, besides weakening and preventing its proper development, offers an excellent opportunity for the ingress of plant diseases and various rots, molds, and fungi. In cases where severe injury to the tassels or male flowers has resulted in a large percentage of them breaking over, inadequate pollinization of the ears may occur and thus result in the diminishing of grain formation.

The actual grain loss resulting from this indirect injury to the ear is difficult to estimate, as it varies greatly in different fields and depends upon several factors, the most important of which are (1) the number of borers per plant; (2) the stage of development of the plant when attacked; (3) the part of the plant selected for attack. In general, however, it may be stated that in very badly infested fields the indirect loss may nearly or quite equal the direct loss sustained by the feeding of the borers on the grain.

EXTENT OF INJURY TO VEGETABLES, FLOWERS, AND FIELD CROPS OTHER THAN CORN.

No instances of infestation in cultivated plants except corn have been observed to date in eastern New York, Pennsylvania, Ohio, and Michigan, although in western New York an occasional borer has been found in experimental areas of millet, sorghum, soy beans, dahlias, and cosmos. A single commercial field of soy beans was also found to be slightly infested.

The extent of injury to vegetables, flowers, and field crops in New England as a direct result of the feeding of the borers is not severe in most instances. Some of these crops which are quarantined, however, especially celery, beans, beets, rhubarb, and spinach, suffer an indirect loss through the restriction of the area in which they may be marketed. This loss for individual growers has amounted in certain seasons to a maximum of 20 per cent of the total value of the crop. In many home vegetable and flower gardens, the feeding of the borers in potato stalks, tomato stalks and fruit, Swiss chard, pepper stalks and fruit, dahlias, asters, zinnias, and similar plants caused considerable loss in the aggregate, but the exact amount involved is difficult to determine. The injury to corn is, of course, the most important consideration in the corn-borer problem, but the extent of infestation in marketable products of other economic crops is also important, because they may contain the insect and serve to carry it to new areas.

During the exceptionally favorable growing season of 1921 there was an increased amount of infestation and injury to some of the vegetable and flower crops, but the economic loss, as a direct result of the feeding of the borers in any instance, seldom exceeded 1 per cent of the value of the crop. The insect was present in nearly every commercial field of rhubarb, beets, celery, and beans examined in the infested area in Massachusetts during this season, the degree of infestation ranging from 1 to 75 per cent. The worst affected portions were usually found in weedy fields and along field borders, where the plants were growing among or in close proximity to infested weeds or corn.

In order to present a general idea of the damage to the plants concerned, and the commercial loss sustained due to the attack of the borer, the following list of plants, with a brief mention of the extent of injury and intensity of attack, will suffice.

RHUBARB.

Affected to a greater extent than any other vegetable or garden crop, excepting sweet corn. Eggs of both generations found on leaves. Borers tunneled in the leaf stalks, seed stalks, and veins

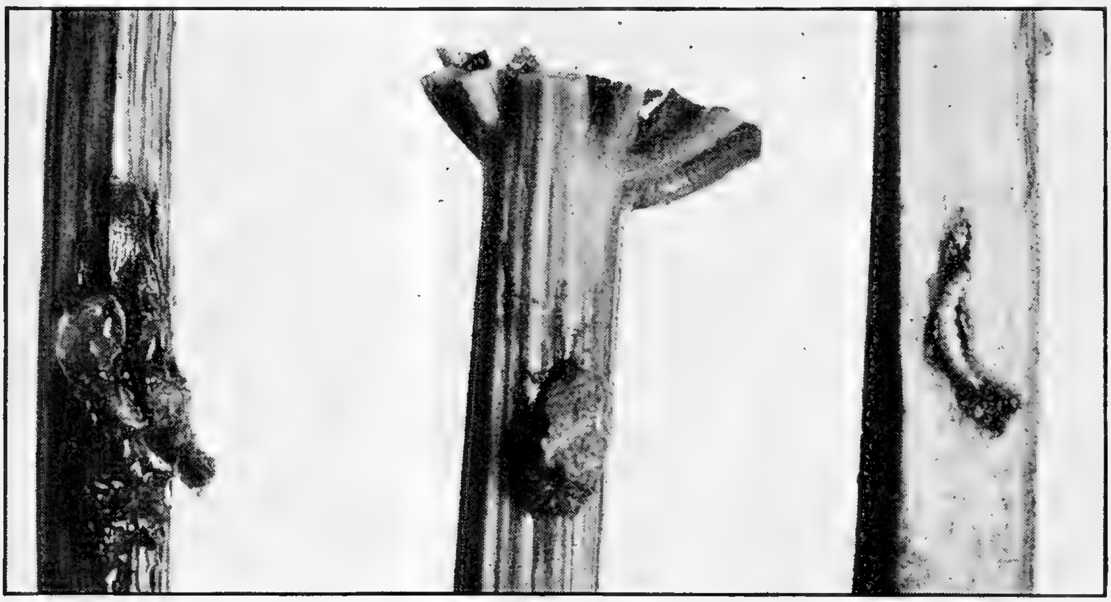

FIG. 12.—Rhubarb stems infested with the European corn borer.

of leaves and frequently caused them to collapse and break over. Injury occurred after close of commercial season and growth of plants did not appear to be seriously affected. (Fig. 12.)

BEETS.

Similar to that outlined under rhubarb. Borers tunneled extensively in leaf stalks and infrequently entered the beet root. Injury did not appear to seriously interfere with the growth of the plant. (Fig. 13.)

CELERY.

Infestation light, but quite general. A few egg clusters found on leaves. Borers tunneled in the leaf stalks and in cases of severe injury the affected parts were unfit for sale. Affected portion usually could be removed with very little commercial injury to the rest of the plant. In the worst infested field noted there was an average of 2 per cent of the plants infested, with a maximum of 60 per cent in the worst affected portions. (Fig. 14.)

Fig. 13.—Beet stems injured by larvæ of the European corn borer.

BEANS.

Confined principally to stalks with an occasional borer in the pods. Egg clusters were found rather infrequently on the leaves from the first week in July to the last week in August. Borers tunneled in stalks and as a result of severe injury breaking over of the affected parts resulted. Very little commercial injury. Less than 1 per cent of the pods were infested in any of the fields under observation. (Fig. 15.)

SPINACH.

A few egg clusters have been found on the leaves each year. Less than 1 per cent of the plants were infested in any case and no appreciable loss resulted.

PEPPERS.

Injury to both stalks and fruit of "sweet" and "hot" varieties. Injury to stalks in some cases caused a reduction in yield, since stalks

FIG. 14.—Stalk of celery injured by the European corn borer. Side of stalk cut away to show borer within. (One-half natural size.)

were broken over before fruit had fully developed. Some fruit was unfit for sale. Estimated loss in worst infested commercial gardens was 5 per cent of value of crop.

DAHLIAS.

Most susceptible of flower crops. Borers tunneled extensively in stalks. Injury resulted in the breaking over and wilting of plant before flowers had attained full development. No infestation in bulbs recorded. Worst affected gardens had 100 per cent of stalks infested. Estimated loss to commercial gardens 5 per cent of value of crop.

ASTERS.

China or garden asters were generally very heavily infested both in home and commercial gardens including both those grown outdoors and to a lesser extent those propagated in greenhouses. Borers tunneled in main stems and flower stalks causing mutilation of plants in heavily infested plantings. Injury often prevented normal development of flowers. Estimated loss in heaviest infested fields ranged from 10 to 15 per cent of total value of crop.

Fig. 15.—Green beans showing the work of European corn borer larvæ.

CHRYSANTHEMUMS.

Infestation confined principally to plants grown under glass. Usually less than 1 per cent of plants injured, although, in a few cases noted, infestation amounted to 10 to 20 per cent. Injury to flower stem often prevented proper development of blooms. Estimated loss in worst infested greenhouses amounted to 2 per cent of total value of crop. (Fig. 16.)

GLADIOLI.

Infestation usually amounted to only a trace, except that in one case where plants were growing near other infested plants a maximum of 6 per cent infestation was recorded. Egg clusters found on leaves. Few borers present in flower stalks. Losses trivial. (Fig. 17.)

ZINNIAS.

Frequently found infested in home gardens and small commercial gardens. Infestation varied from a trace to 10 per cent. Injury seldom interfered with normal development of flowers, except in a few cases. Losses in any instance did not exceed 1 per cent of value of crop.

COSMOS AND HOLLYHOCKS.

The stalks of cosmos and the flower stems and leaf stems of hollyhocks occasionally found infested. No appreciable loss.

OATS.

Stems have occasionally been found infested when plants were growing as volunteers in waste places or among other crops. Detailed examinations of oat straw grown experimentally within the infested area also revealed borers present in both baled and loose straw at the rate of 8 borers to 100 pounds of baled straw and 11 borers to 100 pounds of loose straw. (Fig. 18.)

SEASONAL HISTORY AND HABITS.

There are usually two complete generations annually of the European corn borer in the New England area of infestation, according to observations made since the discovery of the insect in 1917. This habit is subject to some variation, however, in accordance with seasonal climatic fluctuations. In 1920 only one complete generation and a partial second generation were produced, while in 1921 two complete generations and a partial third generation developed.

FIG. 16.—Chrysanthemum stem tunneled by European corn borer. (One-half natural size.)

In the two areas of infestation in New York, one complete generation each year was produced in 1919 and 1920, while in 1921 one complete generation and a limited partial second generation developed.

In the recently discovered areas infested by the European corn borer in Pennsylvania, Ohio, and Michigan there developed during the season of 1921 one complete and a limited partial second generation.

NEW ENGLAND AREA.

The European corn borer passes the winter as a full-grown larva or borer within the tunnel made in its host or shelter plant during the previous summer and fall. The presence of such borers may be detected readily by small holes on the surface of infested plants, with masses of the frass, or castings of the borers, extruding therefrom. This frass is usually white or light brown and closely resembles sawdust. Upon cutting open these plants, the borers (Fig. 19) will be found within.

At this time the borer is nearly an inch long and one-eighth of an inch thick. The head is dark brown or black. The upper surface of the body varies from light brown or dark brown to pink. Each segment, or division of the body, bears a row of small dark-brown spots, while several narrow dark-brown or pink lines extend lengthwise of the body. The under side of the body is flesh colored and devoid of markings.

As soon as warm weather begins, in April or May, the borers resume their activities, although little or no feeding takes place at this period.

About the middle of May the borer cuts a small circular opening from its tunnel to the surface of the plant in order to provide an

FIG. 17.—Gladiolus stems showing European corn borer infestation.

exit for the future moth. It then closes this hole with a thin partition of silk and retreats into its tunnel to a point near the last feeding or shelter place, where it spins a thin cocoon. Inside this cocoon the borer changes into the pupa or resting stage (Fig. 5, *c*, *d*; Fig. 20).

The pupa is shuttle shaped, light brown or dark brown, and from one-half to five-eighths of an inch in length. After remaining in this condition for about 19 days, or until the first week of June, the skin of the pupa splits and the fully developed adult or moth emerges.

The female moth (Fig. 21) has a robust body and a wing expanse of a little more than an inch. The general color is quite variable, and represents all shades from pale yellow to light brown. The outer thirds of both the forewing and hindwing are usually crossed by two narrow zigzag lines darker than the rest of the wing. The male moth (Fig. 21) has a long, slender body, is slightly smaller in wing expanse, and is usually much darker than the female. The general color varies from pale brown to dark brown, sometimes with a blue tinge. The outer third of the wing is usually crossed by two narrow zigzag streaks of pale yellow, and there are frequently small pale-yellow areas on the forewings.

The moths are possessed of fairly strong powers of flight. Marked moths of both sexes have been recovered at distances of from 5 to

Fig. 18.—Oats showing European corn borer larvæ infesting stem.

nearly 20 miles from the point of liberation, while individual moths have been observed to make single flights of nearly 400 yards. During windy periods the direction of flight is usually with the wind.

Soon after emergence the moths mate and begin to deposit eggs. They remain quiet during the day, hiding in patches of weeds and grass or underneath the leaves of other plants. During the early evening and early morning they fly from plant to plant, depositing their eggs in flat, irregularly shaped masses (Fig. 5, *a*) usually composed of from 15 to 20 eggs. From 1 to 133 eggs have been found in individual masses. These egg masses are deposited principally on the underside, although infrequently on the upper side, of a leaf, or on the stem of the host plant. Each egg overlaps the adjoining eggs in the manner of shingles. The female moths of this brood deposit an average of about 350 eggs each, but individual females under observation deposited as many as 724 to 1,192 eggs each. The average length of life of the moths of both sexes is about 18 days.

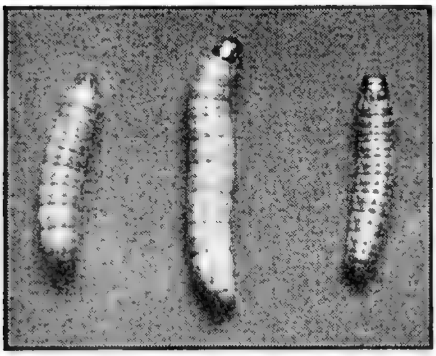

FIG. 19.—Larvæ of the European corn borer, slightly enlarged.

The egg is nearly flat and about one twenty-fifth of an inch in diameter. It is white when first deposited, but later changes to pale yellow, becoming darker just before the young larva or borer hatches therefrom.

The eggs hatch in from 4 to 12 days, with an average of about 7 days, the length of the egg stage varying with the climatic conditions. The newly hatched borer is about one-sixteenth of an inch long, with a black head and a pale yellow body, bearing several rows of small black or brown spots. It feeds for a few days upon the surface of the leaf, near its place of hatching, but soon enters the plant and completes most of its development therein. It may also migrate to other plants by crawling or spinning a suspending thread.

During its growth the borer molts, or changes its skin, five or six times, gradually becoming darker and increasing in size until it is of the same appearance and size as the overwintering borer previously described. By the third week of July, or about 38 days after hatching from the egg, the borer becomes full grown and changes to the pupa, or resting stage, usually inside its tunnel in the host plant. About 11 days later, during the last part of July, or in early August, the moths emerge from these pupæ and deposit their eggs as described for the first brood of moths in June. Many of these eggs are deposited directly upon or closely adjacent to the partly developed ears of field corn and of late sweet corn. An average of about 450 eggs are deposited by each female moth of this second brood, but individual females under observation deposited as many as 1,934 eggs each.

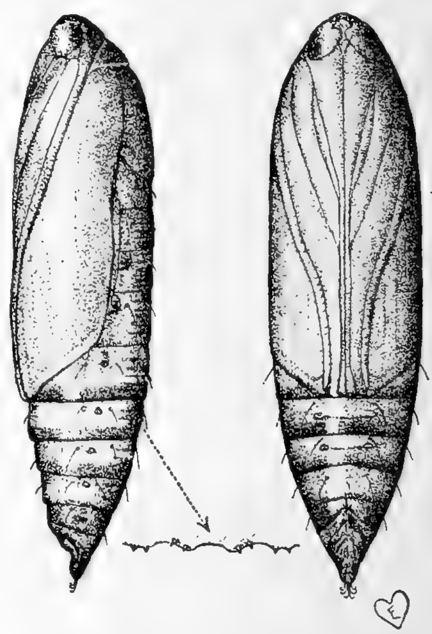

FIG. 20.—Pupa of the European corn borer, lateral and ventral views. About three times natural size. (Caffrey.)

The eggs of this generation hatch in about 7 days, and the resulting borers attack the plant in a manner similar to that described for the first generation.

At this time the injury to the ears of field corn and late sweet corn may be very great, due to the fact that many of the borers make their way directly into the ears after hatching from the egg, and feed within the partly developed ear.

The borers continue to feed at intervals until cold weather stops their activities, in November or early December. They remain in a hibernating condition within their tunnels in cornstalks, corncobs, weeds, crop remnants, or other hosts, throughout the winter.

As stated, there usually are two generations annually in the infested area of New England, and the female moths of both generations deposit an average of about 337 eggs each. As about half of the resulting moths are females, it is evident that the pest is able to multiply very rapidly.

The habits of some individuals of the European corn borer vary from the normal, and this fact should be taken into account when measures for the control or suppression of the insect are under consideration.

Some of the larger borers frequently leave infested plants, or plant material, when such plants are disturbed, or when the infested plants begin to wither or decay. This is especially likely to occur: (1) when infested cornstalks are being collected in the field; (2) when infested cornstalks are left in piles or "stacks" in the field, in the barnyard,

FIG. 21.—Adults, or moths, of the European corn borer: At left, female moth; at right, male moth. Not quite twice natural size.

or under shelter, with the consequent decay or drying out of the plants; (3) when badly infested plants collapse and break over in the field; (4) when infested plants with comparatively small stems, such as oats and some of the weeds, are cut while in a green condition with the consequent rapid withering or shriveling of the stems; (5) during the handling and shipment to market of infested plant products such as sweet-corn ears or beets with top; and (6) when certain plant products, such as celery, are placed in underground pits.

Under these circumstances the migrating borers have frequently been found boring into the crevices and walls of buildings, fences, posts, and other wooden objects. They also crawl underneath the loose bark of trees or fence posts and under rubbish, loose stones, old leaves, and clods of soil. Here they enclose themselves with a rough silken web. They have also been found in the corners and crevices of boxes used for shipping infested sweet-corn ears and similar products. Most of these borers are full grown and many of them are able to pupate and emerge as moths from these shelters.

Full-grown borers have been found to pass the winter successfully and to develop into moths when placed in empty boxes and boxes containing soil, sawdust, dry manure, old leaves, or moss.

The larger borers are able to live for at least a month without food, even during their active period of growth. This habit is especially important, as it renders the insects easily carried in infested material which may be transported considerable distances or kept in storage for a long period.

Experiments have shown that many of the full-grown borers are able to survive total or partial submergence in either fresh or salt water for a period of at least 40 days during their inactive period in the late autumn, winter, or early spring. This fact has an important bearing on the possible drift of infested material in rivers, lakes, etc.

NEW YORK STATE AREAS.

The seasonal occurrence of each stage of the European corn borer is two or three weeks later in New York than in New England and the larva, or borer, stage is much longer.

According to records secured during 1920, the overwintering borers in New York began to enter the pupa or resting stage about the first week of June. The moths began to emerge about the last week of June and were present in the fields depositing eggs until the middle of August. Small borers were found attacking the plants during the first week of July. By the third week of August many of the early hatching borers were apparently nearly full grown, but instead of pupating and emerging as moths to deposit eggs for a second generation, as happens in New England, these large borers continued feeding or boring, with intervals of inactivity, until the advent of cold weather. The later-hatching borers became full grown during September and October.

In 1921 the seasonal occurrence of each stage of the insect in New York was about two or three weeks earlier than in 1920. As a result of this early development a limited second generation was produced. A few pupæ and moths of this second brood were found during late July and early August. These moths began depositing eggs of the second generation during the first week of August. The second-generation borers which hatched from these eggs reached full growth before the end of the season. The appearance of a second generation in this region, it is believed, will occur very rarely.

The general feeding habits of the European corn borer in New York are the same as in New England, except that in New England the borer is known to attack a greater variety of plants at the present time. This difference in feeding habits may be due to the lighter infestation at present existing in New York.

NATURAL ENEMIES.

Although quite a variety of natural enemies of the European corn borer have been recorded in this country, they do not usually attack the insect in any appreciable numbers, and can not be relied upon at the present time to hold the pest in check.

INSECT PARASITES.

In New England, a very small, four-winged, wasplike parasite[24] sometimes destroys large numbers of the eggs of the European

[24] *Trichogramma minutum* Riley.

corn borer. The adult or parent of this parasite deposits small eggs within the eggs of the European corn borer. These parasite eggs hatch into small maggots which devour the contents of the corn-borer eggs. During the late summer of 1919 an average of about 43 per cent and a maximum of 75 per cent of the second-generation eggs were parasitized, as shown by egg collections in 23 towns. In 1921 this parasite destroyed an average of about 30 per cent and a maximum of 74 per cent of the corn-borer eggs in 24 representative towns. This beneficial insect is very variable in its occurrence from year to year, as in 1920 only about 6 per cent of the second-generation eggs were destroyed in the same area. Less than 1 per cent of the first-generation eggs were parasitized each year during the period from 1919 to 1921.

A very small percentage of the borers are destroyed by the young or maggots of six different kinds of two-winged parasitic flies.[25] The maggots of these flies feed upon the internal juices and vital organs of the living borer and finally cause its death. Less than 1 per cent of the borers have been destroyed each year by these beneficial flies.

Eighteen different kinds of four-winged, wasplike parasites[26] have been reared from the larvæ and pupæ of the borer in New England. Less than 1 per cent of the borers have been destroyed each year by these parasites.

Some of the parasites which prey upon the borer in Europe have been introduced into the infested area of New England from France and Italy. The process of establishing these parasites is slow, however, and several years will probably elapse before the result of these introductions will be known.

BIRDS.

A few birds, including blackbirds, woodpeckers, robins, starlings, and pheasants, have been known to feed to a slight extent on the larvæ of the European corn borer in New England.[27] From present indications birds can not be expected to cause much reduction in the numbers of the pest.

INSECTS FREQUENTLY MISTAKEN FOR THE EUROPEAN CORN BORER.

Several different kinds of common and native caterpillars are frequently mistaken for the European corn borer. Some of these caterpillars are similar in appearance to the corn borer, while others are quite different in appearance, but the character of their work somewhat resembles that of the European corn borer. It is, there-

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[25] *Phorocera erecta* Coq, *Exorista pyste* Walk., *Masicera myoidea* Desv., *Exorista nigripalpis* Towns., *Carcelia ochracea* V. D. W., and *Compsilura concinnata* Meig.

[26] *Itoplectis conquisitor* Say, *Sagaritis dubitatus* Cress., *Agrypon* sp., *Amblyteles brevicinctor* Say, *Amblyteles rubicundus* Cress., *Cryptus incertus* Cress., *Microbracon* sp., *Microgaster zonaria* Say, *Meteorus loxostegei* Vier., *Habrobracon gelechiae* Ashm., *Epiurus pterophori* Ashm., *Epiurus tecumseh* Vier., *Epiurus indagator* Cress., *Bassus agilis* Cress., *Labrorychus prismaticus* Nort., *Ephialtes aequalis* Prov., *Campoplex* sp., and *Microbracon caulicola* Gahan.

[27] During 1920 the Bureau of Biological Survey investigated the relation of birds to the European corn borer in New England. As a result of this investigation, one borer was found in the stomach of a pheasant and six borers in the stomach of a single starling. No other species of birds were found to be feeding on the pest at that time.

fore, recommended that any questionable insects found boring in corn be sent to the nearest agricultural experiment station, or to the Bureau of Entomology, for identification.

THE CORN EARWORM.[28]

On account of the similarity of its damage to the ears of corn, the corn earworm (Fig. 22) is very often mistaken for the corn borer. This insect is also known as the cotton bollworm, tomato fruitworm, and tobacco budworm.

The corn earworm, however, is not a true boring insect and usually confines its damage to the silk and kernels of the ear, whereas the corn borer habitually feeds not only upon the silk and kernels of the ear, but also bores into the cob. Unlike the corn borer, the corn earworm does not bore into the stalks, although if the ears have not developed on young plants it often feeds upon the leaves and in the growing tip or "bud" of the plant. This injury sometimes results in broken-over tassels which at a distance resemble corn-borer damage, but close examination will show that these tassel stems have not been tunneled. This characteristic serves to distinguish such injury from that of the corn borer. During the late fall, winter, and early spring the corn earworm is never present in the ears of corn or in the stalks, whereas the corn borer may commonly be found in ears and stalks of corn at this time in areas where the insect is numerous.

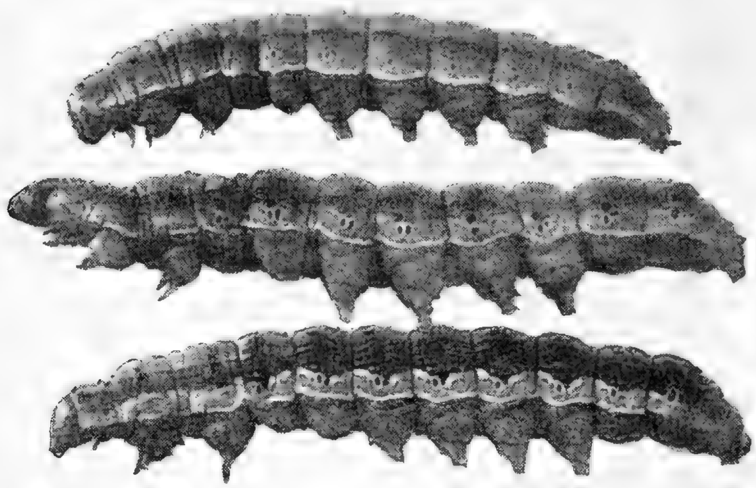

FIG. 22.—Three corn earworm larvæ, seen from the side, showing color types: Upper larva, green; middle one, rose colored; lower one, dark brown. Not quite twice natural size. (Quaintance and Brues.)

The caterpillars of the corn earworm are about $1\frac{1}{2}$ inches long when full grown and very variable in color, ranging from tints of green, pink, rose, yellow, and brown to almost black. They may be beautifully striped, or spotted, with brown, black, or yellow along the side and back, or they may be entirely free of stripes or spots. In appearance they can be readily distinguished from the corn borer by the fact that they are nearly twice the size of the latter. The hairs arising from the *black* tubercles, or warts, on the back of the earworm are much longer and stouter than those arising from the *brown* tubercles on the back of the corn borer. The castings of the earworm are coarse, wet, and foul, while those of the corn borer are more finely divided and usually dry. This insect is widely distributed throughout the corn region of the country and did infinitely more damage in 1921 than the corn borer.

[28] *Heliothis obsoleta* Fab.

THE STALK-BORER.[29]

The stalk-borer (Fig. 23) is often very numerous during the early summer in some sections of the country. It works habitually within the growing tip (heart) and stalk of young corn, and is frequently mistaken for the European corn borer on account of its habit of boring in the cornstalks. In addition to corn, it also bores in the stalks, and infrequently in the fruit, of several other cultivated crops and flowers, and in weeds.

The young caterpillars of the stalk-borer are very easy to distinguish from the corn borer, as they bear a dark-brown or purple band around the middle of the body, and several conspicuous brown or

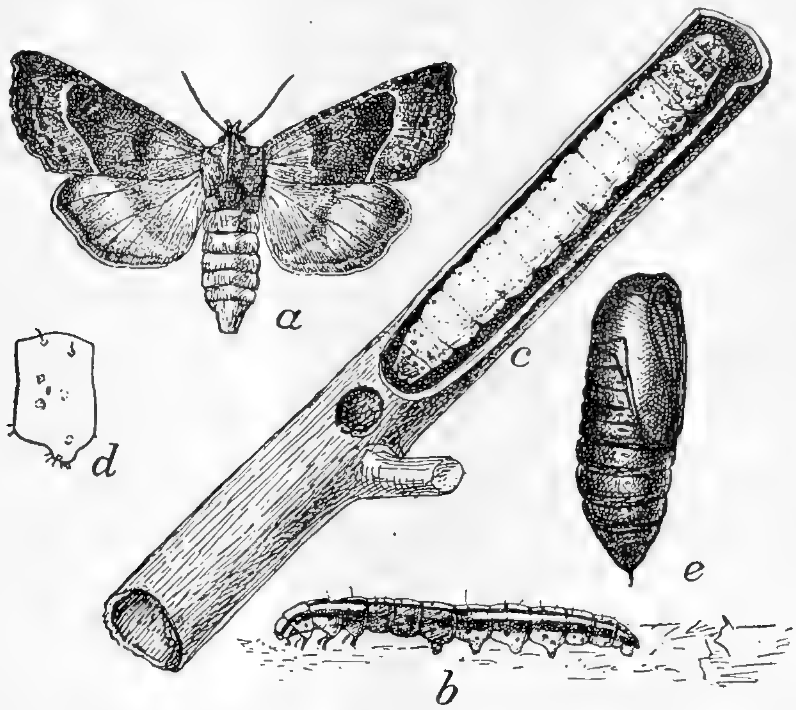

FIG. 23.—Stalk-borer: *a*, Female moth; *b*, half-grown larva, or borer; *c*, full-grown larva in injured stalk; *d*, side view of segment of abdomen of same; *e*, pupa. All somewhat enlarged. (Chittenden.)

purple stripes run lengthwise of the body. The corn borer does not possess these conspicuous bands or stripes. As the stalk-borer becomes full grown, however, these bands and stripes disappear and the color becomes plain creamy white or light purple, with only inconspicuous markings. The full-grown stalk-borer is slightly over an inch long and is much larger throughout than the corn borer. It is never found in cornstalks during the winter.

THE SMARTWEED BORER.[30]

The smartweed borer is very frequently found in corn during the autumn, winter, and spring. The appearance and work of this native borer resemble that of the European corn borer so closely that it is very difficult to distinguish between them. The smartweed borer usually feeds within the stems of smartweed,[31] but it commonly bores into the stalks of corn and other plants when seeking winter quarters.

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[29] *Papaipema nitela* Guen.
[30] *Pyrausta ainsliei* Heinrich.
[31] *Polygonum* spp.

It is known to be very numerous throughout the eastern part of the country, and many reports of European corn borer occurrence have been due to the presence of the smartweed borer.

The caterpillars of the smartweed borer are about three-fourths of an inch long when full grown, slightly smaller than the corn borer, and less robust. They are always slate-colored or gray when full grown, and in the living state they bear a very fine, faint line of darker color running along the middle of the back, whereas in the corn borer this line is decidedly broader and very conspicuous in the living borer. Except for these differences, and one or two microscopic distinctions which are discernible only to an entomologist, these two kinds of borers have the same appearance when full grown. On hatching from the eggs the small caterpillars of the corn borer have black heads, while those of the smartweed borer have pale amber-colored heads.

THE CELERY STALKWORM.[32]

In Massachusetts the celery stalkworm has been frequently found working in celery stalks along with the European corn borer, and on account of its similarity in appearance and damage it has often been confused with the latter. The celery stalkworm, however, usually confines its injury to the surface of the celery stalks, while the corn borer enters the stalks and feeds within as well as upon the surface of the stalks.

The caterpillar of the celery stalkworm is about thirteen-sixteenths of an inch long when full grown, and it resembles the corn borer in general color. The tubercles, or warts, on its back are larger, darker, and support much longer hairs than those of the corn borer. The celery stalkworm is much more active than the corn borer, and moves backward or forward with equal rapidity. It is not known to attack corn.

THE LINED STALK-BORER.[33]

The lined stalk-borer has frequently been confused with the European corn borer in Ohio and to a lesser extent in New York. The work of the lined stalk-borer greatly resembles that which has been described for the stalk-borer, and is usually confined to young corn, especially corn which has been planted on sod land.

The caterpillars of the lined stalk-borer are nearly an inch long and yellowish-white, with several conspicuous reddish-brown stripes running lengthwise of the body. They may be easily distinguished from the corn borer by the presence of these conspicuous stripes and by the absence of the small brown tubercles or "warts" which are present on the corn borer.

THE LARGER CORN STALK-BORER.[34]

In the Southern States, and especially in the South Atlantic States, the larger corn stalk-borer (Fig. 24) is a common enemy of the corn plant, and owing to its habit of tunneling in the stalks of corn it may

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[32] *Nomophila noctuella* Denis and Schiff.
[33] *Hadena fractilinea* Grote.
[34] *Diatraea zeacolella* Dyar.

be easily confused with the European corn borer. The larger corn stalk-borer, however, does not bore into the ears of corn, whereas this habit is characteristic of the corn borer. This southern pest habitually overwinters only in the rootstock of the corn, whereas the corn borer not only winters in the stubble of corn, but may also be found in the stalks and ears of corn and in the stubble and stems of many other plants previously mentioned as hosts.

The caterpillars of the larger corn stalk-borer are of two types—a summer form and a winter form. The summer form, when full

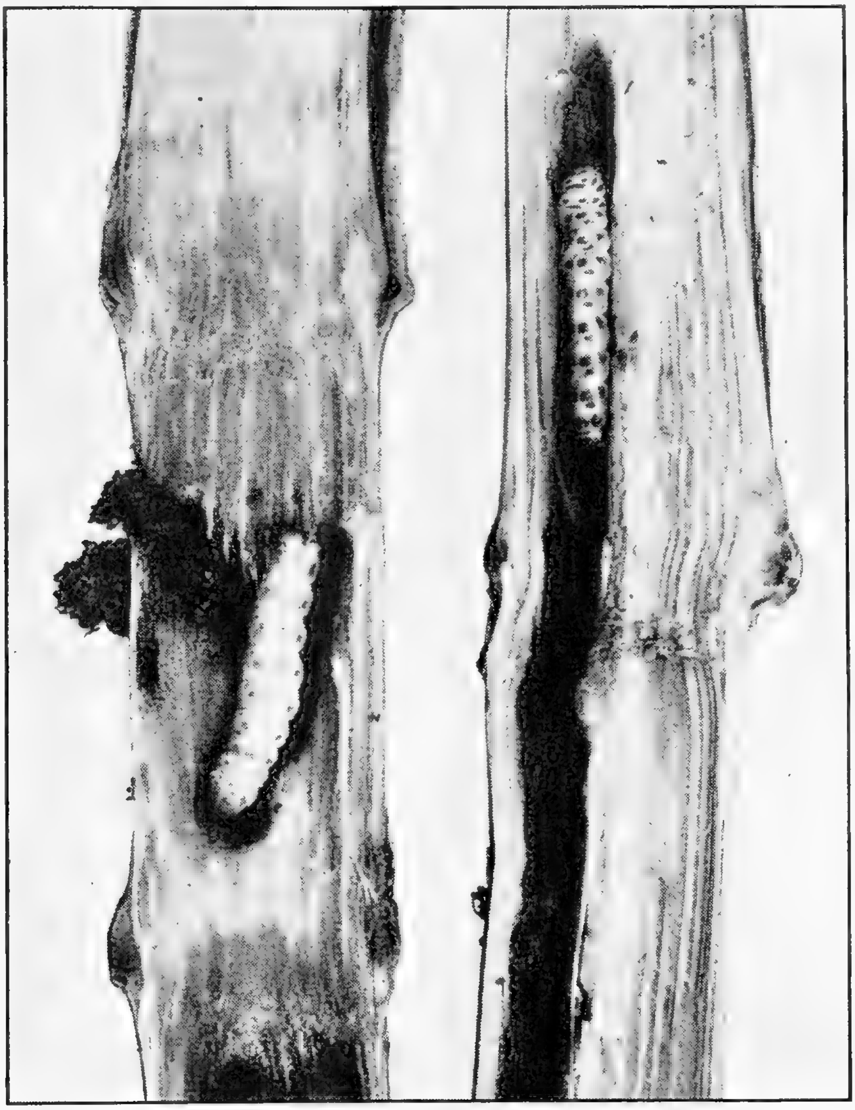

FIG. 24.—The larger corn stalk-borer. Natural size.

grown, is about 1 inch in length, with a dirty white body thickly dotted with round or irregularly shaped darkly colored spots. Each of these spots bears a short, dark bristle. The head region is brownish yellow. The winter form differs from the summer form in that the caterpillar is more robust and is slightly shorter, while the spots referred to above are nearly the same color as the body. In the Gulf strip and on the Mexican border two distinct but very similar and closely related caterpillars[35] may attack corn.

[35] *Diatraea saccharalis* Fab. and *Diatraea lineolata* Walker.

PREVENTING THE SPREAD OF THE INSECT.

THE FEDERAL QUARANTINE AGAINST THE CORN BORER.

The importation from foreign territory of plants likely to contain the European corn borer is regulated or forbidden by the terms of the Federal Quarantine, No. 41, effective July 21, 1921. This is enforced by inspectors of the Federal Horticultural Board at all ports of entry throughout the country.

A domestic Federal Quarantine, No. 43, against the European corn borer was declared by the Secretary of Agriculture, effective on and after March 29, 1920. It is administered by the Federal Horticultural Board in cooperation with the Bureau of Entomology. The original items of the quarantine included 111 towns in Massachusetts, 3 in New Hampshire, 40 in New York, and 1 township in Pennsylvania, and prohibited the shipment of the quarantined products during the entire year. This quarantine was subsequently amended (September 2, 1922) to include 161 towns in Massachusetts, 12 in New Hampshire, 150 in New York, 6 townships in Michigan, 57 in Ohio, and 17 in Pennsylvania, and provides that in the case of corn and broom corn, including all parts of the stalk, cut flowers or entire plants of chrysanthemum, aster, cosmos, zinnia, hollyhock, and cut flowers, entire plants of gladiolus and dahlia, except the bulbs thereof without stems, the quarantine and regulations shall apply throughout the year, and in the case of all other products for the period between June 1 and December 31, in New England territory. It further provides that in the case of corn and broom corn (including all parts of the stalk), all sorghums, and Sudan grass, from infested areas in New York, Pennsylvania, Ohio, and Michigan, the quarantine and regulations shall apply throughout the year.

An amendment of May 1, 1922, provides that the limitation of the restrictions of this quarantine, as provided in the rules and regulations supplemental hereto, to the areas in a quarantined State now, or which may hereafter be, designated by the Secretary of Agriculture as infested by the European corn borer, shall be conditioned upon the establishment and enforcement by the State of such control measures in cooperation with the United States Department of Agriculture with respect to the designated infested areas as in the judgment of the Secretary of Agriculture shall be deemed adequate to effect the control and prevent the spread of the European corn borer.

The inspection and certification of all products, cut flowers, etc. (except spinach), under quarantine, grown within the quarantined area, is conducted in the wholesale markets in all cases, except when the grower ships directly to points outside of the quarantined area, when inspection is made on the premises.

Where the products are found free from infestation by the European corn borer, certificates are granted to cover shipment, each package being covered by a separate certificate. Such certificates (always excepting corn, which can not be certified) permit the product to move outside of the quarantined area. Inspection of spinach is made only in the field.

The terms of this quarantine are enforced in the wholesale vegetable and flower markets by inspectors employed by the Bureau of Entomology. An inspector's office is maintained in the center of the wholesale vegetable districts and in the flower markets in the infested areas. Telephone service is provided and inspectors are on duty at these places from 7 a. m. to 6 p. m., and are subject to the call of merchants, forwarding agents, and private individuals who may wish to ship quarantined products to points outside of the infested areas. Such inspectors are provided with badges of authority issued by the Bureau of Entomology and the Federal Horticultural Board, and supplied with the necessary permits authorizing shipments.

The method pursued may be briefly outlined as follows: A commission merchant receives an order for products included in the quarantine, to be shipped to a point outside the infested area. The products which he wishes to ship were received from some point outside the infested area, but having been received into the infested area, must be covered by a permit authorizing the railroads and express companies to accept them. The person interested notifies the inspector's office by telephone, and the inspector immediately proceeds to the place where the products are located, satisfies himself of their origin by inspecting waybill or other documentary evidence presented, and issues the necessary permits. Where products are grown within the quarantined area, they must be inspected before permits will be granted. These permits are printed on a durable grade of paper, and bear the facsimile signature of the officer in charge of European Corn Borer Control. They are securely fastened to the package in the presence of the inspector. A force of men, sufficient to meet the demand, is maintained in the wholesale flower and vegetable markets within the infested area.

In order to facilitate the shipment of goods packed in oat or rye straw, permits are issued to large commercial houses using hay or straw originating outside the quarantined area, upon satisfactory evidence of origin. In the case of individuals or small concerns who make an occasional shipment, it is necessary for inspectors to issue permits as required.

A constant watch is maintained at railroad, steamship, and electric terminals to prevent violations of the quarantine. A similar surveillance is maintained over long-distance trucks departing from the wholesale market districts for points outside the quarantined area.

Inspectors are also stationed on all main traveled roads at State lines within infested areas during the growing season, for the purpose of stopping and inspecting vehicles to ascertain whether they are carrying products included in Quarantine No. 43. "Warning" posters (see cover-page illustration) are displayed at all roadside stands, produce markets, railroad stations, steamship wharves, express offices, and other public places throughout the infested area, to caution the public against attempting to transport quarantined products to points outside of the infested area. Copies of Quarantine No. 43 may be obtained free of charge upon application to the Secretary of Agriculture or the Federal Horticultural Board, Washington, D. C.

PENALTY FOR VIOLATION OF PLANT QUARANTINE ACT.

The plant quarantine act, August 20, 1912, as amended March 4, 1913, and March 4, 1917, provides: "That any person who shall violate any of the provisions of this act, or who shall forge, counterfeit, alter, deface, or destroy any certificate provided for in this act or in the regulations of the Secretary of Agriculture, shall be deemed guilty of a misdemeanor and shall, upon conviction thereof, be punished by a fine not exceeding $500 or by imprisonment not exceeding one year, or both such fine and imprisonment, in the discretion of the court."

ARTIFICIAL CARRIERS OTHER THAN QUARANTINED PLANTS.

GARBAGE.

During the summer and early autumn the kitchen garbage from hotels, restaurants, private homes, and the like, may contain living borers, or pupæ, in ears or cobs of sweet corn, or portions thereof, which have been discarded after purchase, on account of the presence of the insect. Borers are also frequently present in the husks, silk, undeveloped tips, and the "shank" of the ears. These portions are commonly removed from sweet-corn ears before cooking and thrown into the swill container. Other plant material which frequently harbors the insect and which is commonly discarded during preparation for the table includes the outer stalks of celery, and injured portions of beet tops, rhubarb, Swiss chard, spinach, and string beans.

Garbage of this character may act as a carrier of the insect to new localities, as it is frequently transported considerable distances for use as food for pigs or disposal otherwise. Under these conditions the borers may escape en route, or before the swill is disposed of. Garbage is sometimes thrown into streams or bodies of water which may carry such material long distances through the influence of currents, wind, or tide. Corncobs which have been thrown into pigpens, and subsequently removed when cleaning out the pens, have been found to contain living borers.

Collections of garbage made during the summer, autumn, and spring very frequently contain quantities of infested material consisting of cornstalks, other crop remnants, flowering plants, weeds, and similar plant material. Infested cornstalks and other plant material containing living borers have been found distributed along the beaches of New England, and also upon the shores of islands several miles from the mainland. Infested material of this kind has also been found distributed along the shore of Lake Erie on the Canadian side. It is probable that some of this material, especially cornstalks and weeds, may be washed into streams, and eventually into the ocean or lakes, from farms and gardens during heavy rains or floods.

The dispersion of the borer by means of infested garbage, crop remnants, and certain waste products, as discussed above, is believed to be at least a contributing cause of some of the infestations along the coast of New England and the shore of Lake Erie, as well as along some of the river valleys within the infested areas.

WASTE PRODUCTS.

REFUSE FROM BROOM FACTORIES.

Broom corn when received at broom factories, in the raw state, usually consists of from 18 to 36 inches of the upper part of the broom-corn plant, including the "hurls" or that portion used in brooms, and the upper part of the stalk or "butt."

The European corn borer has been found commonly in that portion of the plant comprising the "butt" in broom corn grown in Massachusetts and also in the "butts" of imported broom-corn material received from Italy. During the process of manufacturing brooms, sections several inches long are usually removed from the base of these "butts" and discarded as refuse. This refuse may become a source of danger, especially when dumped along the banks of water courses. The original infestation along the Mohawk River in eastern New York is supposed to be directly traceable to infested refuse from a broom factory at Amsterdam.

REFUSE FROM CANNING FACTORIES.

The refuse from canning factories using sweet corn from infested areas commonly contains large numbers of living borers. This refuse usually consists of the cobs, husks, silk, "shanks," and ears on which the kernels are not properly developed or are affected by insects or plant diseases. Most of this infested material is hauled away by farmers, often to points outside the infested area, and fed to live stock or used as fertilizer. Under these conditions some of the borers may escape en route and others may escape after reaching the farm, thus starting new infestations.

CONTROL OF EUROPEAN CORN BORER.

INEFFECTIVE MEASURES.

Arsenical poisons not efficient.—The application of arsenical poisons has not been found to protect growing corn plants from injury by the European corn borer, although numbers of the borers may be poisoned in this manner during their early stages. During that period they feed to a slight extent upon the surface of the plants, especially on the leaf blades, but the eggs are deposited over a long period of time, during the growing season, and the borers are hatching almost daily, so that very frequent treatments are necessary in order to keep rapidly growing corn plants covered with the arsenical. Even where as many as 12 arsenical applications were made carefully and at the most advantageous periods, it was found that the plants were severely injured by the borers which escaped the treatments. The substances used in this work were lead arsenate, calcium arsenate, magnesium arsenate, and sodium arsenite in the liquid form at various strengths, and also in combination with nicotine sulphate. Some of these substances were also applied in the powdered form and in combination with hydrated lime.

The cost of applying several treatments of these poisons is prohibitive under field conditions, and they are not recommended to prevent injury by the European corn borer.

METHODS OF CONTROL EFFECTIVE UNDER RESTRICTED CONDITIONS.

REGULATING TIME OF PLANTING.

Injury to the early maturing crops of sweet corn may be reduced to an uncertain extent by regulating the time of planting. On many of the farms and market gardens, where a series of sweet-corn plantings are made on different dates, there is usually a very noticeable difference in the amount of injury to each planting, even where these consist of the same variety, in adjoining areas and under the same soil conditions.

The first planting of early sweet corn is usually injured by the borer to a much greater degree than plantings made from 10 days to 3 weeks later. In Massachusetts sweet corn planted from about April 15 to May 10 has been injured to a greater extent than sweet corn planted from about May 20 to May 30. In New York the earliest planted sweet corn (about May 10) is usually infested to a greater degree than that planted about 10 or 20 days later. The dates of these plantings necessarily will vary from year to year, according to weather conditions, and also with the local development of the season. This method can not be applied for limiting the amount of injury to field corn or late crops of sweet corn in New England, according to present information. These crops are at an attractive stage during the late summer, when the insect is most active and when many of the moths of the second generation in New England are depositing their eggs directly upon the ears.

The variation in the amount of injury to early sweet corn planted at different times may be explained by the fact that at this time of year the moths apparently prefer to deposit their eggs on well-developed plants which have not reached the matured-tassel stage. Subsequently, when later-planted corn becomes available, most of the moths have deposited their eggs, and these later plantings escape serious injury. Although egg masses are frequently found on the leaf blades of very small corn plants, the young borers commonly leave such corn soon after hatching, and enter weeds or other plants near by which have reached a more advanced stage of development.

TRAP CROPS.

Attention has been called to the fact that the earliest plantings of sweet corn usually attract many of the moths which have developed from the overwintering borers, and that these early plantings are commonly very heavily infested. This immediately suggests the use of very early planted sweet corn in fields intended for a main crop of field corn or late sweet corn to act as a trap crop; such plantings to be carefully destroyed, with the contained borers, as soon as the ears are harvested, or preferably just before that period, where the grower is willing to sacrifice the ears and use the plants as green feed for live stock.

This method of limiting damage to the main crop of field corn or late sweet corn might be particularly useful in the one-generation areas of New York. In the two-generation area of New England it can only be used to advantage on the larger fields or farms, judging from results secured at the present writing. On the small farms and market gardens, which now predominate in the badly infested portion of New England, any benefits to field corn or late sweet corn which may be derived from the destruction of a trap crop appear to be partly nullified by the flight of the second-brood moths from adjoining areas of weeds or early corn which has not been destroyed.

Caution.—*Trap-crop plantings which are not destroyed at the proper time constitute a menace to later corn or other susceptible crops.*

SELECTION OF VARIETIES.

Field observations and experimental tests have indicated in some instances that certain varieties of field corn and of sweet corn are less susceptible to severe injury by the corn borer than others.

This apparent difference is usually involved to a certain extent with the time of planting and also with the rapidity or size of growth and the consequent period of maturity. It does not appear, therefore, that any variety on which observations have been made to date possesses anything like entire immunity from attack by the borer, although some varieties suffer much less injury than others.

The varieties of corn having large, heavy stalks seem able to withstand injury to a much greater extent than the slender varieties. This seems especially true of the large, robust dent varieties, such as are grown widely in the Corn Belt States. Throughout the present areas of infestation the northern-grown, early maturing varieties of flint field corn predominate and are usually injured to a greater degree than the later maturing varieties of dent field corn. The stalks and grain of the early maturing varieties of dent field corn appear to be quite susceptible to infestation. Compared with the flint or early dent varieties, the relatively smaller amount of injury observed in the late varieties of dent corn, at least in New York and New England, may be due to their slower development and later maturity, and also to the fact that their greater bulk is able to withstand the work of the borers without so seriously affecting the development of the stalk or ear.

PLOWING UNDER.

The effectiveness of plowing down infested corn stubble, weeds, and crop remnants as a farm practice in reducing corn-borer damage has been made the subject of extensive investigation. It has been determined that by **thoroughly** plowing under this infested material **during the fall**, especially in the soils of eastern Massachusetts, a large proportion of the borers contained in such material are destroyed. This measure alone will probably prove ineffective. In order that it may be rendered even partly effective, practically **all** of the infested material in infested fields must be plowed down to a depth of at least 6 inches in soils of ordinary texture. Deeper plowing increases the effectiveness of this operation and should be adopted when practicable, whenever the character of the soil will permit. Breaking down the cornstalks, stubble, or other standing plant material with a heavy roller, or by dragging with a heavy pole or iron rod before plowing them under, greatly increases the effectiveness of the work. Disk harrowing immediately after plowing serves to break up large clods of soil and aids in burying the plant material where the soil is in a condition that will allow this treatment.

The practice of plowing down infested material in the fall must be regarded as only an aid, or "finishing touch," to other repressive or clean-up measures. In ordinary farm plowing operations, considerable quantities of plant remnants are left on the surface of the soil, or are only partially buried. It is possible, however, under favorable conditions, by exercising proper care, to cover the infested material sufficiently to cause the destruction of many of the contained borers. Any loose plant material left on the surface of the soil should be raked into piles and burned.

Spring plowing has not proved effective, apparently because the borers become active before the soil is in condition for plowing in the spring, and if plowed under at this time, many of them make their way to the surface, even when buried under several inches of soil.

When necessary to plow down fields of standing cornstalks, it is advisable to run a stalk cutter over the field before plowing in order to roll down the stalks and cut them into sections.

PROTECTING GREENHOUSE PLANTS.

Good results have been secured in protecting chrysanthemums and other susceptible plants grown in greenhouses by screening all doors, ventilators, and other openings in such a manner as to prevent the moths from entering the greenhouse. These screens should be put on during the early spring (about May 15), and left in position until the late fall (about November 15). Screen cloth, cheesecloth, and similar materials are suitable for this purpose.

This method is not effective where the plants are allowed to become partly grown in infested fields during the summer and are subsequently moved into the greenhouse in the fall to complete their growth.

Cornstalks, corncobs, large weed stems, and similar plant remnants which are likely to contain the borer should be removed from manure or compost which is intended for use in the greenhouse.

METHODS RECOMMENDED IN MARKET GARDENS.

ABANDONMENT OF SUSCEPTIBLE CROPS.

Several crops commonly grown on market-garden farms in eastern Massachusetts are favorite host plants of the European corn borer, and furnish food for large numbers of caterpillars of the first generation. The resulting moths deposit eggs on later crops and thus produce a second generation of borers in such crops. Sweet corn, which is very susceptible to infestation by the borer within the very heavily infested area in Massachusetts, might profitably be abandoned on market-garden farms, except as a trap crop to be disposed of before July 25. Rhubarb is also attractive to the corn borer, so that it would be advisable to abandon the growing of this crop in badly infested fields, especially where other less susceptible crops may be grown with equal profit. Beet plants are a favorite host for the corn borer, but where these are grown in the early season and sold as bunch beets, or as greens, they are not in the field long enough for the corn borers to mature. For this reason beets should be grown in heavily infested regions only as an early crop and should not be allowed to remain in the field after July 25.

No corn-borer infestation has been observed to date in rhubarb or beets grown under glass.

PLANT QUICK-GROWING CROPS AND CROPS WHICH ARE NOT SUSCEPTIBLE.

The crops grown on these market-garden farms can be handled in a manner to prevent their becoming host plants for the corn borer to develop in. Crops that mature quickly, such as early bunch beets, spinach, and green beans, do not furnish favorable conditions for the development of large numbers of corn borers. Celery, tomatoes, potatoes, and peppers are not likely to be injured by the corn borer where the fields are kept free from weeds, and where corn or rhubarb is not grown in their immediate vicinity.

Cabbage, carrots, cauliflower, cucumbers, dandelion, eggplant, lettuce, onions, parsnips, peas, radishes, squash, and turnips are some of the market-garden crops which may be grown in any situation with very little danger of infestation by the corn borer.

GENERAL METHODS OF SUPPRESSION AND CONTROL.

Any method of suppressing or controlling the European corn borer necessitates the destruction of infested material. This may be done to the best advantage by burning, placing in silo, feeding to live stock, burying in heated manure, or spraying weeds with chemical, weed-killing solutions.

BURNING INFESTED MATERIAL.

The burning of cornstalks and stubble may best be done in the spring or in late winter when the stalks are in a dry condition, and considerable care should be used in the preparation of fires. Some arrangement is necessary whereby a draft can be obtained. This can be done by raising the material to be burned a few inches from the ground by the use of stones or otherwise. In the damp climate of eastern New England the burning of cornstalks is often attended with some difficulty.

Where fields of corn stubble are located near wood lots, a few sticks of dry wood are always available and valuable in starting fires. The application of kerosene by means of ordinary watering pots helps considerably in burning such material. Special attention should be given to the entire consumption by fire of all cornstalks, cobs, and stubble. The process of shelling corn does not injure the borers contained in the cobs, and in infested regions all cobs should be burned immediately after shelling. Corn carried through the winter on the cob and not shelled before May 1 should be placed in a container, so that the moths can not escape after emerging. If a wire screen is used, one having at least 12 meshes to the inch will give satisfaction.

The burning of weeds and crop remnants is easier, as such material will burn readily if left to dry in the sun for a day or two. Any weed or crop-remnant material should not be allowed to dry more than two days after cutting in summer before being burned. If it is allowed to remain longer the borers are likely to leave the infested stalks.

METHODS ADAPTED TO GENERAL FARMING.

Where farms are divided into wood lot, pasture, meadow, and small grains, and only a few acres are in corn, the European corn borer is comparatively easy to control, especially in districts where corn alone is infested.

To accomplish this, all cornstalks should be cut close to the ground as early as the purpose for which they are grown will permit. If this is done with a cutter and binder, the cutter knife should be set as low as possible. If done by hand, a short-handled garden hoe with sharpened blade may be used effectively, and with this tool the stalks and stubble can be cut almost even with the surface of the ground. A corn knife with a blade having a right-angle turn at the end is also convenient for this purpose.

In disposing of cornstalks, care should be taken to destroy them immediately after cutting, either by placing in the silo, shredding and feeding direct to live stock, plowing under, or burning. Good results can not be obtained if stalks are allowed to stand in the fields throughout the winter, because under some conditions many borers migrate to other places of hibernation from such stalks. These operations should be conducted as early in the fall as possible in order to be effective.

The practice of dragging fields of standing stalks with a heavy pole or iron rail while the ground is frozen, and subsequently gathering and burning the broken stalks, is strongly recommended as most useful in the control of the corn borer.

In the spring of the year (before May 1) a good general cleaning up of all corn remnants around barns, etc., should be conducted and such remnants burned.

In areas where the corn borer is seriously damaging fodder corn, it is recommended that alfalfa, red clover, vetch, barley, or similar forage crops be grown, as these crops are not likely to be infested by the corn borer.

BURYING DEEPLY IN SOIL.

Small quantities of infested material may be conveniently and effectively disposed of by burying deeply in the soil during the fall. When this method is followed, it is recommended that the material be covered by at least 18 inches of soil.

BURYING WITHIN PILES OF FRESH HORSE MANURE.

Burying or covering infested plant material in piles of heating horse manure leads to the quick destruction of any borers contained in material thus treated. Care should be taken that the material is completely covered with several inches of manure. This method may often be used to advantage on farms and market garden or florist establishments where large quantities of horse manure are available, but it is not recommended for use in manure or compost which is not in a heating condition.

When corn fodder is used for bedding, or for feeding, the uneaten parts should be kept out of the manure, and burned or otherwise destroyed, unless it is possible to work these portions deeply into manure that is in a heating condition.

DESTRUCTION OF WEEDS.

Weeds serve as refuges for the corn borer and may be killed by spraying with certain chemicals in solution. Many chemicals have been used for this purpose but the two in most common use are iron sulphate and sodium arsenite. Young corn borer larvæ feeding in the tips of weeds may often be killed by such chemicals, but the number destroyed is not sufficient to render this method of value against the corn borer. However, such methods are valuable in destroying weeds on uncultivated land, as in meadows, lawns, borders of roadsides, on public dumping grounds, and on vacant city lots, thus preventing the weeds from becoming a possible source of infestation.

Any reliable type of sprayer may be used in applying these solutions. For large operations on rough land a power sprayer equipped with long lines of hose is most useful. In the experiments carried on by the Bureau of Entomology, a large power sprayer carrying a 400-gallon wooden tank, mounted on an auto truck, was used. A single line of $\frac{1}{2}$-inch hose was run from each tank and fitted with a solid-stream nozzle carrying a $\frac{3}{32}$-inch tip. The method of operation was to run out the entire length of hose, and working back toward the pump, spray a strip about 50 feet wide, repeating this operation until the entire field was covered.

Care should be taken to protect the skin of the operator from the solutions containing sodium arsenite, as this produces severe burning. The remedy for such burns is to apply vinegar to the parts affected.

Weeds should be sprayed before they go to seed, but should not be sprayed when too young as their places may be taken by new plants that sprout from old seed, or new stems may arise from the roots. The best time to spray weeds is when they are in flower, or just before the flowers are formed.

Iron sulphate is often used for killing mustard in grain fields and dandelions in lawns. It will kill almost all broad-leaved weeds, but does not kill grass. There is no danger of poisoning animals which may graze on such sprayed plants. Iron sulphate is also useful for destroying meadow and roadside weeds.

Sodium arsenite is one of the best of the chemical weed killers and is the basis of many of the commercial weed-killing solutions on the market. **It is very poisonous to animals and precautions should be taken to prevent live stock from grazing where plants have been sprayed.** It may be used effectively on public dumping grounds, on vacant city lots, along railroad right-of-ways, or any place where there is no danger of animals grazing. This solution is used at the rate of 3 pounds of sodium arsenite to 100 gallons of water.

Either of the foregoing solutions may be used for destroying weeds on farms, but care should be taken to prevent animals from grazing on plants that have been sprayed with sodium arsenite. It should also be remembered that these solutions kill cultivated plants, and it is difficult to use them along fences and ditches, because the wind is likely to carry some of the solution to the crops. They are useful for destroying weed patches where the land is uneven or where obstructions prevent mowing. The cost of this operation varies, according to the amount of solution used, from $11 per acre up.

In some cases it may become desirable to use a flame-throwing torch with oil as a fuel. In this event any reliable sprayer may be used to produce a spray for oil-burning purposes, providing it is capable of maintaining 100 pounds pressure and is fitted with a spray rod and Bordeaux nozzle. Caution must be exercised to have the nozzle opened as little as possible at 100 pounds pressure, so that oil may not remain on the ground unconsumed. It is advisable to procure ½-inch "oil hose" if possible, as the ordinary spray hose will not last long when used for oil.

Oil-burning of weed areas, headlands, and patches is sometimes useful, especially under suburban conditions, and can be done most economically during the spring, when the material to be burned is dry. At such times it is possible to destroy 99 per cent of the borers contained in the material so treated. It is possible to burn weeds in this way sufficiently when they are green so that, even where they are not entirely consumed by the fire, the heat produced is so intense that the borers are killed. The cost of burning weed areas is high and varies from $12 per acre upward, depending upon the fuel used and the condition of the weed growth. Clean, light fuel oil, not heavier than 0.36 to 0.40 specific gravity, is the cheapest for large operations. Ordinary kerosene is easier to secure and cleaner to handle. After the hose and sprayer have been used for this work, they should be thoroughly washed with soapsuds. Burning over weed areas, after the weeds have been mowed, is helpful, as many borers are likely to be left in the stubble. Oil burning is also of much assistance in consuming material that has been piled or cornstalks that have been raked into windrows.

In the Boston market-garden towns several species of weeds are often heavily infested with the European corn borer. In the cultivated fields these weeds are usually destroyed by cultivation or are plowed under, and many corn borers are killed by these methods. Weeds on the headlands, along fences and ditches, and around buildings are allowed to grow unmolested, however, and furnish ideal breeding places where large numbers of moths are produced to infest cultivated crops in neighboring fields. These fields should be plowed as close to the fences and ditches as possible, thus furnishing more land for cultivation and less for weeds. Orchards should be kept cultivated. Uncultivated land around buildings should be kept as lawns, and uncultivated fields should be turned into meadows or pasture.

Many of the common host plants of the corn borer which occur on the farm, such as barnyard grass, pigweed, smartweed, cocklebur, and horseweed, may be eradicated if they are kept from going to seed. For this reason it is advisable to mow the weeds along fences and around buildings before seed is produced. In order to destroy the corn borers, the weeds should be cut close to the ground, and should be raked into piles and burned as soon as possible. This can usually be done the day after they are cut. If the mowing is delayed until the weeds are in flower, most of such weeds will be killed. Any weeds which send up new stems, or which sprout from new seed, may be destroyed in the fall, winter, or spring by burning over such areas. As most of the headlands and land around buildings are covered with grass, this grass will crowd out the weeds if the mowing and burning is continued for several years. Even the perennial weeds like tansy and goldenrod will be crowded out by the grass if they are mowed, or sprayed with weed-killing substances, several times during the season. Yellow dock, however, is best eradicated by grubbing in the spring. Quantities of weed seeds are often brought on to the land in manure, and for this reason all manure used on garden land should be well composted.

FEEDING INFESTED PLANTS TO LIVE STOCK.

Feeding infested fodder plants to live stock is one of the most effective and economical methods for combating the corn borer. The food value of the fodder is not materially affected by the presence of the borers, except possibly in cases of very severe infestation.

Wherever practicable, the infested plants should be cut close to the ground while green, and placed in the silo, or fed direct from the field. Any borers which escape the silage cutter are destroyed by the conditions existing in the ordinary silo. The common method of feeding corn fodder without shredding does not aid in the least to control the corn borer.

Mature plants, especially cornstalks when too dry to be used for silage, should be shredded, or cut into short sections, before being fed. Live stock relish corn fodder which has been shredded, and this promotes the consumption of the fodder.

When infested cornstalks, or similar plants, are fed direct to live stock, the uneaten parts should be collected and destroyed, preferably by burning.

DESTRUCTION OF CROP REMNANTS.

Celery tops, beet tops, fragments of cornstalks, rhubarb tops, tomato vines, and bean vines which are infested should be destroyed as soon as the crop is harvested, because the borer will crawl from these crop remnants to the growing crops if they are left in the field.

SUMMARY OF CONTROL AND RESTRICTIVE MEASURES.

To control the European corn borer the following practices are recommended:

Burn, or otherwise destroy, before May 1 of each year, all cornstalks, corncobs, corn stubble, vegetable, field, and flower crop remnants, weeds, and large-stemmed grasses of the previous year. Remove all remnants of leaves from rhubarb stems before marketing.

Keep cultivated fields, fence rows, field borders, roadsides, etc., free from large weeds or large-stemmed grasses.

Cut corn close to the ground.

Cut and remove sweet-corn fodder from the field as soon as the ears are harvested. Feed direct to live stock, place in silo, or destroy by burning.

Cut and remove field corn from the field as soon as the ears are mature. Feed the stalks to live stock as soon as possible and burn or otherwise dispose of the uneaten parts before May 1 following. Shred or cut the fodder to increase its consumption.

Plow under thoroughly in the fall all infested cornstalks, corn stubble, other crop remnants, weeds, and similar material which it is impractical to destroy in any other manner. When necessary to adopt this practice, an attempt should be made to plow under **ALL** of the material to a depth of at least 6 inches.

Plant small areas of early sweet corn to act as a trap crop adjacent to the fields intended for field corn or late sweet corn. Feed or otherwise destroy this early sweet corn as soon as the ears are harvested, or preferably just before that period, if the grower is willing to sacrifice the ears. Such plantings, where not destroyed at the proper time, constitute a menace to later corn.

Limit the size of cornfields to areas that can be kept free of weeds.

Do not plant corn within 50 feet of beets, beans, celery, spinach, rhubarb, or flowering plants intended for sale.

Do not throw the uneaten parts of cornstalks used as feed or bedding into the manure pile unless this material is worked into piles containing enough fresh horse manure to produce heating.

Do not transport outside of the infested area any of the plants or plant products listed on page 32.

Do not transport alive, in any of its stages, specimens of the European corn borer outside of the infested areas.

Do not place in swill container any sweet-corn ears or portions thereof, or discarded portions of celery, beets, beans, rhubarb, and spinach when this material is suspected of containing the borer.

Do not dump cornstalks or other plant refuse from the vegetable and flower garden on public dumps or on the edge or flood level of brooks, rivers, and other bodies of water.

Do not attempt to circumvent the quarantine regulations. The penalty is severe.

Do not mix products grown within the infested area with those grown outside the infested area.

Do not label packages containing flowers or other products with misleading statements of contents.

Do not pack produce in boxes or other containers until all old tags and permits have been removed.

Do not feel angry if products are confiscated at State or international border lines for violation of quarantine regulations. Such action is the most lenient that may be taken under the law.

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This bulletin is a contribution from—

Bureau of Entomology, L. O. HOWARD, *Chief.*

Cereal and Forest Insect Investigations, W. R. WALTON, *Entomologist in Charge.*

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