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THE BOLL WEEVIL PROBLEM,

WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., November 20, 1908.

Sir: I have the honor to transmit herewith the manuscript of a paper, by Mr. W. D. Hunter, agent in charge of southern field crop insect and tick investigations in this Bureau, dealing with the boll weevil, especially with reference to means of reducing its damage. So many publications upon different phases of the boll-weevil problem have been issued by this Department during the years since the weevil has invaded the United States that it has seemed advisable to present a summary in a single paper of the practical results recorded therein and including the results, as yet unpublished, of the most recent investigations. This purpose has been carried out in the present paper, the publication of which as a Farmers' Bulletin is hereby recommended, superseding No. 216.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

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THE BOLL WEEVIL PROBLEM, WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

INTRODUCTORY.

This bulletin, dealing with work done under the direction of Dr. L. O. Howard, Chief of the Bureau of Entomology, is intended to cover in a general way the whole field of the control of the boll weevil. As this control is inseparably connected with the life history and habits of the insect and, in fact, must be based thereon, attention is given to the principal features of the insect's economy. In addition, information is given relating to the amount of damage done, the extent of the infested territory, and such other matters as are of special interest at this time.

Like many of the most important injurious insects in this country, the cotton boll weevil is not a native of the United States. Its original home was undoubtedly in the plateau region of Mexico or Central America, and it may originally have fed upon some plant other than cotton. This is not necessarily the case, however, since there is evidence that the same region is the original home of the cotton plant itself. Previous to 1892 the insect had spread through Mexico, but little is known regarding the extent or rapidity of this dispersion. The records indicate, however, that it had probably 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 a half dozen counties in southern Texas and was brought to the attention of the Bureau of Entomology. A preliminary examination, made under the direction of Dr. L. O. Howard by Mr. C. H. T. Townsend, showed the enormous capacity for damage of the pest. Subsequent events have verified in every way the predictions that were made at that time, when the insect had not attracted any considerable amount of attention in the South. Since 1894 the boll weevil has extended its range annually from 40 to 70 miles, although in two instances the winter conditions have been such as to cause a decrease in the infested area. During the first ten years after its advent into this country the annual rate of spread was 5,640 square miles. Since

1901 the annual increase in the infested territory has averaged 26,880 square miles, but in one exceptional season, namely, 1904, 51,500 square miles became infested. 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.

At the present time the weevil is found more or less extensively in five States—Texas, Louisiana, Mississippi, Arkansas, and Oklahoma. In Mississippi 18 counties are infested, in Arkansas 28, and in Oklahoma about one-fifth of the State. The total area infested comprises about 225,000 square miles and this covers about 36 per cent of the cotton acreage of the United States. (See fig. 1.)

DAMAGE.

The damage done by the boll weevil varies greatly from year to year and also in different parts of the infested area. As the rainfall increases the damage becomes greater. In prairie regions, where the insect obtains but little protection through the winter, it never becomes as numerous as in other quarters where favorable conditions for hibernation are found. These facts, together with variations due to winter conditions, make it rather difficult to estimate the exact damage that has been done. Some years ago the writer stated, from the statistics then available, that the weevil caused a reduction of at least 50 per cent of the cotton crop in regions invaded by it, but that after the first few years the farmers generally resorted to proper means to greatly reduce this loss. In many individual cases the means of control perfected by the Bureau of Entomology have been applied so successfully that the crop has been fully as large as before the coming of the weevil. This was not accomplished, however, without somewhat increasing the cost of production. The estimate of an initial falling off in production of 50 per cent was verified by Prof. E. D. Sanderson, formerly State entomologist of Texas, who arrived at his figures in an entirely different way.

The average yield per acre in Texas from 1893 to 1901 (when the weevil had not done damage sufficient to affect the general production) was 0.40 bale. The average since that time, 1902 to 1907, was 0.35 bale. By comparing these periods we have a reasonably accurate basis for estimating the damage the insect has done. The difference is 0.05 bale, or 25 pounds of lint per acre each year. At current prices this means an annual loss of at least $2.25 per acre which has been sustained by the cotton planters of Texas. Assuming that the Texas acreage has averaged 10,000,000, the total loss for the State has annually been $22,500,000.

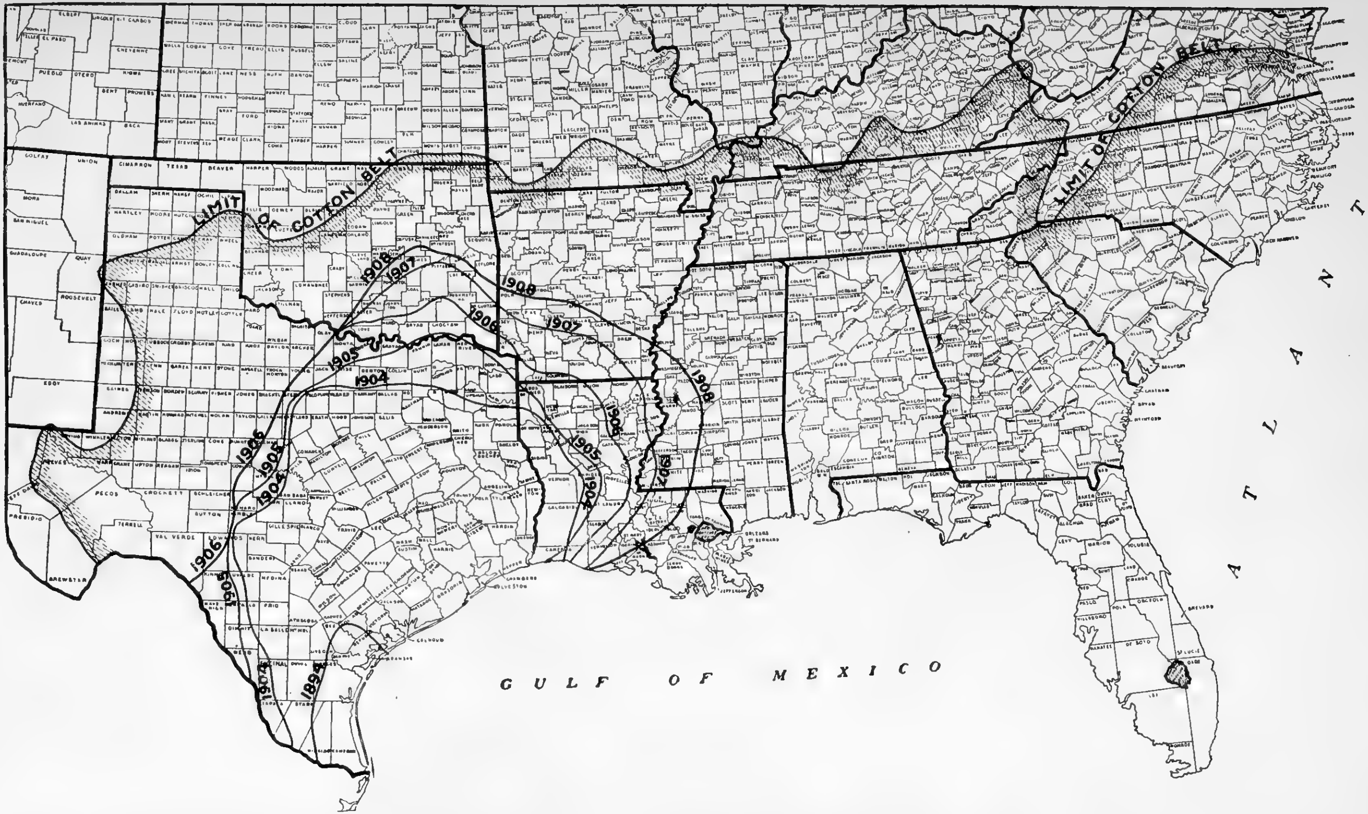

FIG. 1.—Map showing area infested by the boll weevil in 1908 and during various preceding years. (Original.) The line for 1908 includes all territory in which any infestation has been found. Toward the outer part of the infested area very few weevils are to be found. This applies to a belt from 5 to 25 miles wide bordering the line for 1908 on the inside.

Another tangible indication of the manner in which the weevil has affected cotton production is revealed by a comparison of statistics from Louisiana and Texas. From 1899 to 1904 the acreage in Texas and Louisiana increased at about the same proportion, but the crop in Texas decreased at the same time that the crop of Louisiana was increasing. There is an exception to this statement in the years 1900 and 1904, in which the production in Texas did not decrease, but these years were exceptionally unfavorable for the weevil and at the same time very favorable for the general growth of the cotton. In 1907 the yield per acre in Texas (0.24 bale) was the smallest in her history. This followed a winter so mild that more than the usual number of weevils overwintered.

Undoubtedly for several years the boll weevil has caused a loss of about 400,000 bales of cotton annually. Although farmers in older regions, in many cases, are increasing their production, there is loss in the newly infested regions which offsets that gain. A conservative estimate shows that since the weevil has invaded this country it has caused a loss of 2,550,000 bales of cotton, at a value of about $125,000,000.

PROSPECTS.

Reference has been made to the greater damage inflicted in moist regions and where the shelter for hibernation is best. The records of the Weather Bureau show that the annual precipitation increases very rapidly from the West to the East in the cotton belt. This is especially the case during the early growing season of cotton, namely, April, May, and June. The precipitation in the greater part of the cotton-producing area in Texas is normally about 40 inches. In Louisiana, Mississippi, and the eastern States of the cotton belt it is more than 50 inches, and sometimes exceeds 60 inches. The records that have been kept in Texas show that the damage has always been greatest in wet seasons and that the insect has affected land values most where the general conditions approach those of the eastern part of the cotton belt. Without the assistance that is furnished by climatic conditions, especially dry weather during the spring, the farmers of Texas would not have been by any means as successful in producing cotton during the last few years as they have. The system of control outlined in this bulletin increases greatly in effectiveness when assisted by weather conditions. Fortunately in Texas this assistance is given under normal conditions. When this assistance is above the normal, as in 1904 and 1906, the crops will be exceedingly large.

On the other hand, it is clear that the problem of the control of the boll weevil will be more difficult as the pest continues its invasion of the cotton belt. It can not be considered, therefore, that the problem is as yet completely solved. Better means of control must be devised for the region that is becoming invaded, and, if possible, means must be devised that will reduce the enormous loss that is suffered, especially during unfavorable seasons, in Texas. The principal work of the Bureau of Entomology at this time is in attempting to devise means for this requisite additional control.

For the present there is no occasion to lose hope. Though the eastern planter must expect a more serious problem than that which confronted the farmers of Texas, the means of control outlined in this bulletin, especially the destruction of the hordes of weevils about to enter winter quarters, will enable him to continue production, though probably at a reduced profit. The sooner he adapts his plantation management to the necessary changes the less the loss will be.

WORK UPON WHICH THIS BULLETIN IS BASED.

As has been stated, the danger from the boll weevil was appreciated from the beginning by Dr. L. O. Howard, Chief of the Bureau of Entomology. For about ten years, more or less continuous work on the vulnerable points in its life history and the possibility of control in various ways has been done. At first this was not extensive, although it showed the essential steps necessary 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 under the first large appropriation by the establishment of a laboratory at Victoria, Tex., and the beginning of extensive field experiments. It has been the practice from the beginning to carry on field experimental work in direct connection with the laboratory investigations. All means of control suggested by the laboratory work have immediately been tested on large field areas. Later the headquarters of the investigation were moved from Victoria, Tex., to Dallas, Tex., on account of the continued spread of the insect and the necessity for a central location. The Bureau of Entomology has conducted experiments during several seasons on a total of more than 10,000 acres of cotton. This experimental work has been located on well-known plantations throughout the infested territory. The special requirements in different regions have been given particular attention. Almost invariably successful crops have been produced, although special damage, due to local conditions in different regions, has sometimes interfered with the success of the experiments. The present bulletin contains a very condensed report of the results of all this work. The recommendations have all been placed in practical operation under the actual conditions prevailing on different cotton plantations.

Aside from the work directly relating 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 in its province. These have dealt with the breeding of cottons to obtain earliness and productiveness and with the extensive demonstration of the efficiency of the system of control devised by the Bureau of Entomology as the result of careful studies in the field and laboratory.

In addition to the work done by the Department of Agriculture the States concerned have done their part. Several entomologists have been employed by the State of Texas, namely, F. W. Mally, E. D. Sanderson, A. F. Conradi, and C. E. Sanborn. They have dealt with the boll weevil in connection with the numerous other entomological problems of the State and have contributed valuable results that have been made use of in this bulletin. The State of Louisiana has also done very notable work. Prof. H. A. Morgan and, later, Mr. Wilmon Newell, have added considerably to our knowledge of the weevil and the means of controlling it. In many ways their results are incorporated in this bulletin.

DESCRIPTION AND LIFE HISTORY.

The adult boll weevil is about one-fourth of an inch in length, 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 about one-half the length of the body. Variation in size is due to the amount of food the insect has obtained in the larval 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 into the adult stage. The recently emerged individuals are light yellowish in color, but this passes to a gray or nearly black shade in a few weeks' time. The general appearance of the insect will be evident from the accompanying illustrations (fig. 2).

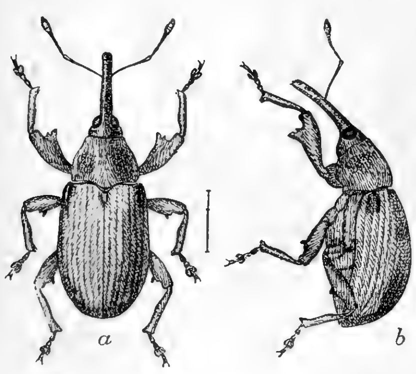

FIG. 2.—Cotton boll weevil: *a*, Beetle, from above; *b*, same, from side. About five times natural size. (Author's illustration.)

Many insects resemble the boll weevil more or less closely. In fact, there are hundreds of species of weevils in this country that may easily be mistaken for the enemy of cotton. Many mistaken reports about the occurrence of weevils far outside of the infested area have been due to mistakes that have arisen on account of this similarity. The only safe way to determine whether any 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 great numbers of squares. However, unfavorable climatic conditions and careless cultivation frequently cause great shedding. If excessive shedding be noticed 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.

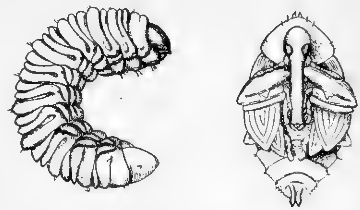

Fig. 3. Cotton boll weevil: Larva at left, pupa at right. About five times natural size. (Author's illustration.)

The boll weevil passes the winter in the adult stage. In the spring and throughout the fruiting season

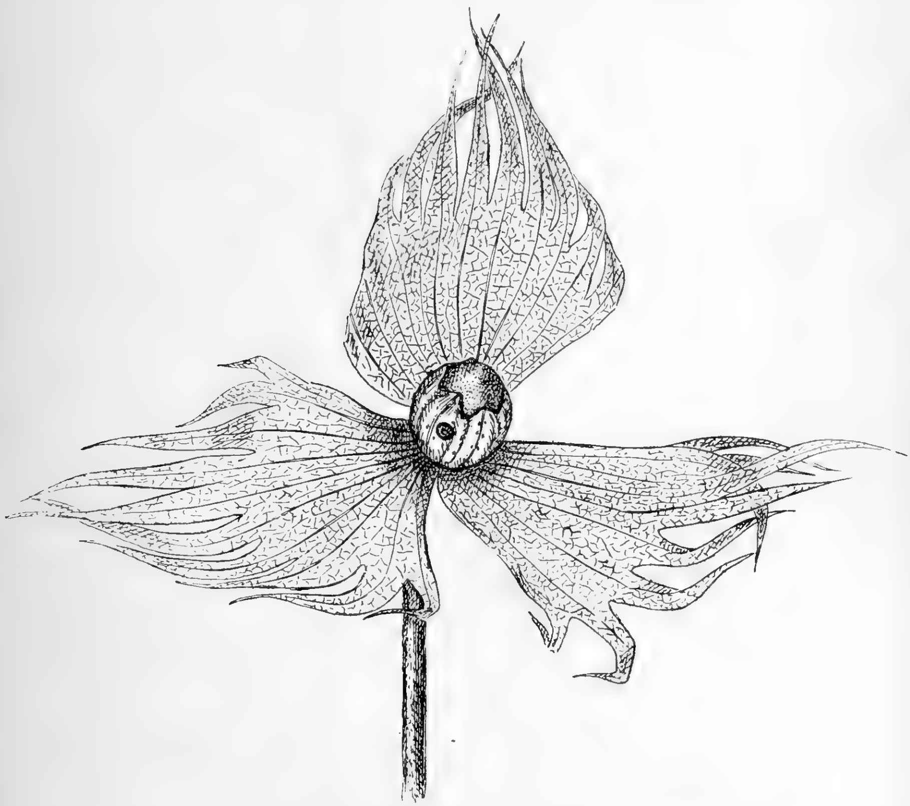

Fig. 4.—Cotton square showing egg puncture of boll weevil and "flaring" of bracts. Natural size. (Author's illustration.)

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 3 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 pupal stage (fig. 3, at right), corresponding to the cocoon of butterflies and moths. This stage lasts from 3 to 5 days. Then the adult issues and in about 5 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 2 to 3 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 from depositing in squares visited by other females. This applies throughout most of the season, but late in the fall, when all 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 are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed. Whenever frost or other unfavorable weather causes the plants to cease putting on squares the weevils attack the bolls. A conservative estimate of the possible progeny of a single pair of weevils during a season beginning on June 20 and extending to November 4 is 12,755,100.

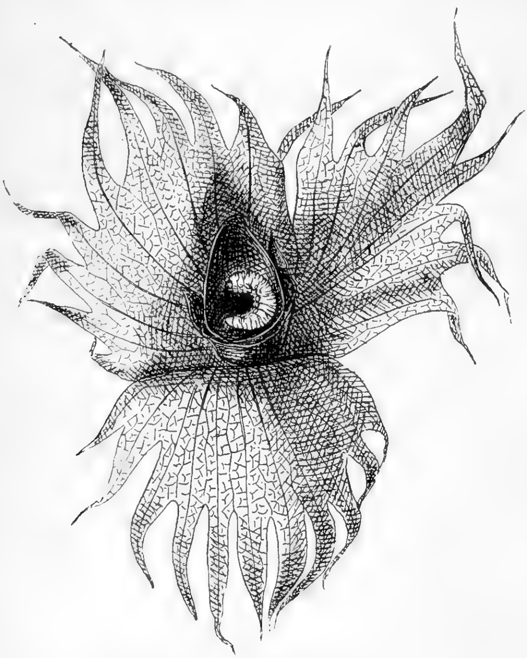

Fig. 5.—Cotton square showing boll weevil in position. Natural size. (Author's illustration.)

The cotton boll weevil, as far as known at present, has no food plant other than cotton. This has been determined by planting various plants related to cotton in the vicinity of infested cotton and in cages in which weevils were placed. It has therefore been demonstrated beyond any doubt whatever that the insect is restricted to the cotton plant for food. When confined in bottles, the weevil will partake of various substances, such as apples or bananas; but this is only under the stress of starvation. Under natural conditions they would pay no attention to these substances.

The boll weevil is strictly diurnal in its habits. Repeated observations made in the field at night have shown that it is not active after sundown. Unlike some related insects, it is not attracted to lights. The fact that somewhat similar species do come to lights in great numbers at times has frequently caused unfortunate confusion.

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 generally contract their limbs and drop to the ground. This habit is not equally strong in all individuals. It has been taken into consideration in plans of control, as will be described beyond.

The age to which weevils live varies under different 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 60 days. During the cooler part of the year many of them live as long as 6 months. The longest-lived weevil on record lived from December 10 to the following October, a period of about eleven months. Undoubtedly such prolonged life is exceptional.

HIBERNATION.

As has been pointed out, the boll weevil passes the winter in the adult stage. In the fall when frosts occur, immature stages may be found in the squares or bolls. Provided the food supply is sufficient, many of these immature stages continue their development at a very slow rate and adults finally emerge. Thus there may be a somewhat continuous production of adults during the winter. Ordinarily, however, this is not conspicuously 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 from trees some distance above the ground. 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. The majority of weevils that hibernate successfully do not pass the winter in the cotton fields. This 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 weeds and 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 hibernating successfully has been determined very accurately for different conditions. Out of 25,000 weevils 2.82 per cent survived the winter of 1905–6. These weevils were placed in a variety of conditions that must have approached those which weevils must naturally encounter. The winter referred to was practically a normal one as far as temperature and precipitation were concerned. In extensive work 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, i. e., from an abundance of protection to practically none. The survival obtained is undoubtedly very close to that occurring under diverse natural conditions of that winter. It must be emphasized that the winter of 1906–7 was abnormally warm. It is undoubtedly true that the rate of survival was much higher than usual. It is supposed that the results of the previous year must approach the average. In other words, less than 3 per cent of the weevils entering hibernation can be expected to survive the winter under average conditions. The tremendous importance of still further reducing this percentage must be evident.

Emergence from hibernation depends primarily upon temperatures in the spring, although there are other minor factors concerned. Generally, from the first to the middle of March the temperature has become high enough to cause weevils to begin to emerge. Naturally, the individuals under the heaviest protection are affected latest by the temperature. The consequence is, that emergence from hibernating is a prolonged operation. During one season (1906) it extended from the middle of March to the 28th of June; during another (1907) from the middle of February to about the first of July. During each of these periods there was a comparatively short time—about ten days—of rapid emergence, preceded by an initiatory movement and followed by a period during which the number emerging day by day decreased with rapidity.

HOW NATURE ASSISTS IN DESTROYING THE BOLL WEEVIL.

In the preceding paragraph attention was called to the possible production of 12,755,100 offspring in a single season by one pair of weevils. As a matter of fact, nature has provided a number of agencies that serve to prevent such excessive multiplication. The most conspicuous of these agencies 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 very few minutes. The insect in this 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 the precipitation is heavy. The more rankly the plants grow and the more the ground is shaded, the less effect in weevil control can be expected from heat. Nevertheless, in many cases in Texas the enormous total of 40 per cent of all the immature weevils in cotton fields inspected have been found to be destroyed through this agency. It was also found, from examinations in many quarters, that the extent of destruction held a direct relation to the amount of shade. When there was no shade practically all of the larvæ and pupæ were killed outright. Some of the important means of control, to be described later, are based upon this consideration.

Insect parasites.—The second of the important agencies provided by nature for the control of the weevil is a large number of predaceous insect enemies. These consist of a variety of forms which prey upon the boll weevil. Forty-five species of these enemies are known. Of these, 23 are parasites, which by means of their ovipositors place eggs on the immature stages of the weevil within the square or boll. The young of the parasite develops by feeding upon the immature boll weevil, which it ultimately kills. A parasite instead of a boll weevil emerges from the injured fruit. Special studies on these parasites have led to many suggestions for practical control. Moreover, the parasites seem naturally to be increasing in numbers and effectiveness against the boll weevil. In one instance in 1907 the mortality due to parasites in a field near Robson, La., was 77 per cent. About the same time 61 per cent of the weevils in a certain field near Victoria, Tex., were killed by parasites. These enemies of the weevil have existed in the country for an indefinite time. Their natural habit has been to prey upon weevils more or less related to the boll weevil that have occurred in this country for many years. They never feed on vegetation. It is undoubtedly true that they are now turning their attention from the original hosts, which are generally not very numerous, to the boll weevil, which offers abundant and favorable opportunities for reproduction. They thus ally themselves with the farmer for the protection of the cotton crop. In the following pages numerous suggestions will be made regarding the means that the farmers may take to increase the effectiveness of the work of these parasites in reducing the numbers of the boll weevil.

Other insect enemies.—In addition to the true parasites described above, the boll weevil suffers from a number of insects which are not parasites in a strict sense but prey upon it as food. The principal ones of these predatory enemies are ants. Of these, 12 species are known to attack the weevil. They are the minute brown ants and 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 a source of 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 found to be destroyed by ants alone. To find 25 per cent so destroyed is not a rare occurrence. In this bulletin methods will be pointed out for making use of these friends of the farmer and increasing the important effect they naturally have in reducing the numbers of weevils.

Other factors in natural control.—In addition to the principal factors in natural control which have been mentioned there are several of minor importance. Among these may be mentioned proliferation, which sometimes crushes the immature weevils, and determinate growth, which may prevent the development of the fall broods of the weevil. Attention is also called to the agency of birds in the destruction of the boll weevil, which has been given full attention in the publications of the Biological Survey of this Department.

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 to 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. Nevertheless, 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 first of September the weevil seems to be seized with an 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 does not fly in any particular direction except as governed 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 individuals carrying the infestation into new regions have been those that happen to radiate in the direction of previously uninfested territory.

The fact that the weevil moves about but little except at one season is of great benefit to the farmer. As the movement referred to does not begin until after the time when a crop is normally made, it amounts to but little after a region has become infested. On the other hand, the limited movement at other times 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 of his efforts being thwarted by the arrival of weevils from fields where no precautions have been taken is not as important as is sometimes considered. In fact, it is not important enough to warrant any farmer in deferring action on account of the indifference of his neighbors.

The above statements give only an outline of the life history and habits of the boll weevil. More complete information can be obtained from Bulletin 51 of the Bureau of Entomology, which may be obtained for 15 cents upon application to the Superintendent of Documents, Government Printing Office, Washington, D. C. In this connection the writer wishes to emphasize the following four important points that have a direct bearing upon control:

(1) It has been demonstrated that the boll weevil subsists on no other food than cotton.

(2) The weevil moves about but little until late in the cotton-growing season; in fact, not until the time when the crop is normally set.

(3) Winter conditions naturally reduce the number of weevils enormously; indeed, the winter is the critical period in the life history of the pest.

(4) Natural agencies operate to destroy a very large percentage of weevils. These agencies are increasing in effectiveness and already are of very great importance to the farmer in reducing his loss. Otherwise it would often be practically complete.

MEANS OF CONTROL.

It will be evident from the preceding statements regarding the life history and habits of the weevil that its control is beset with many difficulties. In fact, it is probably the most serious insect pest that is now known. Its insidious methods of work in the 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, and its enormous power of reproduction and adaptability to new conditions, all tend to place the boll weevil in a class by itself. The difficulties are increased by the necessary procedures in raising cotton. In spite of these difficulties fairly satisfactory means of control are known. A large share of the reasonable success of the warfare against the pest is due to the assistance furnished by natural agencies, which commonly destroy many more weevils in a cotton field than the farmer could by any known method or methods.

Burning infested plants in the fall.—Foremost among the methods of control is the killing of the hordes of adult weevils that are ready to enter hibernation in the fall and the prevention of the development of millions more that would later emerge to pass through the winter. This is accomplished by burning the infested plants in the fall after the weevils have become so numerous that there is no prospect of the maturity of any additional crop. There are many vital reasons why the wholesale destruction of the weevils in the fall should be practiced by every cotton planter in the infested region. Some of these are stated below:

First. Hordes of adult weevils, many for each plant in the field, are killed outright.

Second. Many more weevils that are in the immature stages, possibly as many as a hundred for each plant in the field, are also killed.

Third. The few adult weevils escaping will be weakened by starvation and the great majority will not have sufficient strength to pass through the winter.

Fourth. The development of the late broods, which experiments have shown furnish the vast majority of weevils that pass through the winter, is cut off immediately. In this way hundreds of weevils that would develop from each plant are absolutely prevented from so doing.

Fifth. The removal of the infested plants with the weevils facilitates fall or early winter plowing, which is the best possible procedure in cotton raising. Moreover, this plowing assists greatly in the production of an early crop the following season.

In short, in the fall the weevil is at the mercy of the planter as it is at no other time. If the planter desires to kill the insect he can do so. Work in weevil destruction at that time far outbalances all remedial measures that may be applied at all other times of the year.

Many hundreds of cases are on record showing the benefit from the fall destruction of plants in the control of the boll weevil. The process has not been taken up as generally as it should, but individual instances everywhere show its value. A large amount of experimental work done by the Bureau of Entomology has all pointed clearly toward the supreme importance of this essential method in control. In an experiment performed by the Bureau of Entomology in Calhoun County, Tex., the stalks growing on 410 acres of land were destroyed early in October. Careful records kept during the following season showed that this work had increased the production more than a quarter of a bale per acre over the crop on the check area where such work was not done. Computing the increase in the crop at the current prices, the advantage from the work in the experiment amounted to $14.56 per acre. This was about 29 times the cost of uprooting and burning the plants, as shown by the amount actually paid by the Department for the work. Circumstances surrounding the experiment, referred to in Circular 95 of the Bureau of Entomology, show that the advantage was probably considerably greater than has been indicated here. At any rate, the estimate given is most conservative. In this instance the cotton destroyed was isolated and the results are perhaps somewhat more conspicuous than would have been the case where there were hundreds of cotton fields in the neighborhood. Nevertheless, experience with fields surrounded by others that have been given no attention has shown a great advantage from taking the proper step in the fall. Of course, concerted action will add to the effectiveness of the work and should be followed in every community.

In addition to the field work by the Bureau of Entomology and by many practical planters, a great deal of work has been done in large cages, where the conditions could be studied most carefully. In this way the exact relative advantage of fall destruction at different dates has been determined. It has been shown in this connection that the earlier the work can be done the better the results will be. For instance, seven times as many weevils survived the removal of the infested plants on November 12 as survived after similar work on October 13.

Mr. J. D. Mitchell, of the Bureau of Entomology, calls attention to a striking example of the value of the fall destruction of the weevils that came to his attention in 1908. On opposite sides of the Guadaloupe River near Victoria, Tex., were two farmers, each having about 40 acres in cotton. In one case the stalks were uprooted and burned in September, 1907, and in the other they were allowed to stand until shortly before planting time in the spring of 1908. They were equally good farmers, and the soil was the same on the two places. In the first case the crop of 1908 was 15 bales and in the other 3½ bales. The work done during the preceding fall plainly increased the crop about fivefold.

No definite rule can be laid down as to the proper time for destroying the weevils upon and in the fruit of the plants in the fall. In general, the proper time is whenever the weevils have reached such numbers as to infest practically all of the squares that are being set. This may occur a month or more earlier in some seasons than in others. Fall destruction as late as November will accomplish much, but several times the number of weevils can be destroyed if the work be done in October. Therefore the rule should be to destroy the infested plants at the earliest possible date in the fall. It is much better to sacrifice a small amount of cotton than to defer the operation. The loss will more than be made good by an increase in the next crop.

Some objections to the work of destroying the weevils in the fall are frequently raised. The principal one is that the labor supply is insufficient to enable planters to have the crop picked out in time for such fall destruction as is recommended.[a] One of the respects in which the boll weevil will make revolutionary changes in the system of producing cotton is that smaller areas than formerly must be cultivated by each hand. The production can best be kept up or increased by more intensive methods on smaller areas. If this principle be put in operation on plantations in so far as it is practicable, the objection to fall destruction on account of the scarcity of labor will tend to disappear. A minor objection raised is that the process tends to impoverish the soil. As a matter of fact, the burning of the stalks removes only a small amount of the fertilizing elements, and, moreover, the practice now is to burn the plants a few months later. In

[a] In this connection attention is directed to one of the many advantages of having the crop picked out early. The earlier this is done the cleaner the lint will be, and the better the price. Moreover, the longer the unpicked cotton remains in the fields the greater will be the amount that falls to the ground and soon passes beyond recovery. From every standpoint the cotton should be picked as rapidly as possible.

most cases the humus is more important than the fertilizing elements themselves. The use of commercial fertilizers in one case and the practice of green manuring in the other will solve both of these difficulties.

METHODS OF DESTROYING WEEVILS IN THE FALL.

The reader is referred to Circular 95 of the Bureau of Entomology for particulars regarding methods of destroying the weevils in the fall. In this connection it will be stated that the proper method, in general, is to uproot the plants by means of plows, and to burn them as soon as possible. Other methods are applicable to different conditions. As soon as the plants are uprooted they should be placed in piles or windrows, which will utilize the leaves in the burning. The difficulty in one method of removing the plants—that of cutting them off near the surface of the ground with a stalk cutter or ax—is that during mild seasons many sprouts soon make their appearance to furnish food for weevils that would otherwise starve during the fall or winter. If the ordinary stalk cutter be followed immediately by plows, some of the desired results will be obtained. The great objection is that the innumerable weevils in the bolls and squares will be allowed to develop. Nothing but uprooting and burning will come near meeting the exigencies caused by the weevil.

Grazing.—In some cases the grazing of the fields with cattle, sheep, or goats can be practiced. 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.

Sprout cotton.—A most important result of the proper manipulation of the plants in the fall is that no stumpage or sprout cotton is allowed to grow. The occurrence of such cotton in southern Texas and occasionally in southern Louisiana is there the most important local difficulty in the control of the boll weevil. Sprout plants are sometimes encouraged on account of the production of a small but very early crop. This may have been defensible before the advent of the boll weevil, but at the present time the practice is undoubtedly the worst that could possibly be followed. The sprout plants serve only to keep alive myriads of weevils that could easily be put out of existence by the farmer.

Volunteer cotton.—In addition to stumpage cotton, volunteer cotton, in the strict sense, is of considerable importance in weevil-infested areas. The seed scattered about seed houses and gins frequently give rise to plants, both in the fall and in the spring, that furnish food and breeding places for weevils. It is needless to call attention to the fact that all such plants should be destroyed. They are merely aids to the enemy.

DESTRUCTION OF WEEVILS IN HIBERNATING PLACES.

After the weevil-infested plants have been removed from the field in the fall the farmer can add strength to the blow he has given the insect. As has been stated previously, many of the hibernating weevils are not to be found within the cotton fields nor in their immediate vicinity. Nevertheless, most of those remaining in the field can be destroyed, and this is undoubtedly well worth the effort that it will cost. In many cases surprising numbers of weevils have been found hibernating in the trash and rubbish on the ground in cotton fields. In January, 1907, in one instance, 5,870 weevils per acre were found, of which 70 per cent were alive. This was undoubtedly exceptional, but most of the many examinations made showed more than 1,000 live weevils per acre in old cotton fields. The insects so found are largely at the mercy of the farmer. He can destroy many by carefully raking up the trash and burning it. Plowing and subsequent harrowing of the land will add to the destruction. This work would well be worth while on general agricultural principles if no weevils whatever were destroyed. With the weevil present, that farmer invites loss who does not clean the fields to the best of his ability.

Of the multitudes of weevils that fly out of the cotton fields for hibernation not all are beyond the reach of the farmer. Many are to be found along turn-rows, fences, hedges, and old buildings. The cleaning and burning of hedges, fence corners, and in general the removal of trash from the vicinity of fields will destroy many weevils that would live to assist in the destruction of the crop.

Old sorghum fields, on account of their roughness and the fact that the heavy stubble catches trash moved about by the wind, have been found to furnish very favorable winter quarters for the weevil. The farmer should pay special attention to such fields. They have frequently been found to be the source of the first weevils to damage the cotton in the spring. A little work in the fall or winter will result in the destruction of practically all of the weevils found there. Old cornfields, while not as important as sorghum fields, also furnish favorable hibernating quarters and should be carefully cleared by the farmer who desires to minimize the weevil damage on his place.

A very practical illustration of the danger of trash in aiding in the hibernation of the weevil has occurred repeatedly on the experimental farm of the Bureau of Entomology near Dallas, Tex. Across a narrow lane on one side of the experimental cotton field of 40 acres is a small peach orchard in which the weeds have been allowed to grow unchecked from year to year. Every season the first weevil infestation in the cotton is found in the immediate vicinity of the orchard. In fact, the infestation always starts at that point and radiates into the field. If it were possible to eliminate the hibernating quarters across the lane—and this means only the prevention of the growth of weeds—there would evidently be a considerable reduction in weevil damage, especially early in the season when it is most critical.

LOCATING FIELDS TO AVOID WEEVIL DAMAGE.

The illustration just given emphasizes a method of averting damage by the weevil that can be followed in many individual cases. All planters that have had experience with the weevil know that the portions of their properties near the timber or other hibernating quarters show the first damage by the weevil and consequently the least production. Of course, it is not always possible to plant other crops in such situations. Nevertheless, very frequently farmers can avoid damage by devoting the particular fields known to be most susceptible to weevil injury to other crops. This is not pointed out as a general recommendation. In many cases it would be entirely impracticable, but its importance should be realized by planters in regions where every possible precaution must be taken.

CROP ROTATION.

Save in very exceptional cases the boll weevil never does as much damage on land where cotton follows some other crop as on land where cotton follows cotton. This is due to the fact, as has been pointed out, that the weevils do not fly very far from their hibernating quarters in the spring. Therefore it is evident that a proper rotation of crops may be followed to assist in the fight against the boll weevil. As in the case of the location of the fields referred to above, the recommendation here made is no panacea. Nevertheless, rotation can be made to assist in fighting the weevil, aside from the many other advantages that are known to come from it.

PROCURING AN EARLY CROP.

Although the destruction of the weevils in the fall is the great essential step in controlling the insect, it can not be depended on exclusively. The full benefits of the fall work and the maximum crop can not be obtained unless the next great step, procuring an early crop, is also taken. In fact, the success of the farmer in producing cotton in regions infested by the boll weevil will depend directly upon the extent to which he combines the various methods described in this bulletin.

There are certain localities where the conditions cause the soil to be "late" or "slow." For instance, the planters on the Red River in

Louisiana state that they can procure early crops on their "front" land, but that such is difficult or impossible on the fields back from the river. This is largely a matter of drainage. In some sections in Louisiana and Mississippi the essential step in obtaining an early crop will be largely a question of drainage. Lands so situated that they can not be drained economically to the extent that allows an early crop must be devoted to crops other than cotton.

The advantage of early planting has been demonstrated in every one of the numerous experiments made by the Bureau of Entomology and has now become the general practice among farmers. The reasons for the efficiency of early planting are not far to seek. The small numbers of weevils passing through the winter must have considerable time to multiply. They are unable to breed until squares are put on by the plants, since the food obtained from the fruit is required before reproduction can begin. Moreover, at the time the first squares are put on, the development of the immature stages is comparatively slow, not reaching the very rapid rate that obtains during the warm days and nights of the summer. For these reasons it is possible for the farmer to rush his crop in such a way that a large number of squares and bolls will be formed before the weevils have multiplied to a serious extent. Of course, under usual conditions the weevils will ultimately multiply so that the crop put on after a certain date will all be destroyed. This, however, is of no importance, since a top crop in weevil regions is entirely out of the question. The time it takes the weevils to recuperate after the vicissitudes of winter, especially after the entirely feasible destruction of multitudes in the fall, can thus be taken advantage of in the production of a crop.

Removal of plants.—The first step in the procuring of an early crop is the early removal of the plants, so that the land may be plowed during the fall or winter and the seed bed given thorough and early preparation. In fact, such preliminary preparation should be followed for the production of the best cotton crop under any conditions. The recommendation made is therefore neither onerous nor revolutionary. The tendency has often been to neglect the cotton fields until spring or at least until "after Christmas." It would repay the farmer many times if he would take the slight additional trouble of plowing the fields before that time. Not only a plowing, but one or more harrowings should be given the land during the winter.

Use of commercial fertilizers.—An important step in procuring an early crop under many conditions 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. It has been demonstrated many times by the different experiment stations in the South that the maturity of cotton can frequently be hastened materially by the use of fertilizers, especially those containing a high percentage of phosphoric acid. The recommendation for the use of fertilizers in weevil regions, therefore, does not imply the exhaustion of the soil. It merely means that fertilizers place in the hands of the farmers an important means of averting damage by the boll weevil. 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 soil or different soils upon his own 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.

Use of early varieties of cotton.—Next in importance to early preparation, and fertilization (where necessary), in obtaining an early crop of cotton comes the use of early varieties. In all experiments that have been undertaken the advantage in the use of early varieties has been conspicuous. As in other cases, the greatest advantage in this instance comes with the joint use of the other expedients recommended for weevil control. By far the best method for obtaining seed of early maturing cotton is for the farmer to carry on the selection himself. In many cases, however, this is impracticable. Under such circumstances the farmer should obtain seed of improved varieties from dealers or such individual farmers in the locality as have been able to carry on careful seed selection. A valuable publication on the selection of cotton varieties has been published by this Department as Farmers' Bulletin No. 314, "A Method of Breeding Early Cotton to Escape Boll Weevil Damage," by R. L. Bennett. A copy may be obtained by any planter by application to the Secretary of Agriculture.

Standard early varieties of cotton.—There are a number of standard varieties that have been found of value in weevil-infested regions the seed of which may be obtained from seed dealers. Among them are the Rowden, Triumph, Cleveland Big Boll, Cook's Improved, and King. All of these except the King have either medium-sized or large bolls. The King has a small boll, about 80 being required to make a pound, but is remarkably early and has given the best yields in most of the experiments of the Bureau of Entomology.[a] Hawkins' Early Prolific and Simkins have given good results in recent experiments of the State crop pest commission of Louisiana. In all cases it will pay the planter to exercise care in obtaining seed. Wherever possible it should be obtained from the originator.

Heavy cotton seed.—The Department of Agriculture has called attention to the advantage of planting heavy cotton seed (see Farmers' Bulletin No. 285). This should be taken into consideration along with other means of obtaining an early and vigorous stand. Another recent suggestion of assistance in obtaining an early start in the spring is that the planting be facilitated by covering the seed with paste. This method will make it possible to use an ordinary corn planter in putting in cotton seed and facilitate the work of checkrowing. This matter is discussed fully in the Farmers' Bulletin just referred to.

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 itself. Naturally no set rule can be laid down as to the proper date for planting. There is much variation in the seasons, and it is sometimes impossible to place the fields in readiness as early as is desirable. 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 made at dangerously early dates. Nevertheless, with proper preliminary attention to the fields it would be possible for farmers in most localities to plant from ten to twenty days earlier

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[a] Some of the early maturing varieties of cotton happen to have small bolls, although the plant breeders hold that there is no necessity of an early maturing cotton having small bolls. In view of the fact, however, that some of the best known early maturing varieties at the present time have undersized bolls, occasional objections have been made to planting them. It is true that the picking of cotton from these varieties sometimes involves difficulties. In some cases it is known that pickers have refused to pick small-boll cottons while any other cotton was available despite the offer of additional payment on account of slow picking in the fields of the smaller bolled cotton. This is an actual, practical difficulty that must be taken into consideration. At the present time it is sufficient to call attention to the fact that the practical disadvantage of small bolls may not be as important as appears at first glance. For instance, if small-boll varieties yield 100 pounds of seed cotton per acre more than ordinary cotton, this gain would permit the farmer to pay 10 per cent more for picking, with profit. Thus:

750 pounds small-bolled cotton per acre picked at $1 per cwt., cotton at $3 per cwt., net profit	$15.00
650 pounds large-bolled cotton per acre picked at 90 cents per cwt., cotton sold at $3 per cwt., net profit	13.65
Difference in favor of small-boll cotton	1.35

than they are accustomed to at the present time. This, therefore, is the general recommendation that is made. 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. It is not intended that planting should be made early enough to have this effect upon the plants.

ADDITIONAL EXPEDIENTS IN HASTENING THE CROP.

It was pointed out in connection with the enemies of the boll weevil that under natural conditions a large percentage of the weevils is killed by heat and parasites. The wide spacing of the cotton plants augments the action of both these agencies working against the boll weevil. The effect of the sun heat has been studied in many cotton fields. The mortality becomes remarkably high during the hot days of summer. The farmer can take advantage of it, and even increase it. It is very conservative to state that the weevils will be able to multiply only half as fast in fields where there is plenty of distance between the plants as in fields where plants are close together and the branches cross from row to row. It should therefore be the rule of the planter in weevil regions to give considerably more distance to the plants in the drill and to the rows than he would give under ordinary conditions. On land that produces under normal conditions from 35 to 40 bushels of corn per acre the rows should be 5 feet apart. Even on poor soil it is very doubtful, except in dry regions of the West, whether the distance should ever be less than 4 feet.

Check-rowing.—Considerable attention has been attracted in some localities in Texas to the practice of check-rowing cotton to assist in the control of the weevil. Undoubtedly from this standpoint the practice is to be recommended highly. By following it each plant is given the maximum soil that it can use with consequent beneficial results upon its growth. The greatest possible amount of sunlight is allowed to fall upon the ground where the infested squares are found, to destroy many weevil larvæ outright and at the same time to facilitate the work of the numerous enemies of the weevil that occur in every cotton field. Check-rowing, moreover, saves much labor, thereby reducing the cost of production, and also makes easy the control of noxious weeds. The only important objection is that in some localities it may interfere with drainage.

Cultivation.—During the growing season of the crop the fields should be given very careful cultivations. Most of the benefits of early preparation, early planting, and fertilization may be lost in case the fields are not given the utmost attention subsequently. 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 made to apply. 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 causes 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 have 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 certainly prevent the maturity of the later fruit and, moreover, will be forced to attack bolls which would otherwise not be injured.

Effect of late cultivation.—A very conspicuous illustration of the disastrous effects of careless late cultivation came to the attention of the Bureau of Entomology during the present season (1908). It was learned that some planters in the Red River Valley below Shreveport, La., were making fair crops (in one case 600 bales on 900 acres), while others were making very small yields as, for instance, in one case 200 bales on 800 acres. Upon investigation it was found that all the planters in the neighborhood were compelled to put all their hands on levee work for five weeks to save their places. During that time the cotton remained uncultivated. After the subsidence of the flood the fields were plowed. Where this work was done carefully the good crops were being produced. In cases where the plows were run too deeply and too close to the plants excessive shedding had taken place and the weevils prevented the putting on of any more fruit. Careful investigation on several places where the essential conditions were identical left no doubt that the cause of the difference in yields was primarily the difference in summer cultivation.

Occasionally a farmer is found who has obtained better yields on fields where cultivation has been discontinued early. In fact, the writer has seen fields full of grass that were outyielding perfectly clean ones on the same plantation. Such situations have caused erroneous conclusions. As a matter of fact, the explanation is that the late, careless cultivations had done more harm than good. The importance of careful shallow summer cultivations can not be too strongly emphasized.

SPECIAL DEVICES FOR DESTROYING WEEVILS.

The impression is more or less general that the only important way in which weevils may be killed is by the removal of the infested plants and that all other steps in the system of control are merely to avoid damage by the weevils that have survived that destruction, and their offspring. In spite of this impression, however, it is urged that the destruction of myriads of weevils can be accomplished during the growing season. This is to be done by working in cooperation with the natural agencies that destroy the weevil.

In making examinations of many thousands of infested squares from different localities and different situations in cotton fields it was found that mortality was conspicuously greatest where the sunlight was least obstructed and the heat, consequently, the greatest. The mortality in infested squares in the middles was many times

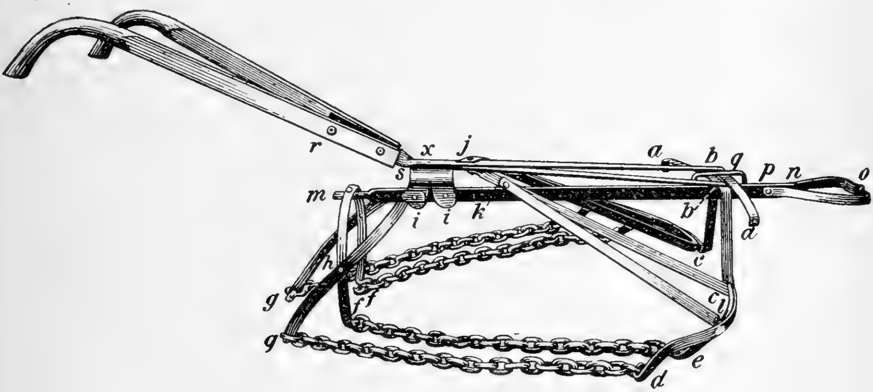

FIG. 6.—Chain cultivator, side view. (Original.)

as great as in the case of squares which remained under the shade of the branches. The temperature at the surface of the ground during warm days runs considerably higher than at a few feet above the surface. For instance, it was found that when the temperature was 100° F. in the regular Weather Bureau shelter about 4 feet above the ground the thermometer registered 140° F. on the surface. Likewise 90° F. in the shelter was accompanied by 120° F. on the ground and 85° F. in the shelter by 110° F. on the ground. It is not surprising, therefore, that the cotton squares that fall to the ground and are not shaded are very quickly baked, so that the weevils perish—if not from heat, then from the hardening of the food supply. In most cases they are simply roasted, their bodies assuming the appearance of larvæ that have been placed in a flame.

Chain cultivator.—When the foregoing facts came to light efforts were made to perfect a device that would bring the infested squares out of the shade of the plants to the middles of the rows. After much experimental work one of the writer's former associates, Dr. W. E. Hinds, devised an implement that accomplishes the desired work in a satisfactory manner. This implement is known as the chain cultivator or chain drag.

The following specifications should enable any blacksmith to construct an effective chain cultivator. (See fig. 6.)

The draft bar (*n m*), made of $\frac{1}{2}$ by $\frac{5}{16}$ inch tire steel, about 52 inches long, is designed to be about 16 inches above the ground, and this is the height of the rear arch (*f h m*), which is of this size and form to allow old cotton roots, etc., to pass through freely without clogging at the rear.

The distance between the rear ends of the chains (*g g*, *f f*) is in each pair fixed at about 10 inches. The distance between a chain of one pair and that of the other at their front ends should be about 9 inches. The chains used are of the size known as "log chains," having short, close links of $\frac{3}{8}$-inch iron. This style of chain can be cut to the length needed in each case. The chain is easily attached by simply making the hooks at *d*, *e*, *f*, and *g* so that the end of the hook is as wide as will pass through the length of the link and narrow enough at the middle of the bend to allow the link to turn and bag the other way. So long as the chains are kept tight they can not become unhooked. The hooks should also be turned, or faced, in such a way that they will not be likely to catch the passing plants or rubbish.

The clevis (*o p*) is simply hinged, so that there will be no tendency to pull the front of the machine off of the ground, and it is also broad enough in front to allow of the point of draft being moved from one side to the other, so that the front of the machine may be thrown closer to one row if desired.

The front guard on each side (*a b c d*) is made of one piece of spring steel, $\frac{7}{8}$ by $\frac{3}{16}$ inch. This size seems sufficiently strong and best adapted to carry the tension of the chains (*d g*) while still yielding to the pressure against the bases of the plants as they may strike the outer, sloping ends near *d*. The inner ends of these guards (*a b*) are horizontal, about 18 inches each in length, and serve to carry the front guard above the draft bar (*n m*) and, passing through the keeper (*q*), guide in the adjustment for width. The machine can not be extended beyond the bent ends at *a* or closed beyond the angles at *b*. The vertical section between *b* and *c* is about 12 inches long, so that the remainder of the front guard from *c* to near *d* will be about 4 inches above the ground. This prevents the pushing of dirt and squares toward the plants and allows the chains to catch them where they lie. The hooks at *d* and *e* are therefore bent downward and somewhat backward through about 5 or 6 inches. Care must be taken especially in forming the outer ends between *c* and *d* to secure best results. The downward bend for the hook at *a* should not be abrupt, as a gradual slope helps to prevent catching on any obstacles. The hooks at *f* and *g* are formed so as to hold the chains firmly and yet not interfere with the passage of rubbish. The method of carrying the rear ends of the outer chains is shown at *i h g*. The piece *k l* is nearly parallel with the chains and may be used for their proper adjustment as to tension by several holes near the end where it is bolted at *k*. The chains are between 30 and 36 inches long. The stand *s* upon which the handles are pivoted by a ½-inch bolt is made of a piece of boiler plate bent and cut so as to have a horizontal top surface about 4 inches square and standing about 2½ inches above the draft bar, to which it is securely bolted. The handles are bolted, as at r, to the heavy pieces of iron (about 2 by ½ inch tire steel) which are bent to receive them just behind the pivotal point at *x*, at such an angle as to bring the handles to the proper height and position. In front of *x* these pieces bearing the handles need not be so heavy and may therefore be tapered and welded to smaller steel running forward to *b*, where it is bolted to the front guard. The operation of this arrangement is similar to that of a huge pair of shears—when the handles are pushed apart the front of the machine is spread wider, and vice versa. The braces *j c e* serve to support, strengthen, and carry the front guard. They are riveted to the adjusting irons at *j*, one above and one below the "shear" pieces, to prevent their interference with the closing of the machine. At *c* this iron is bent to conform to the front guard, to which it is riveted between *c* and *l*, at which point it is bent downward and forms the hook *e*. Ordinary tire steel about 1 by ¼ inch may be used for all parts like the clevis (*o p*), rear arches (*f h m* and *i h g*), and braces (*k l* and *j c e*). The front guard (*a b c d*) should be of spring steel, as specified. The rivet heads on the front guard should be round and fit smoothly. In nearly all other places the irons are fastened together by ¼-inch square-headed bolts, with washers as needed.

In operation the implement is drawn by a single animal. The chains at *d* and *e* pass under the branches of plants and close to the stems. The forward motion of the machine causes these squares to be drawn inward by the chains, which must be kept taut, and leaves them in a narrow pathway where the chains approach within a short distance of each other at the opposite end of the machine. (See figs. 7, 8.) The two chains are provided so that squares that may pass over the first are taken up by the second on either side. In actual practice it has been found that more than 90 per cent of squares may be brought to the middle of the rows. This means that the natural mortality among the weevils due to the effects of sunshine can be at least doubled.

Although the chain cultivator was designed primarily for bringing the squares to the middles, it was found in field practice to have a most important cultural effect. The chains (so-called "log chains") are heavy enough to establish a perfect dust mulch (see figs. 7 and 8) and to destroy small weeds that may be starting. In fact, it is believed that this cultural effect would more than justify the use of the machine, regardless of the weevil. With the effect against the insect and the important cultural effect it is believed that this implement or

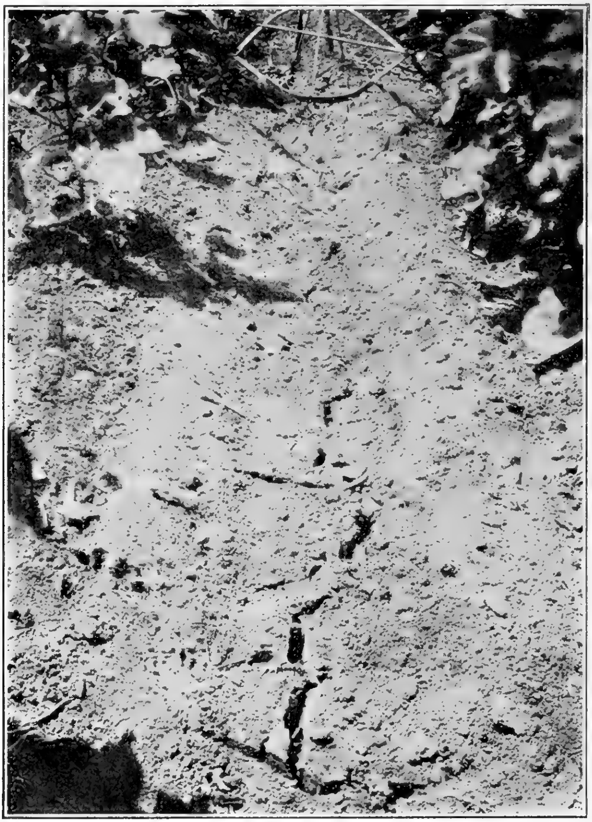

FIG. 7.—Work on the chain cultivator: Cotton row before use of cultivator, showing fallen squares, crack, and rough condition of ground. (Original.)

one similar to it should be used by every farmer in the weevil territory.

In order that the use of this machine could be obtained by all farmers at the smallest possible cost, a patent has been taken out in the name of the Department of Agriculture and for the benefit of the people of the United States. Under this patent it is impossible for anyone to manufacture the machine exclusively and to charge unnecessarily high prices.

Attachments for ordinary cultivators.—Some of the effects of the chain cultivator may be obtained by attaching chains to ordinary cultivators by the use of special attachments. In this way some of the effect of the chain drag would be added to the work of the cultivator. Wherever for any reason it is impossible to obtain chain drags, it is suggested that the principle be incorporated in some simple attachments to cultivators.

FIG. 8.—Work of the chain cultivator: Same row shown in fig. 7, after cultivator has passed; majority of squares brought to middle, crack filled, and dust mulch established. (Original.)

The use on ordinary cultivators of an arm or projection that will brush or agitate the plants in passing will assist to a certain extent in destroying the weevil. The squares will be knocked to the ground earlier than they would fall, and this would naturally increase the effect of heat. At the same time a very few adult weevils will be knocked to the ground, but this has been found to be unimportant. In repeated experiments in jarring and beating cotton plants on which known numbers of weevils were found it was ascertained that very few, if any, left the plants by reason of any agitation that would not break the branches or bark the stems. Occasionally, however, a weevil passing over a leaf is jarred to the ground. Often entirely too much stress is placed upon the importance of jarring the adult weevils to the ground. When specimens are collected by hand and thrown on the surface of the ground, especially if it be finely pulverized, the great majority will be killed almost instantly by the heat. This has caused the mistake on the part of careless observers of supposing that many weevils could be killed by jarring them to the ground. The difficulty, as pointed out, is that it is totally out of the question to jar more than one weevil out of many hundreds to the ground by any process that would not injure the plants severely. Nevertheless, the effect of a cross-arm of wood or iron whipping through the tops of the plants is recommended for the reason that the squares are thrown to the ground, where the heat has its earliest possible effect upon them.

HAND PICKING OF WEEVILS.

Gathering the weevils by hand is an operation of limited applicability. Where the fields of cotton are small and there is an abundance of labor it is sometimes practicable to pick the early emerging weevils from the plants and later to pick up the early fallen squares. Everything depends, however, on the conditions being favorable. On large places it will undoubtedly not often be found practicable to carry on this process. In an experiment performed by the Bureau of Entomology on a plantation worked by convict labor, giving the optimum conditions for the experiment, no results whatever followed thorough pickings twice each week for two months in the spring, beginning with the appearance of the first weevils. In another instance, at Gurley, Tex., more than 40,000 weevils were picked on an area of 8 acres by means of paid labor, beginning in April and continuing until July. On the 8 acres where this work was done a crop of about 50 pounds per acre in excess of that on other areas was obtained. This was not sufficient, however, to pay for more than a very small fraction of the work done. From these and other experiments the Bureau of Entomology recommends in a guarded manner the picking by hand of weevils and squares. Undoubtedly good may be accomplished under certain conditions, but planters should be careful not to depend too much upon it and not to make too great an outlay for it.

Disposition of adult weevils and infested squares.—When adult weevils are picked by hand they should be killed by means of oil or fire, or buried deeply in the ground. When infested squares are picked, however, an entirely different procedure should be followed. Many of the weevil larvæ in the infested squares will be found to harbor parasites. It is entirely practical, as has been pointed out by Mr. Wilmon Newell, of the Louisiana crop pest commission, to let these parasites develop and continue their work against the weevils in the fields. This is done simply by placing the infested squares in wire cages. The parasites, on account of their small size, will escape, while the weevils soon die from a lack of food. The meshes of the wire of the cage should be at least 16 to the inch. However, some weevils will escape through this mesh, and about 5 per cent through a 14-mesh screen. Even if the finer wire can not be obtained, it is advisable to use what can be had. A calculation will show that there is a direct advantage even if a few of the weevils escape, if all of the parasites do. By burning or destroying the squares in any other way the farmer is simply working against and counteracting an agency in the control of the weevil that is much more important than any amount of hand picking he is likely to be able to do.

TOPPING OF PLANTS.

The practice of topping plants is sometimes recommended for fields infested by the boll weevil. The results of work by different experiment stations have shown that topping has exceedingly uncertain general results. As often as otherwise it decreased instead of increased the crop. In any case the topping of plants can probably do no harm in fields that are being damaged by the weevil. It is probable that the general results will be beneficial in causing the more rapid growth of the crop on the lower and middle branches. It has never been possible to demonstrate this in an exact way. Nevertheless, for the general effects stated the topping of plants is included among the recommendations that should be followed, although as one of minor importance.

COTTON LEAF-WORM AND BOLL WEEVIL.

The relation between the formerly dreaded leaf-worm or so-called "army-worm" and the boll weevil deserves special attention. A quarter of a century ago the efforts of entomologists and planters were directed toward some means of destroying the leaf-worm. The use of Paris green was found to be effective. Various changes in the general system of cropping cotton also caused the injuries of the leaf-worm to become less conspicuous year after year. Even up to the time of the spread of the weevil into Texas, however, poisoning was a more or less regular operation on all cotton farms. The insects never did any considerable damage before the middle or latter part of the season. The object in destroying the leaf-worm was that it prevented the maturity of a fall crop. For this reason the saving of the top crop and in exceptional seasons a part of the middle crop was all that was desired. The work of the boll weevil has changed all this. After the careful studies that have been given the problem it is evident that no top crop of cotton can be expected in infested regions. This, of course, reduces the leaf-worm to an insect of no importance where the boll weevil exists.

The change has actually been even greater than this, for the work of the leaf-worm has a disastrous effect upon the boll weevil. As has been pointed out in the discussion of fall destruction, the late developing weevils are the ones that pass through the winter. Consequently, if the leaf-worms defoliate the plants and stop the formation of squares, a certain degree of fall destruction is accomplished. It can never be as satisfactory as the poorest artificial fall destruction, because the plants continue to leaf out after the defoliation by the worms, thus giving the weevils a supply of succulent food. It is not recommended that the work of the leaf-worm be depended on in place of fall destruction. Nevertheless, allowing the leaf-worms to proceed with their work, or even encouraging them, will assist as a general procedure against the boll weevil at least when, for any reasons, the more important steps are not taken. In some cases where the injury by the leaf-worms begins unusually early, it may still be advisable to check it by poisoning in the well-known manner, but save in such exceptional circumstances it will now be better to allow the leaf-worm to work unrestrictedly.

It has been suggested by Mr. Wilmon Newell that in special cases where there are difficulties in the following of the fall destruction of the plants, it may be advisable to take means to encourage the leaf worm. This could be done by breeding larvæ and pupæ to be scattered in the fields and by carrying the pupæ from localities, as the hills, where they appear first, to the valley fields, which are normally not reached until some time later.

DESTROYING THE WEEVIL IN COTTON SEED.

It has been abundantly shown that cotton seed is of importance as a medium through which the weevil may be carried. Many individuals that happen to be carried to the gin on the cotton pass uninjured through the gins to the seed houses. Consequently every seed house connected with a gin in the infested territory harbors more or less weevils, depending upon the amount of cleaning the staple is given. Of course such seed is exceedingly dangerous when taken into uninfested regions. Undoubtedly the present absolute embargoes against cotton seed from the infested region are wise. In general, they should be strictly construed. In some special cases, however, when, for instance, it is desired to obtain special improved seed, proper precaution can be taken to destroy all weevils by means of fumigation with carbon bisulphid. The method was described by the writer in Farmers' Bulletin 209, from which the following is quoted:

The following plan for this work is proposed: A tight matched-board box should be provided having sides 4 feet high, open on top, and of other dimen-

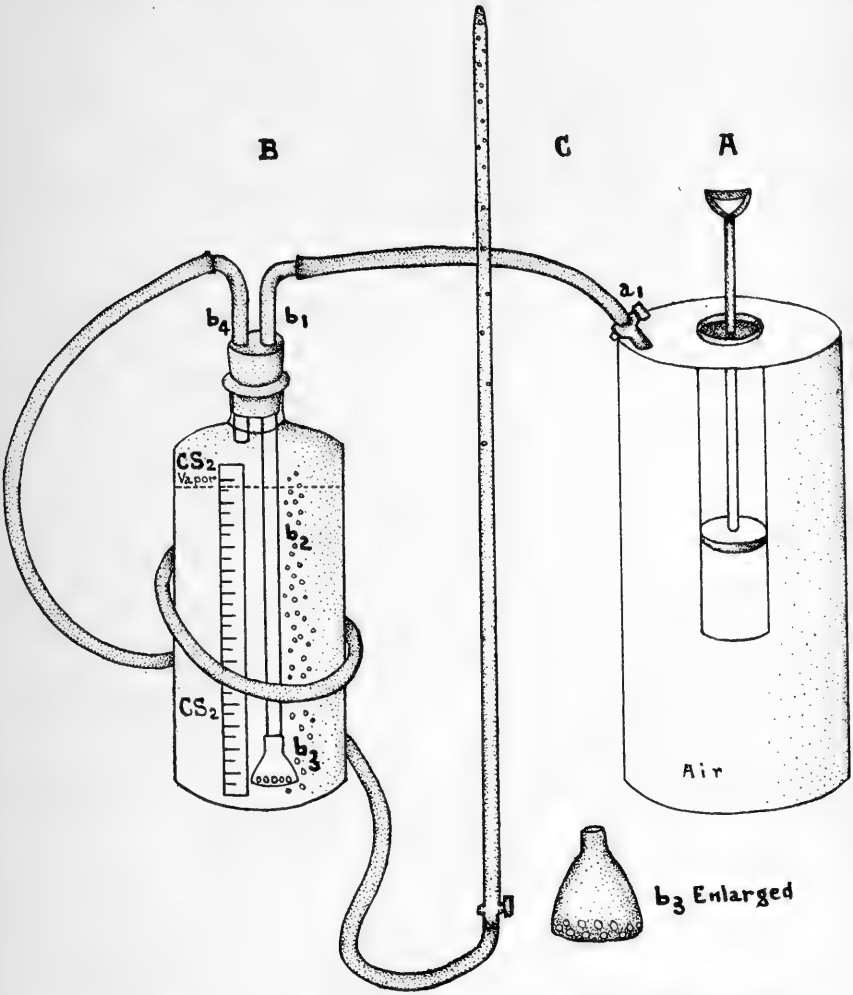

FIG. 9.—Apparatus for fumigating cotton seed in the sack. (Author's illustration.)

sions to accommodate 12 or more 100-pound sacks of cotton seed placed upright upon the bottom. Another tier of sacks could be added if desired. Into each one of these sacks about 1 ounce of carbon bisulphid should be forced by an apparatus for volatilizing the liquid and mixing the vapor with air. The accompanying illustration (fig. 9) will give an idea of this apparatus. It should consist of three essential parts, as shown in the illustration. *A* is an air pump having sufficient storage capacity to enable it to maintain a steady discharge of air for several minutes without continuous pumping. The stopcock at a_1 regulates or prevents the escape of air, as may be desired. *B* is an ordinary 2-quart bottle fitted at b_1 with a tight stopper of good length, having two openings, through which the inlet and outlet pipes pass. These pipes may be of glass or metal and should be as large as can be used. The inlet pipe, b_2, reaches nearly to the bottom of the bottle and is provided at the lower end with a perforated metal cap as large as will pass through the neck of the bottle. This allows the escape of the air in small bubbles and insures rapid evaporation. The outlet pipe, b_3, reaches only through the stopper. Upon the outside of the bottle is pasted a paper marked with 1-ounce graduations. *C* is a piece of ordinary ⅜-inch iron gas pipe about 3½ feet long, but this may be any desired length. It is closed and roundly pointed at the tip, and for about 15 to 18 inches of its length provided with small perforations pointing in all directions to give free escape to the vapor into all parts of the sack of seed at once.

The connections may be of rubber tubing, but as little rubber as possible should be used for this apparatus, as it is affected by the vapor of the bisulphid, and the couplings will have to be frequently replaced. This, however, will not be a considerable item of expense. With the apparatus just described one operator would be able to accomplish the entire work of disinfection. The amount of carbon bisulphid recommended is about 1 ounce for each 3-bushel sack. It is safe to say that this can be secured for less than 1 cent per ounce when purchased in 25 or 50 pound lots, making the cost of bisulphid not over 1 cent per sack. As it requires but from two to three minutes to vaporize 1 ounce of the liquid in the manner described, the expense for labor in application would not amount to one-half a cent per sack. Fumigation with carbon bisulphid can therefore be effectively made at the slight expense of from 1 to 1½ cents per 100-pound sack.

Application of the bisulphid in this manner reduces the elements of danger to a minimum, as the vapor is almost wholly confined and the slight quantity escaping, mixed with the open air, would not be in either inflammable or explosive proportions. It has been determined that the slight trace of bisulphid vapor in the air would not injure the operator in the slightest degree. The sacks should be left in the box for forty hours after the gas is injected.

RELATION OF MEANS OF CONTROLLING THE BOLL WEEVIL TO THE CONTROL OF OTHER INSECTS.

The cotton bollworm.—The most important insect enemy of cotton in the United States, aside from the boll weevil, is the bollworm. This pest has existed in this country for many years and frequently reduces the crop very considerably. The annual damage to cotton in the United States has been conservatively estimated at over $8,000,000. In addition to the injury to cotton this insect is a very important enemy of corn, tomato, okra, cowpeas, and some other crops. Careful studies of the bollworm were conducted by Mr. 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 resorted to 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 Mr. Quaintance on this subject:

> The steps in the production of early cotton, outlined above, 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 cotton aphis.—Of the numerous minor enemies of the cotton plant in the United States there is one, the cotton aphis, or plant-louse, that may occasionally cause unusual damage by reason of early planting. This will only happen to any appreciable extent during wet seasons. Under such conditions the aphis may sometimes make it necessary to replant.[a] Nevertheless, this is not an important difficulty. It is not of sufficient moment to be considered at all, in view of the enormous benefit in avoiding damage by the boll weevil by means of early planting. If the other steps in the control of the boll weevil be taken and the fields made clean during the winter and the rubbish in the fence corners and along the turn-rows destroyed, it is not likely that the aphis will do any considerable damage, even during the coolest and wettest springs.

The injury inflicted by several other insects, such as the cotton square borer, webworm, and cutworms often makes the crop somewhat later, and consequently likely to be injured by the weevil.

GENERAL CONTROL THROUGH QUARANTINES.

There is no doubt whatever that the weevil can not be prevented from extending its range to the extremes of the cotton belt in this country. However, the damage is so great and the disturbance of economic conditions so extensive that all reasonable precautions should be taken to prevent the early accidental importation of the weevil to uninfested regions. Practically all of the States in the cotton belt have enactments designed to this end. Undoubtedly they should be enforced to the fullest extent.

At one time considerable inconvenience was caused the shipping interests by the lack of uniformity of quarantines in different States and the inclusion of articles in which there is very little danger. At the present time these difficulties have largely been removed. All that it is advisable to include in the absolute quarantines are cot-

[a] On the contrary, cases have been noticed where early breaking and thorough working caused a lessening in the number of aphides, due to the destruction of the ant that protects them. Mr. Wilmon Newell calls our attention to an instance of this kind in Louisiana in 1908.

ton seed, seed cotton, cotton-seed hulls, and baled cotton. These commodities are likely to carry the weevil with them. In fact, it has been amply demonstrated that the insects are frequently carried in this way. Other articles, and even empty cars, may occasionally transport weevils, but the degree of danger is so much less than in the cases of the articles specified above that they do not need to be taken into consideration.

It is entirely feasible to eradicate small isolated colonies of the boll weevil. An important office of the State authorities, concerned in State quarantines should therefore be to investigate reported outbreaks of the weevil and be prepared to take the necessary steps toward eradication at the earliest moment. The Bureau of Entomology will assist the state authorities in any cases of this kind.

ATTEMPTS TO POISON THE BOLL WEEVIL.

From the very beginning of the fight against the boll weevil attempts have been made to poison it. In 1894 and 1895, in the region originally infested in Texas, agents of the Bureau of Entomology conducted careful experiments with poison. Since that time various advocates of poisons have appeared. The idea appeals so strongly to farmers that these advocates have sometimes enlisted considerable followings. This has made it necessary for the Bureau of Entomology to carry on a large number of special investigations relating to poisons. In order to understand the difficulty of poisoning it must be remembered that during the growing season the boll weevil feeds only by inserting its beak deeply into the squares or bolls. It is therefore entirely out of the question to place the poison in a position where the insect will feed upon it.

Early in the season, however, before any squares are formed, the hibernated weevils that may have emerged feed upon the opening leaves on the so-called bud of the young cotton plant. At this time it is possible to destroy a considerable percentage by the application of poison. In all experiments performed in the field by the Bureau of Entomology very heavy applications throughout the season from chopping to picking have failed to show any advantage in the use of poison. Even light applications have been found to have insidious injurious effects upon the plants. The reason for the ineffectiveness of poisons is that the great majority of the weevils do not emerge from hibernating quarters until after the squares have begun to be formed. The destruction of some of the early emerging individuals does not prevent the remainder from causing complete infestation of the fields at the usual time.

Arsenate of lead.—Recently Mr. Wilmon Newell, of the State crop pest commission of Louisiana, has published a preliminary report regarding experiments with powdered arsenate of lead as a poison for the boll weevil. This substance has the advantage of being absolutely harmless to the plants, whereas Paris green applied to the tender terminal growth frequently causes the plants to become stunted, to remain so throughout their lives. Although the powdered arsenate of lead has this advantage, the question still remains as to whether enough weevils can be poisoned to result in any special benefit to the crop. The following is Mr. Newell's statement on this subject:

As it is, the profit to be derived from applying the powdered arsenate of lead when the cotton is in the budding stage can only be determined by actual tests in the field, in which the production of poisoned and nonpoisoned cotton (both under conditions otherwise exactly alike) is carefully determined.

It will be noted from Mr. Newell's statement that no field experiments have been carried on to determine whether any direct benefit can be obtained from the use of powdered arsenate of lead. The Bureau of Entomology therefore urges that until further notice no farmers go to the expense of attempting to poison the boll weevil in any way.

Many attempts have been made to cause poisoned substances to be attractive to the weevil by introducing sweets and other ingredients. All these have failed completely. Some known sweets, such as honey, have a slight attraction for the weevil, but not enough to assist in practical control even regardless of their expense.

Contact poisons.—Poisons designed to kill the weevil by suffocating rather than by being taken into the digestive organs, have been proposed. They can not, of course, be effective against the immature weevils within the cotton fruit. The difficulties in reaching the adults are in their manner of work. Normally these insects are found inside the bracts of the squares, where they can not be reached by sprays. In fact, nature designed the bracts to prevent the heaviest rains from reaching the square within. An additional difficulty is in the expense of applying sprays, not only on account of labor, but on account of the special machinery that is necessary. Although there is some very remote possibility that dry poisons may be found of assistance in controlling the weevil, on account of the facts mentioned it is not at all probable that liquid sprays can ever be used.

Effect of confinement.—There is one peculiarity of the weevil that has led to many unwarranted claims as to the efficacy of remedies. The insect will die within a very short time when confined in a bottle or jar or even in a cage. Even when cages are placed over growing plants it is found that numbers of the insects die and fall to the ground, though no poison has been applied. In many instances experimenters have applied their preparations under such conditions and have found dead weevils later. They have made no allowance for the weevils that would have died under these conditions without any treatment whatever. In such experimental work special pains should always be taken to provide one or more careful checks upon the weevils that have been subjected to treatment.

FALSE REMEDIES.

The extreme seriousness of the boll-weevil problem has called forth many hundreds of suggestions in control. These have covered such methods as changes in manner of planting, attracting the insects to food plants or lights, soaking the seeds to make the plants distasteful, sprays, machines, smokes, 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 fallacious methods that have been proposed.

Late planting.—Foremost among the futile means of control is late planting. At various times different persons have suggested that late planting, especially if following early fall destruction, would so lengthen the hibernating period that no weevils would be permitted to 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 performed in Kerr County, Tex., the plants were removed very thoroughly early in November. No stumpage or volunteer plants were allowed to grow during the winter. There was no other cotton 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. A similar experiment was carried out under different conditions by the State crop pest commission of Louisiana and the results published in Bulletin 92 of the Louisiana Experiment Station. The results obtained in Louisiana agree in every way with those obtained by the Bureau of Entomology in Texas.

The reasons for the failure of late planting are evident from a study of the habits of the insect. 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 between 6 to 12 weeks after emergence. This ability to survive without food, together with the late emergence, render it entirely out of the question to exterminate the boll weevil by late planting. Moreover, there are always to be found along roads, turn-rows, in cotton fields, and elsewhere, a considerable number of volunteer plants which come from seed scattered accidentally or blown from the bolls during the fall. 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, regardless of how late it might be. In 1906, for instance, at Dallas, Tex., it was found that 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.

Trap-rows.—The idea of attracting weevils to a few early plants or trap-rows seemed hopeful at one time. Practical work in the field, however, has shown that nothing whatever can be expected from this means. The difficulty is that the early plants exert very little attraction. Moreover, before the majority of the weevils have emerged from hibernation the planted cotton is always large enough to furnish them plenty of food. In practice it has been found impossible to defer planting long enough to concentrate any appreciable number of weevils on the trap plants. Trapping weevils to hibernating quarters is an equally mistaken idea. They can not be induced to resort to any particular places. It is likewise impossible to attempt to make the cotton fields more favorable for hibernation than places outside of the field.

There is one way in which trapping may occasionally be resorted to with good effect. When the plants are destroyed in the fall and the weather is so warm that the majority of weevils have not entered hibernation, many of them will be found upon the plants that are left. Under these conditions the farmer can leave a few trap-rows to good advantage. They should be uprooted and burned within ten days of the time the other plants are destroyed, to kill the weevils that may be found upon them. Hand picking at frequent intervals before destruction may be practicable where labor is inexpensive.

Attraction to lights.—Many insects more or less resembling the boll weevil are attracted to lights. This has caused many persons to attempt to destroy the cotton pest by taking advantage of the supposed habit. It has been found, however, that the boll weevil is not attracted to lights to any extent whatever. In one experiment a number of strong lanterns were placed in cotton fields in Victoria County, Tex. In all, 24,492 specimens of insects were captured, representing about 328 species. Of these, 13,113 specimens belong to injurious species, 8,262 to beneficial species, and 3,111 were of a neutral character. Not a single boll weevil was found among all these specimens, notwithstanding the fact that the lights were placed in the midst of fields where there were millions of these insects.

Chemical treatment of seed.—It is scarcely necessary to call attention to the fallacy of attempting to destroy the boll weevil by soaking the seed in chemicals in a hope of making the plants that are to grow from them distasteful or poisonous to the insect. Any money expended by the farmer in following this absurd practice is entirely wasted.

Other proposed remedies.—Many remedies for the destruction of the weevil, consisting of sprays, poisons, and fumigants or "smokes," have been proposed. Hundreds of these proposed remedies have been carefully investigated. The claims of their advocates in practically all cases are based upon faulty observations or careless experiments. The strong tendency of the weevil to die in confinement, which has been referred to, has caused many honest persons to suppose that the substances they are applying have killed it. Moreover, an insuperable difficulty that these special preparations have encountered is the impracticability of the application in the field. Hundreds of known substances will kill the weevil when brought in contact with it. The difficulty is to apply them in an economical way in the field. A striking instance of the unwarranted claims of some discoverers of "remedies" for the weevil was the case of a man who demonstrated the efficacy of his preparation by placing a feather in the bottle containing it and applying this to a weevil in his hand. Of course the death of the weevil was very far from a demonstration of the practical working of the supposed remedy. On account of the many difficulties in reaching the weevil and the necessity of obtaining special machinery for applications of poisons or sprays in the field, it is now considered, after much careful experimentation, that there is only the remotest hope of any such substances being of any practical avail whatever in the fight against the boll weevil. 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.

Mechanical devices.—Many machines have been constructed to collect the weevils from the plants, or the bolls and squares from the ground. These have consisted of suction and jarring devices. Many of them will destroy a certain number of weevils, but the habits of the insect are such that none has been found to yield results that pay even a small portion of the cost of operation. It is emphasized in this connection that there are plenty of proper ways in which all available mechanical ingenuity may be utilized in the fight against the weevil. There is great need for effective machines for assisting in the destruction of the weevils in the fall, and also for assistance in the cultivation of the crop. The present implements for cultivation, while effective in their way, could be improved in many respects, especially for the purpose of hastening the maturity of the crop. For instance, cultivators like the chain-cultivator mentioned in this bulletin, to establish a dust mulch rather than to plow the ground, are much needed. There are some cultivator attachments, such as the spring-tooth attachment, which are exceedingly useful tools in maintaining a surface dust mulch, but these are not as yet in general use.

SUMMARY.

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 studies 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 consisting of several parts. The planter can insure success in proportion to the extent to which he combines the different essential parts.

(1) Destroy the vast majority of weevils in the fall by uprooting and burning the plants. This is the all-important step. It results in the death of millions of weevils. It insures a crop for the following season.

(2) Destroy also many weevils that have survived the preceding operation and are found in the cotton fields and along the hedgerows, fences, and buildings. This is done by clearing the places referred to thoroughly. (See pp. 22–23.)

(3) As far as possible, locate the fields in situations where damage will be avoided. This can not be done in all cases but can frequently be done to good advantage.

(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) Provide wide rows, and plenty of space between the rows and the plants in the drill, for the assistance of the natural enemies of the weevil, which do more against the pest than the farmer can do himself by any known means. Check-rowing, wherever practicable, is an excellent practice.

(6) Insure an early crop by early planting of early-maturing varieties, and by fertilizing where necessary.

(7) Continue the procuring of an early crop by early chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivation too deep or too close to the rows.

(8) Where the labor is sufficient, pick the first-appearing weevils and the first-infested squares. Do not destroy the squares but place them in screened cages. By this means the escape of the weevils will be prevented, while the parasites will be able to escape to continue their assistance on the side of the farmer. (See pp. 34–35.)

(9) Use a crossbar of iron or wood, or some similar device, to cause the infested squares to fall early to the ground, so that they will be exposed to the important effects of heat and parasites.

(10) Do not poison for the leaf-worm unless its work begins at an abnormally early date in the summer.

(11) Do not go to the expense of buying special preparations for destroying the weevil. Disappointment and loss is certain to follow. In case of doubt communicate at once with the Bureau of Entomology or with the entomologist of the State experiment station.

SPECIAL TREATMENT OF SMALL AREAS.

In some cases, where, for instance, a farmer has a small area of cotton growing for seed selection, it is practicable to resort to special means of control that would be impossible in general field practice. For the benefit of the many farmers in the infested area who are beginning to improve their cotton by selection, the following suggestions are made: The plat or plats should be far from timber, hedgerows, seed storage houses, and other protection for hibernating weevils. On the appearance of the earliest weevils the plats should be carefully picked over by hand. This should be continued until well after the squares begin to fall. If the falling of the squares continues it will be found practicable to rake them by hand to the middles or entirely outside of the plats to a bare place, where the sun will soon destroy the larvæ within. Of course all other general suggestions that are applicable in the field should be added to these special ones.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. PPp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
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FARMERS' BULLETIN 378.

METHODS OF EXTERMINATING THE TEXAS-FEVER TICK.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., July 22, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Methods of Exterminating the Texas-fever Tick," by H. W. Graybill, scientific assistant in the Zoological Division of this Bureau.

For many years these ticks, which transmit the disease of cattle known as Texas or tick fever, have been a cause of heavy loss and a great handicap to live-stock raising in the southern part of the United States. The progress so far made, however, in the cooperative campaign by this Department and State authorities with the object of completely eradicating this pest from the country demonstrates that it is entirely possible to accomplish that result, although a number of years of hard work will be required. It is of great importance for the success of this undertaking that the efforts of the officials should be supplemented by individual work by the farmers. This paper gives simple and practical directions for exterminating the ticks, and I respectfully recommend its publication in the popular Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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METHODS OF EXTERMINATING THE TEXAS-FEVER TICK.

INTRODUCTION.

The eradication of the cattle tick (*Margaropus annulatus*) from the Southern States is a problem of prime importance to the agricultural interests of that section. Moreover, the good that would result from the elimination of the tick would not be entirely confined to the region directly concerned, and thus the matter assumes to a certain degree a national importance.

A number of valuable papers on the life history of the cattle tick, its habits, and methods for its eradication have been published by the United States Department of Agriculture and by various investigators in the States included within the infested region. Some of these publications are rather extensive and include much that is only of scientific interest, while others, of a more practical nature, are not available for general use. The present bulletin is prepared with the view of bringing together from these various sources information of practical value relating to the tick and its eradication, for the use of the farmer or stockman who has begun or who contemplates undertaking the complete extermination of this pest from his farm. Some unpublished results of investigations carried on by the writer in connection with the cooperative work between the Zoological Division of the Bureau of Animal Industry and the veterinary department of the Alabama Polytechnic Institute have also been taken into consideration.

REASONS FOR ERADICATING THE CATTLE TICK.

There are various kinds or species of ticks occurring on cattle in the Southern States, but the one that chiefly concerns us here is that commonly called the "cattle" or "Texas-fever" tick (*Margaropus annulatus*). It is the one most frequently found on cattle and is much more abundant than the other species. When the losses occasioned by this parasite are once thoroughly understood by farmers and stockmen there will be little need for arguments in favor of tick eradication. Some of the losses are not directly noticeable and consequently make little impression, while other losses properly chargeable to the tick are frequently attributed to other causes.

It is hardly necessary to emphasize the important fact that the tick is something more than a simple parasite drawing blood from its host, it being the carrier of a dangerous micro-organism or germ, which it transmits to the blood of cattle, thus causing a disease known by many names, among which are Texas fever, tick fever, splenetic fever, and murrain.[a] Without the tick there can be no Texas fever, and it is by preventing the spread of the tick beyond its natural bounds that the fever has been prevented from waging destruction among northern cattle, which are especially susceptible to the disease. In order to restrict the distribution of the tick the National and State governments maintain a quarantine line extending from the Atlantic to the Pacific coast, marking the boundary between the States or portions of States harboring this pest and those that do not. Cattle of the quarantined area can not be driven across this line, and may be shipped only in accordance with the regulations of the Secretary of Agriculture to prevent the spread of splenetic fever of cattle.

The more important losses for which the tick is responsible are as follows:

1. Deaths from tick fever among native cattle and purebred cattle imported from the North for breeding purposes.

2. Deaths of cattle north of the quarantine line from fever following the occasional accidental introduction of the tick.

3. The temporary and permanent arrest of growth and development resulting from attacks of the fever.

4. The decrease in weight and the lessened rate in putting on flesh in the case of beef cattle, and the decrease in the amount of milk produced by dairy cattle, as the result of the irritation and loss of blood occasioned by great numbers of ticks.

5. The prevention of southern breeders from exhibiting their stock in the North.

6. The decreased price that southern cattle bring on the market on account of the restrictions placed upon them.

7. The considerable expense incurred each year by the Federal Government and the infested States in establishing quarantine lines and in enforcing regulations to prevent the spread of Texas fever.

Various writers have estimated the annual loss due to the tick at from $40,000,000 to $100,000,000. These figures should be ample argument, even to the most conservative, for the eradication of the tick.

The South needs more and better live stock and a larger and better dairy industry, and these objects would both be greatly promoted by the destruction of the tick. Furthermore, the increased produc-

[a] For information as to this disease and how it is transmitted by the ticks the reader is referred to Farmers' Bulletin 258, "Texas or Tick Fever and Its Prevention."

tion of live stock, by reason of its important bearing in maintaining and improving the fertility of the soil, would be of distinct benefit in increasing the yield of field crops. An incidental though important advantage of stock raising and dairying would be found in the distribution of the farmer's income throughout the year, enabling him to live on a cash basis. It can thus be seen that the benefits which would accrue to southern agriculture from the extermination of the cattle tick would be very great and far-reaching.

LIFE HISTORY OF THE TICK.

Before methods of eradication can be carried out intelligently and successfully, it is necessary to know the life history of the tick, and the influence of temperature, moisture, and other climatic conditions on the various stages of its existence. These matters will therefore be taken up first, it being understood that whenever the term "tick" or "cattle tick" is used, it refers to the one species or kind, *Margaropus annulatus*.[a]

The usual host for this tick is the cow or ox. Frequently, however, horses, mules, deer, and sometimes even sheep serve as hosts. But none of these latter animals, with the possible exception of deer, are susceptible to tick fever, consequently they suffer from the tick as a simple parasite and not as a transmitter of disease, although they must be considered in plans for eradication.

Only a part of the development of the tick takes place on the host; the rest of the development occurs on the pasture occupied by the host.

DEVELOPMENT ON THE GROUND.

In tracing the life history of the cattle tick it will be convenient to begin with the large, plump, olive-green female tick (fig. 1), somewhat more than half an inch in length, attached to the skin of the host. During the few preceding days she has increased enormously in size as a consequence of drawing a large supply of blood.

When fully engorged she drops to the ground, and at once, especially if the weather is warm, begins to search for a hiding place on moist earth beneath leaves or any other litter which may serve as a protection from the sun and numerous enemies. The female tick may be devoured by birds or destroyed by ants, or may perish as the result of unfavorable conditions, such as low temperature, absence or excess of moisture, and many other conditions; so that many which fall to the ground are destroyed before they lay eggs.

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[a] The reader desiring fuller information as to the life history of the cattle tick is referred to Bulletin 72 of the Bureau of Entomology, United States Department of Agriculture, which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 15 cents.

Egg laying (see fig. 2) begins during the spring, summer, and fall months in from two to twenty days, and during the winter months in thirteen to ninety-eight days. The eggs are small, elliptical-shaped bodies, at first of a light amber color, later changing to a dark brown, and are about one-fiftieth of an inch in length. As the eggs are laid they are coated with a sticky secretion which causes them to adhere in clusters and no doubt serves the purpose of keeping them from drying out. During egg laying the mother tick gradually shrinks in size and finally is reduced to about one-third or one-fourth her original size. Egg laying is greatly influenced by temperature, being retarded or even arrested by low temperatures. It is completed in from four days in the summer to one hundred and fifty-one days beginning in the fall. During this time the tick may deposit from a few hundred to more than 5,000 eggs. After egg laying is completed the mother tick has fulfilled her purpose and dies in the course of a few days.

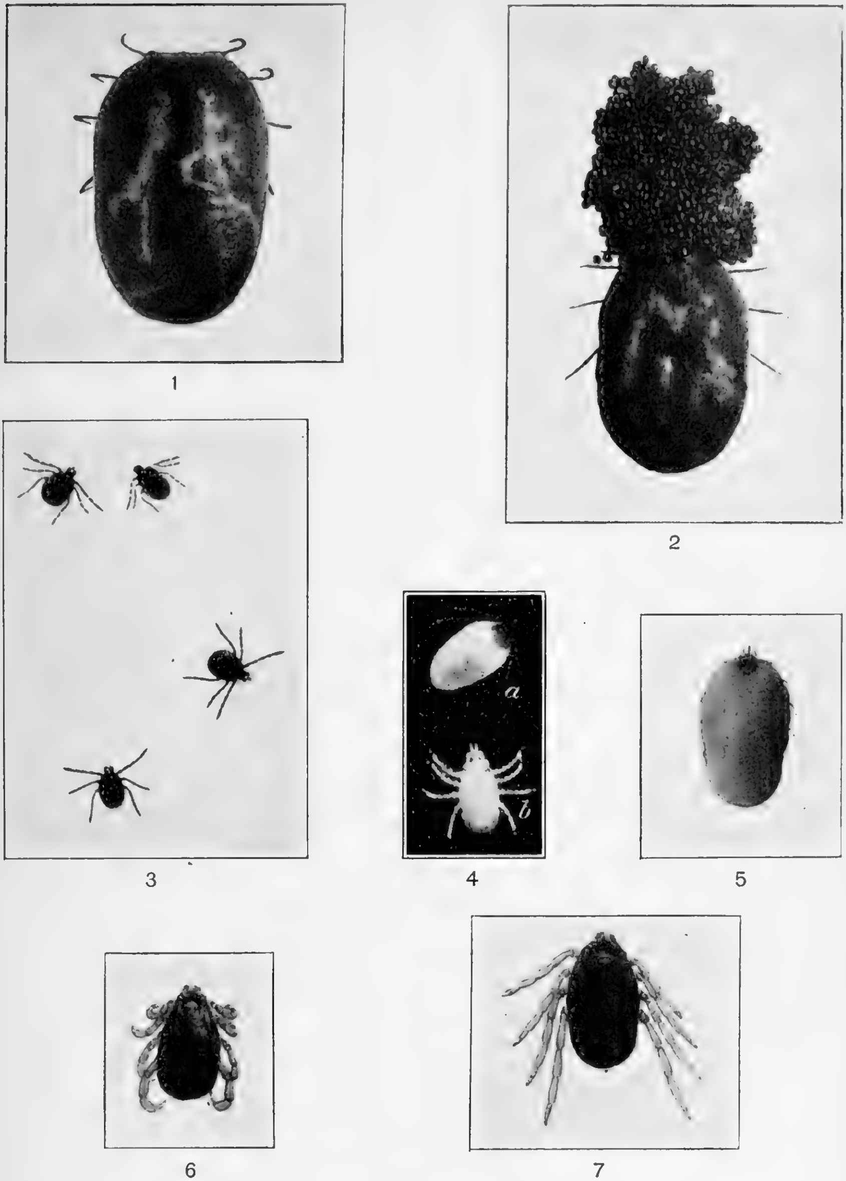
After a time, ranging from nineteen days in the summer to one hundred and eighty-eight days during the fall and winter, the eggs begin to hatch. From each egg issues a small, oval, six-legged larva or seed tick (fig. 3), at first amber colored, later changing to a rich brown. The seed tick, after crawling slowly over and about the shell from which it has emerged, usually remains more or less quiescent for several days, after which it shows great activity, especially if the weather is warm, and ascends the nearest vegetation, such as grass, other herbs, and even shrubs.

Since each female lays an enormous mass of eggs at one spot, thousands of larvæ will appear in the course of time at the same place and will ascend the near-by vegetation and collect on the leaves. This instinct of the seed ticks to climb upward is a very important adaptation to increase their chances of reaching a host. If the vegetation upon which they rest is disturbed, they become very active and extend their long front legs upward in a divergent position, waving them violently in an attempt to seize hold of a host.

The seed tick during its life on the pasture takes no food and consequently does not increase in size, and unless it reaches a host to take up the parasitic portion of its development, it dies of starvation. The endurance of seed ticks is very great, however, as they have been found to live nearly eight months during the colder part of the year.

DEVELOPMENT ON CATTLE.

The parasitic phase of development begins when the larvæ or seed ticks reach a favorable host, such as a cow. They crawl up over the hair of the host and commonly attach themselves to the skin of the escutcheon, the inside of the thighs and flanks, and to the dewlap. They at once begin to draw blood and soon increase in



FIGS. 1 to 7.—Cattle ticks in various stages. 1. Full-grown female tick, engorged and ready to drop to ground and deposit eggs. (Magnified 3 times.) 2. Tick laying eggs. One tick may lay as many as 5,000 eggs. (Magnified 3 times.) 3. Larvæ or seed ticks after emerging from eggs. (Magnified 9 times.) 4. Young ticks before (*a*) and after (*b*) first molt. At this stage the ticks have attached themselves to a host (cow, steer, etc.), and have changed from a brown color to white. It will be noticed that the tick has six legs before molting and eight afterwards. (Magnified 9 times.) 5. Young tick nearly ready to undergo the second molt. The tick at this stage is known as a nymph. (Magnified 6 times.) 6. Male tick. (Magnified 6 times.) 7. Female tick after second molt. This tick is now sexually mature and slightly larger than the male, but will later greatly increase in size until ready to drop to the ground and deposit eggs. (Magnified 6 times.)

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size. In a few days the young tick changes from a brown color to white (fig. 4, *a*), and in from five to twelve days sheds its skin. The new form has eight legs instead of six, and is known as a nymph (fig. 4, *b*, and fig. 5).

In from five to eleven days after the first molt the tick again sheds its skin and becomes sexually mature. It is at this stage that males and females are with certainty distinguishable for the first time. The male (fig. 6) emerges from his skin as a brown, oval tick, about one-tenth of an inch in length. He has reached his growth and goes through no further development. He later shows great activity, moving about more or less over the skin of the host. The female (fig. 7) at the time of molting is slightly larger than the male. She never shows much activity, seldom moving far from her original point of attachment. She still has to undergo most of her growth. After mating the female increases very rapidly in size, and in from twenty-one to sixty-six days after attaching to a host as a seed tick she becomes fully engorged (fig. 1) and drops to the pasture, to repeat the cycle of development.

SUMMARY OF LIFE HISTORY.

To sum up, on the pasture there are found three stages of the tick—the engorged female, the egg, and the larva; and on the host are found four stages—the larva, the nymph, the sexually mature adult of both sexes, and the engorged condition of the female.

METHODS OF ERADICATION.

In undertaking measures for eradicating the tick it is evident that the pest may be attacked in two locations, namely, on the pasture and on the cattle.

In freeing pastures the method followed may be either a direct or an indirect one. The former consists in excluding all cattle, horses, and mules from pastures until all the ticks have died from starvation. The latter consists in permitting the cattle and other animals to continue on the infested pasture and treating them at regular intervals with oils or other agents destructive to ticks and thus preventing engorged females from dropping and reinfesting the pasture. The larvæ on the pasture, or those which hatch from eggs laid by females already there, will all eventually meet death. Such of these as get upon the cattle from time to time will be destroyed by the treatment, while those which fail to find a host will die in the pasture from starvation.

Animals may be freed of ticks in two ways. They may be treated with an agent that will destroy all the ticks present, or they may be rotated at proper intervals on tick-free fields until all the ticks have dropped.

TIME REQUIRED TO KILL TICKS BY STARVATION.

The time required for the ticks to die out after all animals have been removed from infested fields and pastures varies considerably, depending principally on climatic and weather conditions. The dates when pastures will be free of ticks, beginning during each month of the year, are given in the following table:

Time required to free pastures from ticks by starvation.

Date of removal of all animals from pasture.	Date when pasture will be free from ticks.	Date of removal of all animals from pasture.	Date when pasture will be free from ticks.
July 1	March 1.	December 15 to March 15, inclusive.	September 1.
August 1	May 1.	April 1	September 15.
September 1	July 1.	April 15	October 15.
October 1 to November 1, inclusive.	August 1.	May 1 to June 15, inclusive	November 1.
December 1	August 15.		

The above table is based on investigations by Hunter and Hooker [a] at Dallas, Tex., and by the writer at Auburn, Ala., under cooperation between the Bureau of Animal Industry and the veterinary department of the Alabama Polytechnic Institute. All the periods obtained by Newell and Dougherty (1906) [b] in work carried on at Baton Rouge, La., which is much farther south, are shorter. The above periods should be found ample for all localities lying no farther north than Dallas, Tex., or Auburn, Ala. The periods necessary to starve out an infestation for many localities in the southern part of the infested region are no doubt somewhat shorter than those given above. In general, moisture and cold prolong and dryness and heat shorten the duration of an infestation. If various portions of the same pasture differ with regard to temperature and moisture, as is frequently the case, some parts become free of ticks before others do. Other things being equal, high, dry, unshaded land becomes tick free sooner than low, damp, shady land.

The simplest and safest plan in most cases, however, will be to follow the foregoing table in the region indicated for it. It is probable that the periods given in the table should be lengthened a little for the northern part of the infested region. The experiments conducted thus far in various places indicate this and it will place the eradication work in that region on the safe side. For example, E. C. Cotton [c] obtained at Knoxville, Tenn., records for September and April somewhat longer than those given above. They are as follows:

Cattle removed April 15; pasture free of ticks November 13.
Cattle removed September 15; pasture free of ticks July 18.

In localities with temperature and other conditions similar to those at Knoxville, Tenn., these periods should be followed.

[a] Bulletin 72, Bureau of Entomology, U. S. Department of Agriculture.
[b] Circular 10, State Crop Pest Commission of Louisiana.
[c] Bulletin 81, Agricultural Experiment Station of the University of Tennessee.

TIME REQUIRED TO RENDER CATTLE FREE OF TICKS WHEN PLACED ON UNINFESTED FIELDS.

Before discussing plans for rendering farms tick-free, involving the use of the information given in the foregoing table, it will be necessary to indicate how animals may be entirely freed from ticks by placing them on uninfested fields. This is based on the fact that the female tick must drop from the host to the ground before eggs can be laid and before young ticks will develop.

The shortest time in which seed ticks will appear after engorged females have been dropped is twenty days. Consequently cattle placed on a tick-free field during the warmer part of the year are not in danger of becoming infested again with young ticks until twenty days have elapsed. The time required for all the ticks to drop after cattle have been placed on uninfested land varies with the temperature. It is much longer during the winter than during the summer. The time required, beginning at various times of the year, is given in the following table:

Time required for all ticks to drop from cattle placed on tick-free land.

When ticky cattle are placed on tick-free land during—	All ticks will have dropped in—	When ticky cattle are placed on tick-free land during—	All ticks will have dropped in—
August	Six weeks.	March	Seven weeks.
September	Do.	April	Six weeks.
October	Eight weeks.	May	Do.
November	Nine weeks.	June	Do.
January	Ten weeks.	July	Five weeks.
February	Seven weeks.		

FREEING CATTLE OF TICKS BY ROTATION ON TICK-FREE LAND.

The plan of freeing cattle of ticks by rotating them from one lot or field to another is as follows: Beginning at any time of the year from February to September, inclusive, the cattle are removed from the tick-infested pasture they have been occupying to a tick-free lot or field, and continued there for not more than twenty days. During this time a considerable number of ticks will drop. In order to prevent the cattle from becoming reinfested (by seed ticks resulting from eggs laid by females that have dropped), the herd is then changed to a second tick-free inclosure for twenty days longer, and if they are not free of ticks by that time they are placed in a third tick-free inclosure for twenty days more. Should the two changes at intervals of twenty days have been made, sixty days will have elapsed, which is ample time for all ticks to have dropped during the portion of the year indicated, and the animals are ready to be placed on a tick-free pasture or field without danger of becoming reinfested. The periods to free cattle (given in the above table) are believed to be ample. It will, however, be a wise precaution to make a careful examination of the cattle for ticks before placing them in the non-infested field they are to occupy.

During the part of the year from October to January, inclusive, the time required for seed ticks to appear after females have dropped is much longer than the time necessary for all the ticks to drop from cattle. Consequently, if it is desired, the herd may be continued on the same field for the required length of time without danger of becoming reinfested.

FREEING BOTH CATTLE AND PASTURES OF TICKS BY THE ROTATION METHOD.

The particular scheme of rotation to be followed on a farm depends much on the conditions which have to be met. In figures 8 to 11 four plans of rotation are represented. In these diagrams no attempt has been made to indicate, except in a very rough way, the relative size of the fields, since this depends on the number of cattle and on various conditions of a more or less local nature. It rests with the farmer to select his fields with regard to location and size so as to carry out properly and successfully the plan which he adopts.

The matter of the dissemination of ticks deserves particular attention in considering rotation methods. The engorged females which drop on a pasture will crawl at most only a few feet. The same may be said of the larvæ or seed ticks. It is possible, however, for seed ticks to be passively carried considerable distances at times. Dogs, cats, and other animals which ordinarily pass unhindered over farms may become covered with seed ticks while going through one field, and later some of these may be brushed off the animal while passing through the herbage of an adjoining field. Even though the danger of ticks being spread in this manner is not great, it will be well, when practicable, to take precautions against it.

Again, engorged females, eggs, and seed ticks may be carried by running water from a pasture without being injured in any way. The danger from this source is probably greatest where there are many small streams subject to frequent floods of short duration and on hillsides where the water runs off with great force during heavy rains. This will, no doubt, in some localities present a rather serious problem in tick eradication.

Ticks may crawl from the edge of one pasture into an adjoining pasture, or engorged females may drop from the heads of animals reaching through a dividing fence. These difficulties are best overcome by constructing a double fence with an intervening space of 15 feet. Such a double fence, if the land does not slope greatly, will also greatly reduce the danger of ticks being washed from one pasture to the other during rains.

Plan requiring four and one-half months.—The plan of rotation represented in figure 8 requires four and a half months for its completion. Some time during the spring the pasture is divided in the middle by two lines of temporary fence 15 feet apart. The herd is first confined in field No. 1A. On June 15 it is moved from this portion of the pasture to the other portion, designated field No. 1B, and on September 2 is moved to field No. 2A. The cattle are permitted to remain twenty days on each of the fields designated 2A, 2B, and 3. At the end of this time (November 1) all the ticks on the cattle have dropped, and the herd is returned to field No. 1A, which in the meantime has become free of ticks. Later, if it is desired, the cattle may be placed in field No. 4. They should not, however, be returned to any of the other fields or driven across them, since these are infested with ticks. Field No. 1B will be free from ticks July 1 of the following year, at which time the temporary double fence may be removed and the cattle allowed to graze over the entire pasture. The rest of the farm will be free of ticks by August 1. If found desirable, the herd may be continued longer in field No. 3, even as late as February 15, the only objection to this being that it will break the crop rotation by preventing the sowing of oats in the fall.

It is well, when practicable, to have double fences with an intervening space of 15 feet between the different fields in order to prevent the ticks getting from one field to another. If this is not possible on account of the expense and time required to build the extra line of fence, the next best thing is to throw up with a plow several furrows on each side of the dividing fences.

When there are streams running through the farm or the slope of the land is considerable, so that ticks may be washed from one field to the other during rains, the fields should be so arranged or selected that the drainage is from field No. 1A to No. 1B, and from field No. 3 toward fields Nos. 2A and 2B.

Plan requiring eight months.—The plan indicated in figure 9 is begun fifteen days later than the preceding one and requires eight months for its completion. The pasture is divided as before. The herd is moved July 1 from field No. 1A to No. 1B, and on October 15 is moved from there to field No. 2. The herd may be continued on fields Nos. 2 and 3 until February 15 in any way found most convenient, since there is no danger of young ticks hatching during that time. The herd is moved not later than February 15 to field No. 4. All the ticks on the cattle will have dropped by December 20, consequently the herd may be moved to field No. 4 as early as that date, if found desirable.

By March 1 the original pasture is free and the cattle are returned there. Field No. 1B will be free of ticks by August 1, at which time the double fence separating the two parts of the pasture may be removed. The rest of the farm will not be certainly free of ticks until September 1. The drainage in general should be from field No. 1A toward No. 1B, and from field No. 4 toward field No. 2.

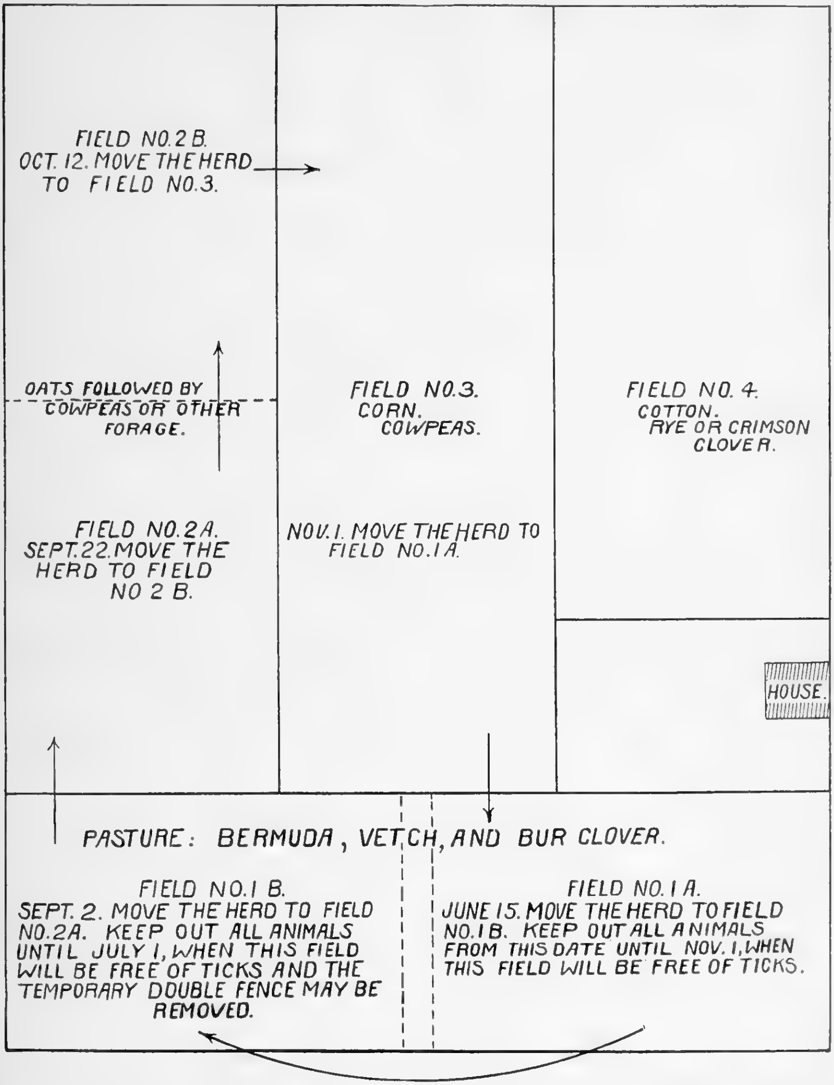

FIG. 8.—Plan for freeing cattle and pastures from ticks by rotation, requiring four and one-half months.

Plan requiring four months, with a new pasture.—The plan of rotation represented in figure 10 involves changing the location of the pasture. The oat field (field No. 4) after the grain has been harvested is reserved for this purpose. It should be sown in cowpeas, Bermuda grass, and bur clover. The herd is moved October 15 from the original pasture, field No. 1, to field No. 2, where it may be kept for a month or two, or until the feed becomes short, then moved to field No. 3, where it is kept until February 15, when it is moved to the

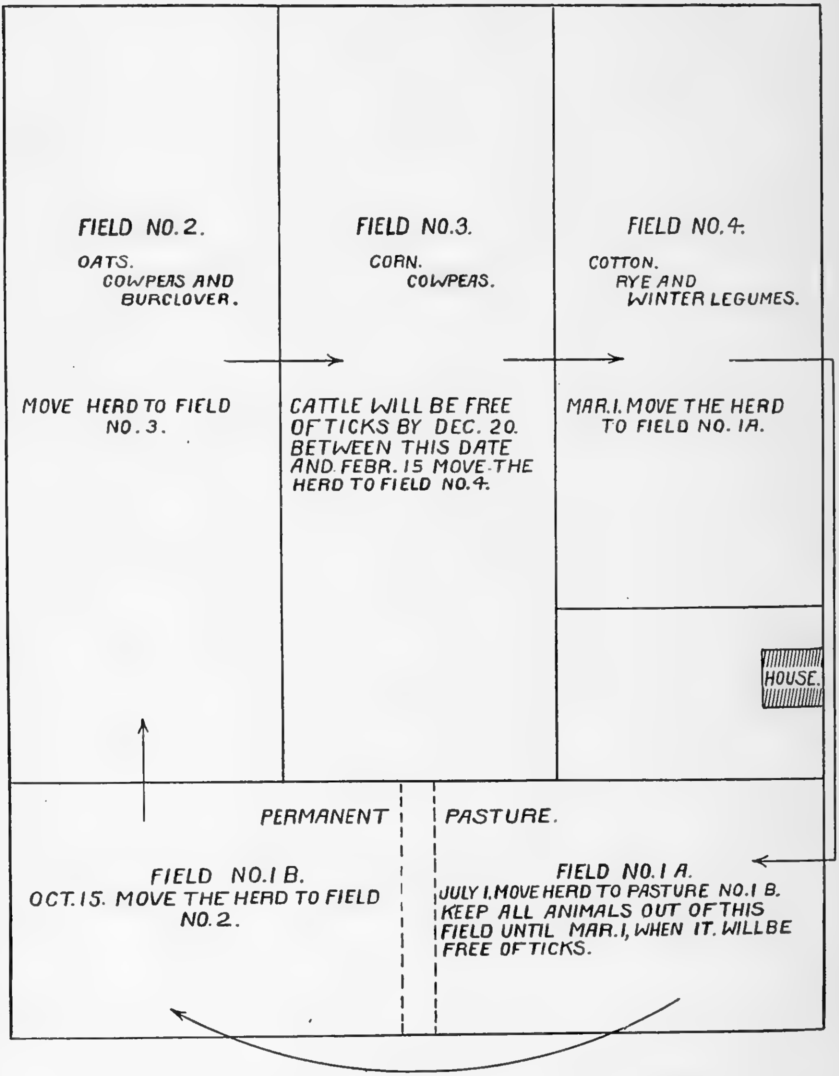

Fig. 9.—Plan for freeing cattle and pastures from ticks by rotation, requiring eight months.

new pasture, field No. 4. The old pasture may be planted in oats. The drainage should be from field No. 4 toward field No. 2.

The feed-lot or soiling method, requiring four and one-half months.—In the plan given in figure 11 the feed-lot or soiling method is made use of to free the cattle of ticks. In the spring field No. 3B, located near the farmyard, is sown in corn for a soiling crop. The area devoted to corn should be sufficient to supply feed for the herd for five or six weeks. Field No. 3A, after the oats are harvested, should be

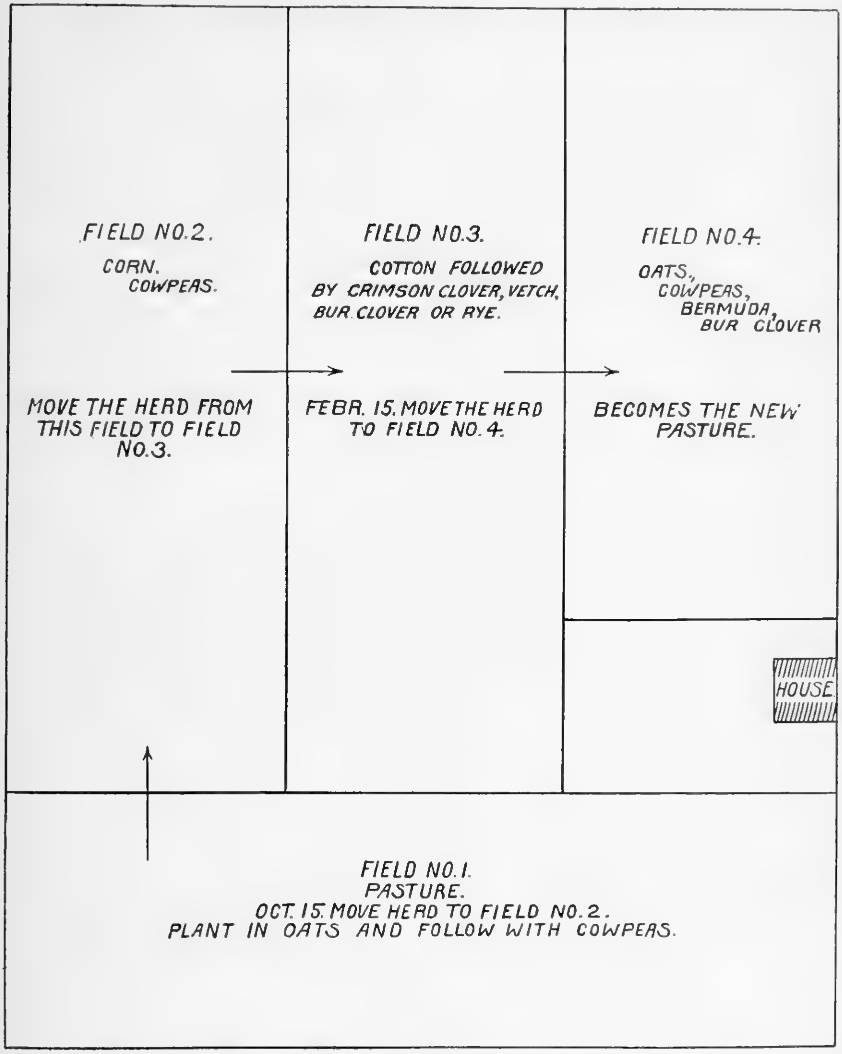

FIG. 10.—Plan for freeing cattle and pastures from ticks by rotation, requiring four months, with new pasture.

sown in sorghum and cowpeas or millet and cowpeas, and should be large enough to furnish feed for the herd until November 1. These fields should not have had cattle on them for at least ten months.

Previous to June 15 three lots, each large enough to accommodate the herd, are fenced off in field No. 3B. These lots should not be located on a stream, and the drainage should be from field No. 3A toward field No. 3B. There should be a space of 15 feet or more between the lots. On June 15 the herd is moved to lot No. 1, and afterwards to lots Nos. 2 and 3 at intervals of twenty days. After the cattle have spent the required time in lots Nos. 1 and 2, if it is found

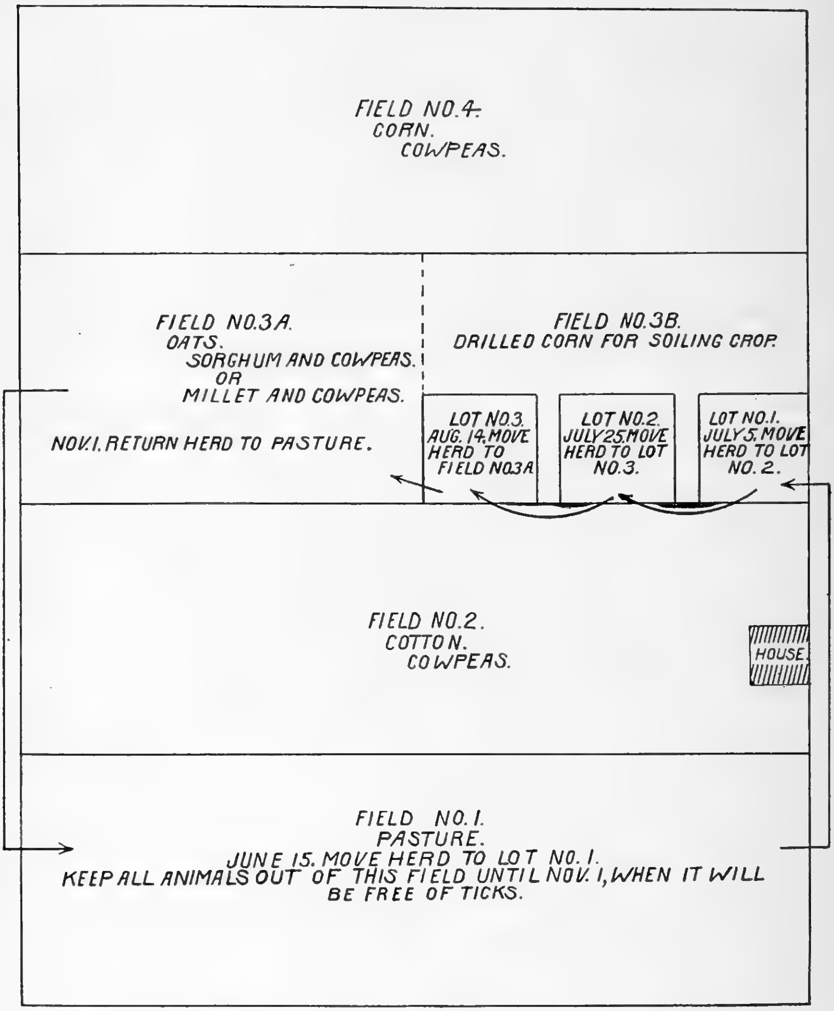

Fig. 11.—Plan for freeing cattle and pastures from ticks by rotation; feed-lot or soiling method.

after a careful examination made by some one familiar with such work that the cattle are free of ticks, they may be turned directly into field No. 3A. If they are not free they should be placed in lot No. 3 until they are free, or, if this can not be determined with certainty, until fifteen or twenty days more have elapsed, which will be much longer than necessary for all ticks to drop during July and August.

If desirable, the corn in each lot may be cut and removed before the cattle are placed in it. As soon as possible after the cattle are removed from a lot the female ticks and eggs present on the ground should be plowed under and the ground along the fence sprayed with crude petroleum or some other disinfectant to prevent any seed ticks which may hatch from getting beyond the area of the lot. Another valuable precaution will be to use for feed, as far as possible, the corn opposite or in advance of the lot in which the cattle are located, since this is less likely to harbor seed ticks.

The pasture will be free of ticks by November 1, and the cattle may then be returned there if desired. The herd may, however, be continued on field No. 3A as long after that date as the forage lasts, or, in case of a shortage of feed previous to November 1, it may be moved to either field No. 2 or 4, provided one of these is ready for pasturage. These fields may be used for fall and winter pasturage in any way that may be found desirable.

DIPPING, SPRAYING, AND HAND DRESSING.

Ticks upon cattle may be destroyed by using various "tickicides," such as oils, arsenic, etc. These may be applied in three ways, namely, by hand, by the use of spray pumps, and by means of the dipping vat.

Hand application is practicable only when a few animals are to be treated. The substances of value in this method are a mixture of lard and kerosene, cotton-seed oil, or a half-and-half mixture of cotton-seed oil and kerosene, and finally, crude petroleum, which in general has proved the most effective, although it has some drawbacks, chief of which are the difficulty of obtaining oil of the proper quality, its expense, its bulk, which makes its transportation costly, and the liability of injury to cattle when the treatment is applied in hot weather. Any of these may be applied with a mop or a good-sized paint brush, but unless great pains are taken this method of treatment is not thorough, and even at the best some portions of the body where ticks may be located will be missed.

Spraying is adapted for small-sized herds. The arsenical mixture or the crude petroleum or emulsions of the same may be applied by means of an ordinary pail spraying pump (fig. 12). There are also pumps on the market designed for making a temporary mechanical mixture of oil and water. Cotton-seed oil, or cotton-seed oil and kerosene in a half-and-half mixture, or crude petroleum, may be used in these pumps, and a 20 per cent mixture of any one of these will kill most of the ticks.

A large spraying machine which is now on the market and which has met with considerable favor in the treatment of large herds of cattle for mange is equally adapted to the application of remedies for ticks, but on account of its expense is not likely to come into general use, and dipping in a vat is therefore on the whole the best and cheapest method of applying remedies when large herds are to be treated.

Farms and pastures may be freed of ticks by treating all cattle at regular intervals with an effective tick-destroying agent. If the treatment is applied with such success as to destroy all ticks

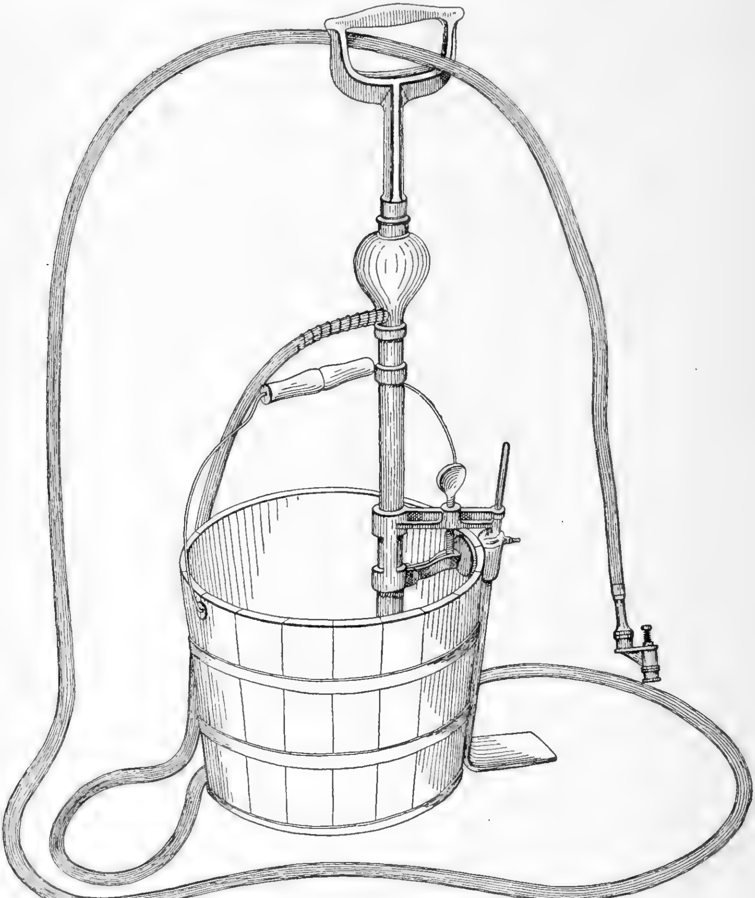

FIG. 12.—Pail spraying pump for small herds.

that reach the cattle from time to time, thus preventing any engorged females from dropping on the pasture after the beginning of the treatment, the pasture will become free of ticks after the same period of time has elapsed as would have been required if all animals had been excluded, beginning on the same date; that is, a perfectly successful treatment would be practically the same as the complete exclusion of the herd. The dates on which the starving out of an infestation will be effected when begun at various times of the year have already been given in the table on page 11. In actual practice, however, the best treatment will in many cases not be absolutely successful, as some ticks will escape and may reinfest the pasture and thus prolong the time necessary to accomplish eradication. This method offers the advantage that the pasture may be used continuously.

Dips, their preparation and use.—*Crude petroleum.*—Various kinds of crude petroleum have been used with more or less success in destroying ticks. The heavier varieties of oil are very injurious to cattle. On the other hand, the very light oils are so volatile that their effects last but a short time, thus rendering them less efficient. The petroleum known as Beaumont oil, obtained from Texas wells, has given the best results. The best grade of this oil to use is one that has a specific gravity ranging from 22½° to 24½° Beaumé, containing 1¼ to 1½ per cent of sulphur, and 40 per cent of the bulk of which boils between 200° and 300° C. The oil may be applied by employing a spray pump or a dipping vat.

Animals that have been dipped in crude oil, especially during warm weather, should not be driven any great distance immediately afterwards, and should be provided with shade and an abundance of water. Unless these precautions are observed serious injury and losses may result.

Emulsions of crude petroleum.—In the majority of cases the best agent to use is an emulsion of crude petroleum, preferably Beaumont crude petroleum. The use of the emulsion makes the treatment less expensive than when the oil alone is used. The emulsion is not so injurious to the cattle and is almost if not quite as effective as the oil alone. The formula for preparing an emulsion of crude petroleum is as follows:

Hard soap	pound	1
Soft or freestone water	gallon	1
Beaumont crude petroleum	gallons	4

Making 5 gallons of 80 per cent stock emulsion.

When a greater quantity of stock emulsion is desired, each of the quantities in the above formula should be multiplied by such a number as to furnish the required amount. For example, if it should be convenient to mix 10 gallons at one time, the quantities would have to be multiplied by 2, and if 15 gallons were desired, they would have to be multiplied by 3, and so on.

In preparing the emulsion the soap should be shaved up and placed in a kettle or caldron containing the required amount of water. The water should be brought to a boil and stirred until the soap is entirely dissolved. Enough water should be added to make up for the loss by evaporation during this process. The soap solution and the required amount of oil are then placed in a barrel or some other convenient receptacle and mixed. The mixing may be effected by the use of a spray pump, pumping the mixture through and through the pump until the emulsion is formed. A convenient and time-saving method is to do the mixing in a barrel by first pouring in one part of hot soap solution and then four parts of crude petroleum and repeating this until the barrel is filled. The oil should be poured in with as much force as possible and the mixture stirred constantly with a long paddle until the oil is completely emulsified. The mixing is facilitated also by dipping up the mixture and pouring it back with a pail. If made properly, this stock emulsion is permanent and will keep indefinitely.

To prepare the stock emulsion for use, it is diluted with water to a 20 or 25 per cent emulsion. In order to obtain a 20 per cent emulsion of oil, it is necessary to use one part of the stock emulsion to 3 parts of water, and for a 25 per cent emulsion one part of stock emulsion to $2\frac{1}{5}$ parts of water. The stock emulsion is permanent, but the diluted emulsion does not remain uniformly mixed, so that if allowed to stand it should be thoroughly mixed by stirring before using. Only rain or freestone water should be used for diluting, and if this is not available, the water should be "softened" by adding a sufficient amount of concentrated lye, sal soda, or washing powder. Care should be observed in this process not to use an excess of these preparations.

An 80 per cent stock emulsion is on the market, and much time and labor can be saved by obtaining this instead of making the emulsion. To prepare it for use, it should be diluted in the same manner as indicated above for the homemade stock emulsion.

The arsenical dip.—This dip is used considerably on account of its cheapness and the ease with which it is prepared. In general it has proved very effective in destroying ticks, and is less likely than crude petroleum or emulsions of the same to injure cattle when dipping has to be done in hot weather. Some injury to the skin is, however, likely to occur when the arsenical mixture is used, and this injury, which will be so slight as to be scarcely noticeable if the cattle are properly handled, is liable to be serious if the cattle are driven any distance, especially if allowed to run while being driven within a week after treatment. The formula given below for making an arsenical dip is the one most commonly used in this country:

Sodium carbonate (sal soda)	pounds	24
Arsenic trioxid (white arsenic)	do	8
Pine tar	gallon	1

Sufficient water to make 500 gallons.

If a stronger arsenical dip is desired, 10 pounds of arsenic may be used in place of 8 pounds, but in general the stronger solution should not be used. In warm weather particularly it is not advisable to use a solution stronger than that given in the above formula, if the animals are to be treated every two weeks.

In preparing the dip, a large caldron or galvanized tank is required for heating the water in which to dissolve the chemicals. Thirty or forty gallons of water should be placed in the caldron or tank and brought to a boil. The sodium carbonate is then added and dissolved by stirring. When this is accomplished, the arsenic is added and dissolved in a similar manner. The fire is then drawn and the pine tar added slowly in a thin stream and thoroughly mixed with the dip by constant stirring. This strong stock solution is diluted to 500 gallons before using.

If one desires, double or triple the amount of stock solution indicated above may be prepared at one time, provided a large enough vessel is available. In case a small vessel holding 20 to 25 gallons must be used, half of the stock solution indicated may be prepared. This will, however, consume so much more time in preparing large quantities that when possible it is advisable to provide a large vessel for dissolving the chemicals.

The stock solution, if it is to be used for dipping, may be placed in the vat as fast as it is prepared, or, if it is to be used for spraying, may be stored in barrels. The most convenient way of diluting the dip is to run the water into the vat through a hose or pipe. The capacity of the vat, if not known, should be calculated, and for convenience the water line marked at several places on the sides. After the exact amount of stock solution necessary to furnish diluted dip to fill the vat has been prepared and placed in the vat, all that is necessary is to allow water to flow into the vat until the surface of the dip reaches the marks made on the sides of the vat. For example, if the capacity of the vat is 2,000 gallons, then four times the amount of the stock solution necessary to make 500 gallons of the dip should be prepared, placed in the vat, and the latter filled with water to the 2,000-gallon mark.

When for any reason it is not convenient to follow the above method of diluting the dip, a stock solution may be prepared in which the quantity of ingredients for 500 gallons of diluted dip are dissolved in 50 gallons of water. Nine parts of water to one part of this stock solution will then give the proper dilution. This stock solution is found very convenient when small amounts of diluted dip are required from time to time for spraying cattle. Fifty gallons of the stock solution can be placed in a barrel and just the amount required each time taken out and diluted.

The diluted arsenical solution may be left in the vat and used repeatedly, replenishing with the proper quantities of water and stock solution when necessary. When not in use the vat should be tightly covered with a waterproof cover to prevent evaporation on the one hand and further dilution by rain on the other hand. Securely covering the vat when not in use also lessens the risk of accidental poisoning of stock and human beings.

Precautions in use of arsenic.—On account of the fact that arsenic is a dangerous poison, great care must be observed in making and using the arsenical dip. From the time the arsenic is procured from the druggist until the last particle of unused residue is properly disposed of, the most scrupulous care should be taken in handling this poison. Guessing at weights or measures or carelessness in any particular is liable to result in great damage, and not only may valuable live stock be destroyed, but human beings may lose their lives as well.

In the use of arsenical dips care should be taken not only to avoid swallowing any of the dip, but persons using the dip should also bear in mind the possibility of absorbing arsenic through cuts, scratches, or abrasions of the skin, and the possibility of absorbing arsenic by inhalation of vapors from the boiler in which the dip is prepared, or by the inhalation of the finely divided spray when the spray pump is used. It should be remembered that the absorption of even very small quantities of arsenic if repeated from day to day is liable ultimately to result in arsenical poisoning.

Cattle should always be watered a short time before they are dipped. After they emerge from the vat they should be kept on a draining floor until the dip ceases to run from their bodies; then they should be placed in a yard free of vegetation until they are entirely dry. If cattle are allowed to drain in places where pools of dip collect, from which they may drink, or are turned at once on the pasture, where the dip will run from their bodies on the grass and other vegetation, serious losses are liable to result. Crowding the animals before they are dry should also be avoided, and they should not be driven any considerable distance within a week after dipping, especially in hot weather. If many repeated treatments are given the cattle should not be treated oftener than every two weeks.

In addition to properly protecting vats containing arsenical dip when not in use, another precaution must be observed when vats are to be emptied for cleaning. The dip should not be poured or allowed to flow on land and vegetation to which cattle or other animals have access. The best plan is to run the dip in a pit properly protected by fences. The dip should also not be deposited where it may be carried by seepage into wells or springs which supply water used on the farm. The same precautions should be observed when animals are sprayed as when they are dipped.

Method of spraying.—Spraying is probably the most practicable and convenient way of treating cattle on the majority of farms. A good type of pail spray pump (fig. 12), costing from $5 to $7, will be found satisfactory for treating small herds. About 15 feet of $\frac{3}{8}$-inch high-pressure hose is required, and a type of nozzle furnishing a cone-shaped spray of not too wide an angle will be found satisfactory. A nozzle with a very small aperture should not be used, because the spray produced is too fine to saturate properly the hair and skin of the animals without consuming an unnecessary amount of time.

The animal to be sprayed should be securely tied to one of the posts of a board or rail fence, or, better still, when convenient, to the corner post in an angle of the fence. This will facilitate the spraying by preventing the animal from circling about to avoid the treatment, and will reduce the amount of help necessary. Every portion of the body should be thoroughly treated, special attention being given to

FIG. 13.—Spraying cow from pail with hand pump.

the head, dewlap, brisket, inside of elbows, inside of thighs and flanks, the tail, and the depressions at the base of the tail. Crude oil alone may be used, but in general a 20 to 25 per cent emulsion will be found more satisfactory.

All the cattle on the place should be sprayed every two weeks with this emulsion. The horses and mules should be kept free of ticks by picking or other means. If on account of heavy rains or other causes the oil disappears rather rapidly from the skin of the cattle, spraying should be carried out oftener. The interval should never be greater than two weeks, and spraying should not be discontinued simply because the ticks have become scarce or seem to have disappeared. This is a great temptation to the busy farmer, on account of the labor and expense incident to spraying, but in the long run it is shortsighted economy, since in most cases it will increase the time necessary for eradication. If the ticks have entirely disappeared from the cattle during the fall and winter, this does not necessarily mean that eradication has been accomplished, because there may be present on the premises dormant seed ticks, live females, and eggs that will hatch with the coming of warm weather. It can not be determined until the next summer whether eradication has been entirely accomplished.

In localities where ticks commonly occur on cattle in considerable numbers during the winter time it will be advisable to continue spraying. In localities where ticks disappear or are present in very small numbers during the winter, the cattle should be inspected

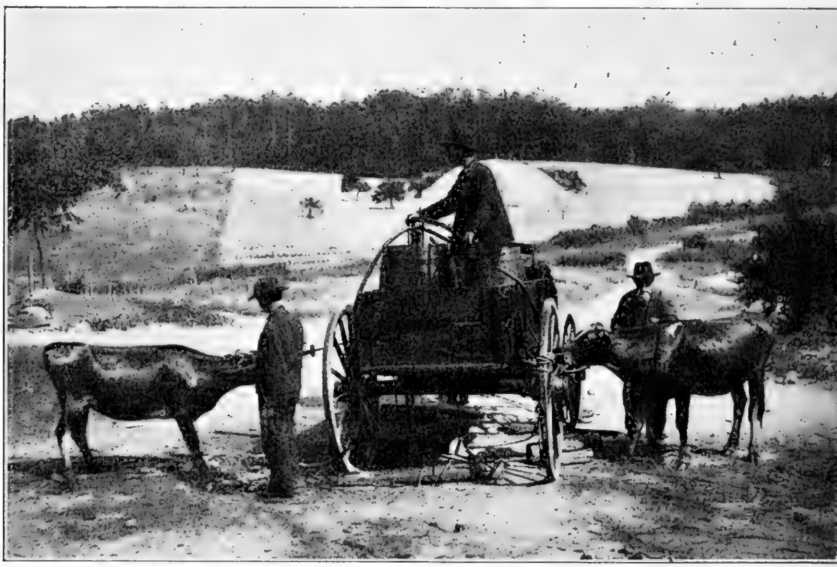

FIG. 14.—Spraying cattle with hand pump from barrels on wagon.

carefully each week to remove and destroy any ticks that may be present. When warm weather comes, it will be well in all cases in which spraying has been discontinued during the winter to begin spraying and continue until it can be determined with certainty that eradication has been accomplished. The spraying should not be delayed until ticks show again in considerable numbers. One tick destroyed in the early spring will save the trouble of destroying thousands a few months later.

At the time of the first spraying all the large ticks should be removed by hand and destroyed. This will also be a very helpful thing to do at each spraying, when it is possible, because large females are likely to drop in a few hours after the cattle have been treated, and consequently may not suffer a great deal from the oil. The farmer who has a small herd which is handled every day should be constantly on the lookout for large ticks. A few minutes spent each day in removing and destroying these ticks will materially aid any treatment employed to eradicate the tick. Eradication will also be much facilitated if at the beginning of the work all litter and manure are removed from stables, sheds, and yards that have been occupied by the cattle, and deposited on land where cattle are not permitted to run. After this is done the buildings should be thoroughly disinfected to destroy any eggs or ticks that may be there. For this purpose the following substances may be used:

1. A mixture made with not more than $1\frac{1}{2}$ pounds of lime and one-fourth pound of pure carbolic acid to each gallon of water.

2. Any coal-tar creosote dip permitted by the United States Department of Agriculture in the official dipping of sheep for scabies, diluted to one-fifth of the maximum dilution specified for dipping sheep.

A spray pump should be used to apply the disinfectant, and the walls, floors, and various fixtures of the buildings should be thoroughly sprayed.

Specifications and materials for a dipping vat.—A vat constructed according to the accompanying plans will hold 2,088 gallons when filled to a depth of 5 feet.

Excavation.—Excavate for the vat, as shown by the drawings (fig. 15), to the proper depth. Level the bottom of the pit for the sills. After the vat is completed fill in around it, using the surplus earth to bring the grade at the sides of the vat a little above the natural grade and slope the surface away from the vat. Dig the holes required for all posts, etc.

Carpenter work.—The drawings show the vat constructed according to two methods. One method is to make the sides of 4 by 4 inch posts spaced about 3 feet apart and lined with 2 by 8 inch dressed, sized, and bevel-edged plank, using 20-penny spikes to fasten them to the posts and braces. All the joints are to be calked with oakum well driven in with a calking iron and pitched. The floor of the vat and the inclines are to be made of 2-inch plank with joints calked, the exit incline to have 2 by 4 inch cleats spiked to the plank flooring. The slide should have an angle of about 25° and should be covered with No. 16 galvanized iron.

The other method is to build the sides of the vat of 2 by 4 inch posts and 2 by 4 inch braces spaced about 16 inches on centers. The 2 by 4 inch posts and braces are to be lined with $\frac{7}{8}$ by 8 inch tongued-and-grooved flooring, blind nailed at every bearing with 10-penny nails. All the joints are to be laid in white lead paste and the boards firmly driven up.

Lumber.—The lumber used in the construction of the vat must be thoroughly dried and seasoned stock, free from large and loose knots, straight grained, and free from sap.

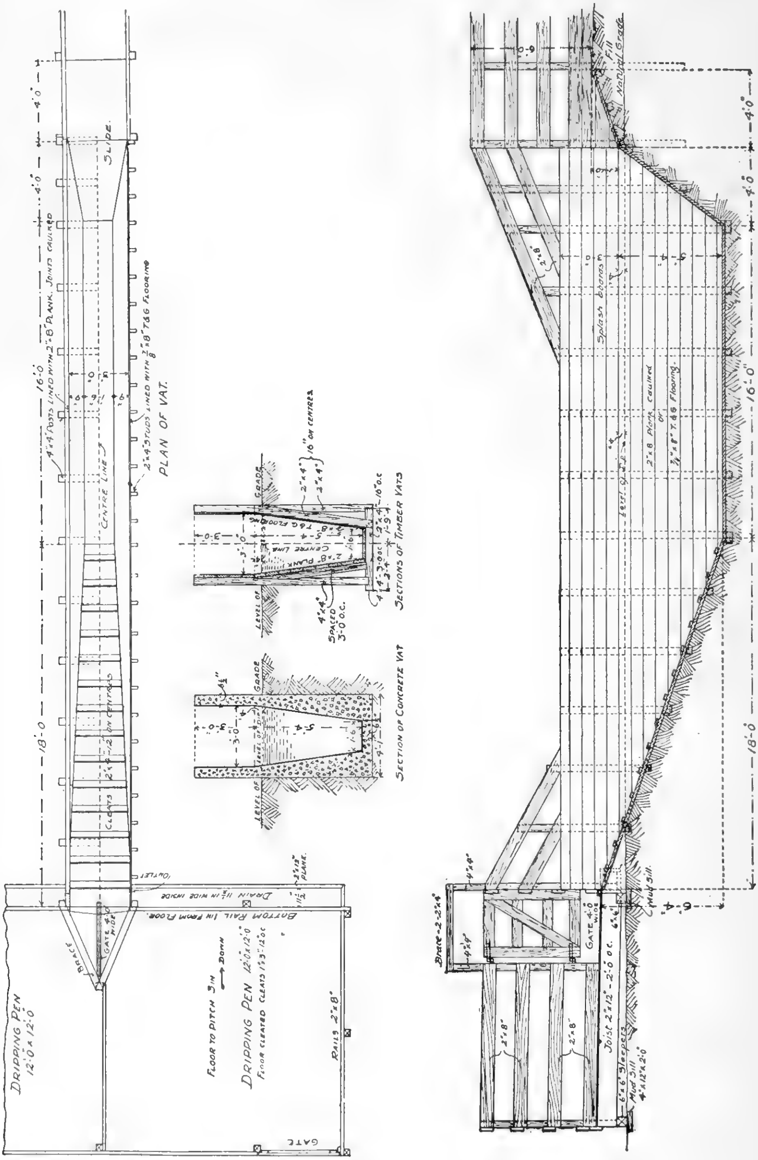

FIG. 15.—Drawings for wood or concrete dipping vat.

Gutters.—The gutters for the dripping pens should be made of sound stock, the bottom plank housed into the sides and ends, and the ends housed into the sides. All the joints are to be laid in white lead paste and thoroughly nailed. Gutters are to have 3-inch fall in 11 feet.

Concrete vat.—The concrete vat should be made of concrete composed of 1 part by measure of good Portland cement, 3 parts of clean sharp sand, and 5 parts of broken rock, the broken rock to be not larger than will pass in any direction through a 2-inch ring. The rock should be washed free of dust. Concrete should be mixed wet and well tamped into place.

Bill of materials for vat and draining pens.—*Vat.*—Lumber for vat when constructed of 2-inch material and 4 by 4 inch posts:

Sills	8 pieces 4 by 4 inches by 10 feet long.
Posts	1 piece 4 by 4 inches by 16 feet long. 1 piece 4 by 4 inches by 14 feet long. 6 pieces 4 by 4 inches by 12 feet long. 5 pieces 4 by 4 inches by 10 feet long.
Braces	1 piece 4 by 4 inches by 16 feet long. 6 pieces 4 by 4 inches by 12 feet long. 1 piece 4 by 4 inches by 10 feet long. 1 piece 4 by 4 inches by 6 feet long.
Guards	2 pieces 2 by 8 inches by 18 feet long. 1 piece 2 by 8 inches by 16 feet long. 2 pieces 2 by 8 inches by 12 feet long. 1 piece 2 by 8 inches by 10 feet long.
Sides	18 pieces 2 by 8 inches by 20 feet long. 25 pieces 2 by 8 inches by 18 feet long. 2 pieces 2 by 8 inches by 16 feet long. 2 pieces 2 by 6 inches by 18 feet long. Dressed one side and two edges. Edges bevelled for calking.
Floor	3 pieces 2 by 10 inches by 20 feet long. 2 pieces 2 by 10 inches by 16 feet long. 1 piece 2 by 10 inches by 14 feet long. 1 piece 2 by 10 inches by 7 feet long. 1 piece 2 by 12 inches by 12 feet long. Dressed one side and two edges. Edges bevelled for calking.
Cleats	4 pieces 2 by 4 inches by 12 feet long.

Lumber for vat when constructed of flooring and 2 by 4 inch posts:

Sills	7 pieces 2 by 4 inches by 14 feet long.
Posts	28 pieces 2 by 4 inches by 18 feet long. 4 pieces 4 by 4 inches by 11 feet long.
Braces	15 pieces 2 by 4 inches by 12 feet long. 2 pieces 2 by 4 inches by 10 feet long. 2 pieces 2 by 4 inches by 16 feet long.
Guards	Materials the same as specified above.
Sides	550 feet b. m. $\frac{7}{8}$ by 8 inches tongue and grove flooring.
Floor	Materials the same as specified above.
Cleats	Materials the same as specified above.

Lumber for draining pens:

Mud sills	10 pieces 4 by 12 inches by 2 feet long (cedar or cypress).
Sleepers	4 pieces 6 by 6 inches by 12 feet long.
Joists	13 pieces 2 by 12 inches by 12 feet long.
Floor	360 feet b. m. tongue and grove flooring $\frac{7}{8}$ by 8 inches—12-foot pieces.
Cleats	265 linear feet 1 by 3 inches.
Gutters	Sides: 4 pieces 2 by 12 inches by 11 feet long (dressed). Bottom and ends: 2 pieces 2 by 12 inches by 12 feet (dressed). Bottom housed into sides and ends. Ends housed into sides. All joints calked and white leaded or pitched.
Posts	11 pieces 4 by 4 inches by 7 feet long. 2 pieces 4 by 4 inches by 8 feet long. 2 pieces 4 by 4 inches by 9 feet long.
Rails	2 pieces 2 by 8 inches by 18 feet long. 5 pieces 2 by 8 inches by 16 feet long. 18 pieces 2 by 8 inches by 12 feet long.
Braces	2 pieces 2 by 4 inches by 10 feet long.
Gates	7 pieces 1 by 6 inches by 12 feet long. 6 pieces 1 by 6 inches by 10 feet long.

Hardware for vat and draining pens:

4 pairs 12-inch heavy T hinges and screws.
4 wrought-iron hooks and staples.
1 pair wrought-iron hook hinges, 12-inch, wood screw hooks, and screws.
50 pounds 20-penny wire nails.
15 pounds 10-penny wire nails.
12 square feet No. 16 galvanized iron.

When vat is constructed of flooring and 2 by 4 posts, the following additional hardware will be required:

19 pounds 20-penny wire nails.
12 pounds 10-penny wire nails.

Material for concrete vat:

Concrete, 1 part Portland cement, 3 parts sand, 5 parts broken rock or gravel.
19 cubic yards broken rock or gravel.
18 cubic yards sand.
30 barrels Portland cement.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to any **Senator, Representative, or Delegate in Congress,** or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals.
24. Hog Cholera and Swine Plague.
27. Flax for Seed and Fiber.
28. Weeds: And How to Kill Them.
30. Grape Diseases on the Pacific Coast.
32. Silos and Silage.
33. Peach Growing for Market.
34. Meats: Composition and Cooking.
35. Potato Culture.
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52. The Sugar Beet.
54. Some Common Birds.
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77. The Liming of Soils.
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81. Corn Culture in the South.
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86. Thirty Poisonous Plants.
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91. Potato Diseases and Treatment.
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96. Raising Sheep for Mutton.
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98. Suggestions to Southern Farmers.
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128. Eggs and Their Uses as Food.
131. Household Tests for Detection of Oleomargarine and Renovated Butter.
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133. Experiment Station Work—XVIII.
134. Tree Planting on Rural School Grounds.
135. Sorghum Sirup Manufacture.
137. The Angora Goat.
138. Irrigation in Field and Garden.
139. Emmer: A Grain for the Semiarid Regions.
140. Pineapple Growing.
142. Principles of Nutrition and Nutritive Value of Food.
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155. How Insects Affect Health in Rural Districts.
156. The Home Vineyard.
157. The Propagation of Plants.
158. How to Build Small Irrigation Ditches.
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 397.

BEES.

BY

E. F. PHILLIPS, Ph. D.,

In Charge of Bee Culture, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology.
Washington, D. C., March 8, 1910.

Sir: I have the honor to transmit herewith a manuscript entitled "Bees," by E. F. Phillips, Ph. D., in charge of bee culture in this Bureau. In the preparation of this paper, which is intended to supersede Farmers' Bulletin No. 59, the aim has been to give briefly such information as is needed by persons engaged in the keeping of bees, and to answer inquiries such as are frequently received from correspondents of the Department. No attempt has been made to include discussions of bee anatomy, honey plants, or the more special manipulations sometimes practiced, such as queen rearing. The discussion of apparatus is necessarily brief. I respectfully recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

BEES.

INTRODUCTION.

Bee keeping for pleasure and profit is carried on by many thousands of people in all parts of the United States. As a rule, it is not the sole occupation. There are, however, many places where an experienced bee keeper can make a good living by devoting his entire time and attention to this line of work. It should be emphasized that it is unwise for the average individual to undertake extensive bee keeping without considerable previous experience on a small scale, since there are so many minor details which go to make up success in the work. These must be thoroughly understood before there is any hope for continued success. It is, therefore, most desirable to begin on a small scale, make the bees pay for themselves and for all additional apparatus, as well as some profit, and gradually to increase as far as the local conditions or the desires of the individual permit.

Bee culture is the means of obtaining for human use a natural product which is abundant in almost all parts of the country, and which would be lost to us were it not for the honey bee. The annual production of honey and wax in the United States makes apiculture a profitable minor industry of the country. From its very nature it can never become one of the leading agricultural pursuits, but that there is abundant opportunity for its growth can not be doubted. Not only is the honey bee valuable as a producer, but it is also one of the most beneficial of insects in cross-pollinating the flowers of various economic plants.

Bee keeping is also extremely fascinating to the majority of people as a pastime, furnishing outdoor exercise as well as intimacy with an insect whose activity has been a subject of absorbing study from the earliest times. It has the advantage of being a recreation which pays its own way and often produces no mean profit.

It is a mistake, however, to paint only the bright side of the picture and leave it to the new bee keeper to discover that there is often another side. Where any financial profit is derived, bee keeping requires hard work and work at just the proper time, otherwise the surplus of honey may be diminished or lost. Few lines of work require more study to insure success. In years when the available nectar is limited, surplus honey is secured only by judicious manipulations and it is only through considerable experience and often by expensive reverses that the bee keeper is able to manipulate properly to save his crop. Anyone can produce honey in seasons of plenty, but these do not come every year in most locations and it takes a good bee keeper to make the most of poor years. When, even with the best of manipulations, the crop is a failure through lack of nectar, the bees must be fed to keep them from starvation.

The average annual honey yield per colony for the entire country, under good management, will probably be 25 to 30 pounds of comb honey or 40 to 50 pounds of extracted honey. The money return to be obtained from the crop depends entirely on the market and the method of selling the honey. If sold direct to the consumer, extracted honey brings from 10 to 20 cents per pound, and comb honey from 15 to 25 cents per section. If sold to dealers, the price varies from 6 to 10 cents for extracted honey and from 10 to 15 cents for comb honey. All of these estimates depend largely on the quality and neatness of the product. From the gross return must be deducted from 50 cents to $1 per colony for expenses other than labor, including foundation, sections, occasional new frames and hives, and other incidentals—not, however, providing for increase.

Above all it should be emphasized that the only way to make bee keeping a profitable business is to produce only a first-class article. We can not control what the bees bring to the hive to any great extent, but by proper manipulations we can get them to produce fancy comb honey, or if extracted honey is produced it can be carefully cared for and neatly packed to appeal to the fancy trade. Too many bee keepers, in fact the majority, pay too little attention to making their goods attractive. They should recognize the fact that of two jars of honey, one in an ordinary fruit jar or tin can with a poorly printed label, and the other in neat glass jar of artistic design with a pleasing, attractive label, the latter will bring double or more the extra cost of the better package. It is perhaps unfortunate, but nevertheless a fact, that honey sells largely on appearance, and a progressive bee keeper will appeal as strongly as possible to the eye of his customer.

LOCATION OF THE APIARY.

The location of the hives is a matter of considerable importance. As a rule it is better for hives to face away from the prevailing wind and to be protected from high winds. In the North, a south slope is desirable. It is advisable for hives to be so placed that the sun will strike them early in the morning, so that the bees become active early in the day, and thus gain an advantage by getting the first supply of nectar. It is also advantageous to have the hives shaded during the hottest part of the day, so that the bees will not hang out in front of the hive instead of working. They should be so placed that the bees will not prove a nuisance to passers-by or disturb livestock. This latter precaution may save the bee keeper considerable trouble, for bees sometimes prove dangerous, especially to horses.

The plot on which the hives are placed should be kept free from weeds, especially in front of the entrances. The hives should be far enough apart to permit of free manipulation. If hives are too close together there is danger of bees entering the wrong hive on returning, especially in the spring.

Fig. 1.—A well-arranged apiary.

These conditions, which may be considered as ideal, need not all be followed. When necessary bees may be kept on house tops, in the back part of city lots, in the woods, or in many other places where the ideal conditions are not found. As a matter of fact, few apiaries are perfectly located; nevertheless, the location should be carefully planned, especially when a large number of colonies are kept primarily for profit.

As a rule, it is not considered best to keep more than 100 colonies in one apiary, and apiaries should be at least 2 miles apart. There are so many factors to be considered, however, that no general rule can be laid down. The only way to learn how many colonies any given locality will sustain is to study the honey flora and the record of that place until the bee keeper can decide for himself the best number to be kept and where they shall be placed.

The experience of a relatively small number of good bee keepers in keeping unusually large apiaries indicates that the capabilities of the average locality are usually underestimated. The determination of the size of extensive apiaries is worthy of considerable study, for it is obviously desirable to keep bees in as few places as possible, to save time in going to them and also expense in duplicated apparatus. To the majority of bee keepers this problem is not important, for most persons keep but a small number of colonies. This is perhaps a misfortune to the industry as a whole, for with fewer apiaries of larger size under the management of careful, trained bee keepers the honey production of the country would be marvelously increased. For this reason, professional bee keepers are not favorably inclined to the making of thousands of amateurs, who often spoil a location for a honey producer and more often spoil his market by the injudicious selling of honey for less than it is worth or by putting on the market an inferior article.

Out apiaries, or those located away from the main apiary, should be so located that transportation will be as easy as possible. The primary consideration, however, must be the available nectar supply and the number of colonies of bees already near enough to draw on the resources. The out apiary should also be near to some friendly person, so that it may be protected against depredation and so that the owner may be notified if anything goes wrong. It is especially desirable to have it in the partial care of some person who can hive swarms or do other similar things that may arise in an emergency. The terms under which the apiary is placed on land belonging to some one else is a matter for mutual agreement. There is no general usage in this regard.

EQUIPMENT IN APPARATUS.

It must be insisted that the only profitable way to keep bees is in hives with movable frames. The bees build their combs in these frames, which can then be manipulated by the bee keeper as necessary. The keeping of bees in boxes, hollow logs, or straw "skeps" is not profitable, is often a menace to progressive bee keepers, and should be strongly condemned. Bees in box hives (plain boxes with no frames and with combs built at the will of the bees) are too often seen in all parts of the country. The owners may obtain from them a few pounds of inferior honey a year and carelessly continue in the antiquated practice. In some cases this type of bee keeping does little harm to others, but where diseases of the brood are present the box hive is a serious nuisance and should be abolished.

HIVES.

It is not the purpose of this bulletin to advocate the use of any particular make of hive or other apparatus. Some general statements may be made, however, which may help the beginner in his choice.

The type of hive most generally used in this country (fig. 2) was invented by Langstroth in 1851. It consists of a plain wooden box holding frames hung from a rabbet at the top and not touching the sides, top, or bottom. Hives of this type are made to hold from eight frames upward. The size of frame in general use, known as the Langstroth (or L) frame ($9\frac{1}{8}$ by $17\frac{5}{8}$ inches), is more widely used than all others combined. The number of frames used depends on the kind of honey produced (whether comb or extracted), and on the length of honey flow and other local factors. There are other hives used which have points of superiority. These will be found discussed in the various books on bee keeping and in the catalogues of dealers in bee keepers' supplies.

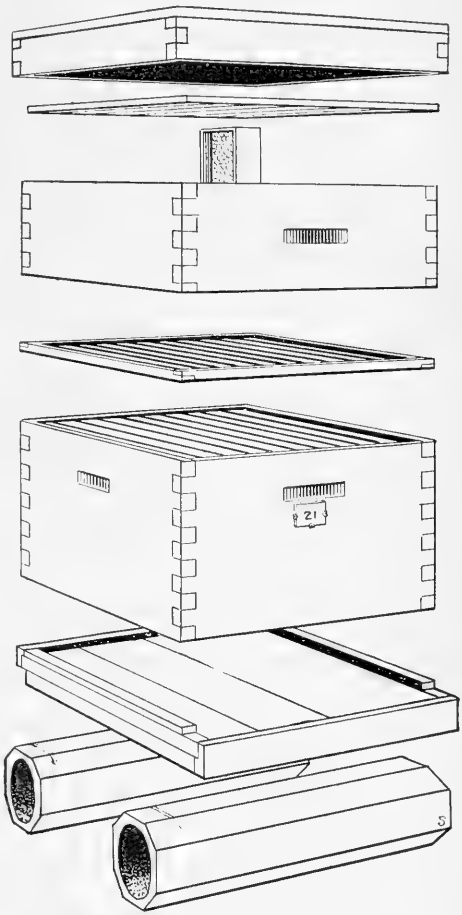

FIG. 2.—A ten-frame hive with comb-honey super and perforated zinc queen excluder.

Whatever hive is chosen, there are certain points of importance which should be insisted on. The material should be of the best; the parts must be accurately made, so that all frames or hives in the apiary are interchangeable. All hives should be of the same style and size; they should be as simple as it is possible to make them to facilitate operation. Simple frames diminish the amount of propolis, which will interfere with manipulation. As a rule, it is better to buy hives and frames from a manufacturer of such goods rather than to try to make them, unless one is a good wood worker.

The choice of a hive, while important, is usually given undue prominence in books on bees. In actual practice experienced bee keepers with different sizes and makes of hives under similar conditions do not find as much difference in their honey crop as one would be led to believe from the various published accounts.

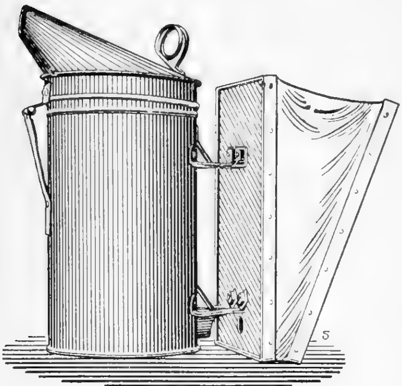

FIG. 3.—Smoker.

HIVE STANDS.

Generally it is best to have each hive on a separate stand. The entrance should be lower than any other part of the hive. Stands of wood, bricks, tile (fig. 2), concrete blocks, or any other convenient material will answer the purpose. The hive should be raised above the ground so that the bottom will not rot. It is usually not necessary to raise the hive more than a few inches. Where ants are a nuisance special hive stands are sometimes necessary.

OTHER APPARATUS.

In addition to the hives in which the bees are kept some other apparatus is necessary. A good smoker (fig. 3), consisting of a tin or copper receptacle to hold burning rotten wood or other material, with a bellows attached, is indispensable. A veil of black material, preferably with a silk tulle front (fig. 4), should be used. Wire-cloth veils are also excellent. Even if a veil is not always used, it is desirable to have one at hand in case the bees become cross. Cloth or leather gloves are sometimes used to protect the hands, but they hinder most manipulations. Some sort of tool (fig. 5) to pry hive covers loose and frames apart is desirable. A screw-driver will answer, but any of the tools made especially for that purpose is perhaps

FIG. 4.—Bee veil with silk-tulle front.

better. Division boards, drone traps (fig. 6), bee escapes (figs. 7 and 8), feeders (figs. 14, 15, 16, 17), foundation fasteners, wax extractors, bee brushes (fig. 9), queen-rearing outfits, and apparatus for producing comb or extracted honey (figs. 2, 18, 19) will be found described in catalogues of supplies; a full discussion of these implements would require too much space in this bulletin. A few of these things are illustrated, and their use will be evident to the bee keeper. It should be remembered that manipulation based on a knowledge of bee activity is of far greater importance than any particular style of apparatus, and in a short discussion like the present it should be given more space, especially since supply dealers will be glad to furnish whatever information is desired concerning apparatus.

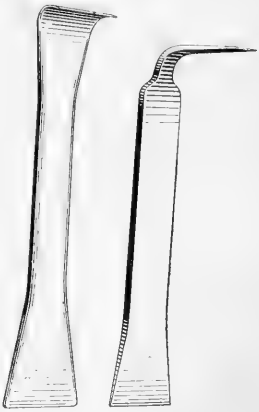

FIG. 5.—Hive tools.

EQUIPMENT IN BEES.

As stated previously, it is desirable to begin bee keeping with a small number of colonies. In purchasing these, it is usually best to obtain them near at home rather than to send to a distance, for there is considerable liability of loss in shipment. Whenever possible, it will be better to get bees already domiciled in the particular hive chosen by the bee keeper as the best, but if this is not practicable then bees in any hives or in box hives may be purchased and transferred. It is a matter of small importance what race of bees is purchased, for queens of any race may be obtained and introduced in place of the original queen, and in a short time the workers will all be of the same race as the introduced queen. This is due to the fact that during the season worker bees die rapidly, and after requeening they are replaced by the offspring of the new queen.

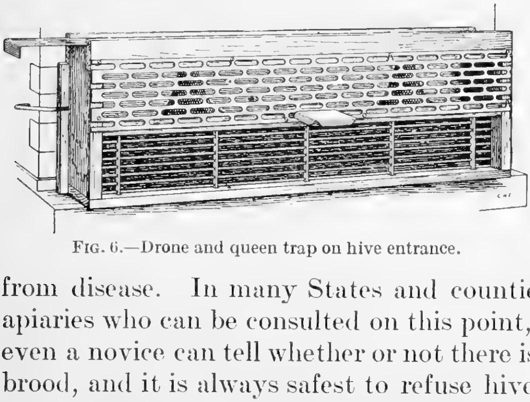

FIG. 6.—Drone and queen trap on hive entrance.

A most important consideration in purchasing colonies of bees is to see to it that they are free from disease. In many States and counties there are inspectors of apiaries who can be consulted on this point, but if this is not possible even a novice can tell whether or not there is anything wrong with the brood, and it is always safest to refuse hives containing dead brood.

The best time of the year to begin bee keeping is in the spring, for during the first few months of ownership the bee keeper can study the subject and learn what to do, so that he is not so likely to make a mistake which will end in loss of bees. It is usually best to buy good strong colonies with plenty of brood for that season of the year, but if this is not practicable, then smaller colonies, or nuclei, may be purchased and built up during the season. Of course, no surplus honey can be expected if all the honey gathered goes into the making of additional bees. It is desirable to get as little drone comb as possible and a good supply of honey in the colonies purchased.

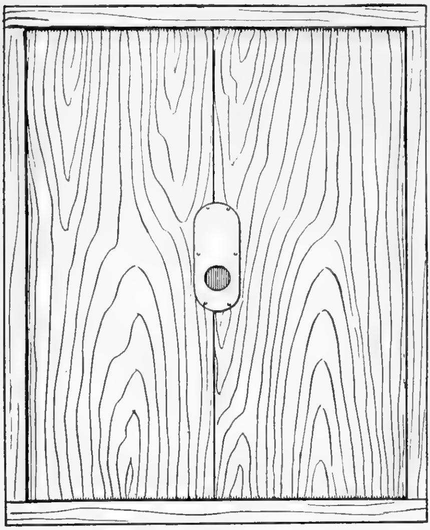

Fig. 7.—Bee escape for removing bees from supers.

The question as to what race and strain of bees is to be kept is important. If poor stock has been purchased locally, the bee keeper should send to some reliable queen breeder for good queens as a foundation for his apiary. Queens may be purchased for $1 each for "untested" to several dollars each for "selected" breeding queens. Usually it will not pay beginners to buy "selected" breeding queens, for they are not yet prepared to make the best use of such stock. "Untested" or "tested" queens are usually as good a quality as are profitable for a year or so, and there is also less danger in mailing "untested" (young) queens.

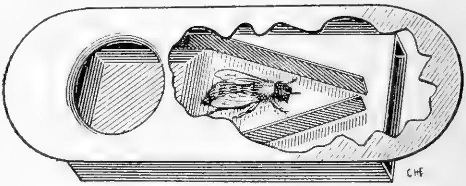

Fig. 8.—Spring bee escape.

Various races of bees have been imported into the United States and among experienced bee keepers there are ardent advocates of almost all of them. The black or German race was the first imported, very early in the history of the country, and is found everywhere, but usually not entirely pure. As a rule this race is not desirable. No attention has been paid to breeding it for improvement in this country, and it is usually found in the hands of careless bee keepers. As a result, it is inferior, although it often produces beautiful comb honey.

Fig. 9.—Bee brush.

The Italian bees, the next introduced, are the most popular race among the best bee keepers in this country, and with good reason. They are vigorous workers and good honey gatherers, defend their hives well, and above all have been more carefully selected by American breeders than any other race. Especially for the last reason it is usually desirable to keep this race. That almost any other race of bees known could be bred to as high a point as the Italians, and perhaps higher, can not be doubted, but the bee keeper now gets the benefit of what has been done for this race. It should not be understood from this that the efforts at breeding have been highly successful. On the contrary, bee breeding will compare very unfavorably with the improvement of other animals or plants which have been the subject of breeding investigations.

Italian bees have been carefully selected for color by some breeders to increase the area of yellow on the abdomen, until we now have what are known as "five-banded" bees. These are very beautiful, but it can scarcely be claimed that they are improved as honey producers or in regard to gentleness. They are kept mostly by amateurs.

Some breeders have claimed to select Italians for greater length of tongue, with the object of getting a bee which could obtain the abundance of nectar from red clover. If any gain is ever made in this respect it is soon lost. The terms "red-clover bees" or "long-tongued bees" are somewhat misleading, but are ordinarily used as indicating good honey producers.

Caucasian bees, recently distributed throughout the country by this Department, are the most gentle race of bees known. They are not stingless, however, as is often stated in newspapers and other periodicals. Many report them as good honey gatherers. They are more prolific than Italians and may possibly become popular. Their worst characteristic is that they gather great quantities of propolis and build burr and brace combs very freely. They are most desirable bees for the amateur or for experimental purposes.

Carniolan and Banat bees have some advocates, and are desirable in that they are gentle. Little is known of Banats in this country. Carniolans swarm excessively unless in large hives. Cyprians were formerly used somewhat, but are now rarely found pure, and are undesirable either pure or in crosses because of the fact that they sting with the least provocation and are not manageable with smoke. They are good honey gatherers, but their undesirable qualities have caused them to be discarded by American bee keepers. "Holy-land," Egyptian, and Punic (Tunisian) bees have also been tried and have been universally abandoned.

BEE BEHAVIOR.

The successful manipulation of bees depends entirely on a knowledge of their habits. This is not generally recognized, and most of the literature on practical bee keeping consists of sets of rules to guide manipulations. This is too true of the present paper, but is due to a desire to make the bulletin short and concise. While this method usually answers, it is nevertheless faulty, in that, without a knowledge of fundamental principles of behavior, the bee keeper is unable to recognize the seemingly abnormal phases of activity, and does not know what to do under such circumstances. Rules must, of course, be based on the usual behavior. By years of association, the bee keeper almost unconsciously acquires a wide knowledge of bee behavior, and consequently is better able to solve the problems which constantly arise. However, it would save an infinite number of mistakes and would add greatly to the interest of the work if more time were expended on a study of behavior; then the knowledge gained can be applied to practical manipulation.

A colony of bees consists normally of one queen bee, the mother of the colony, and thousands of sexually undeveloped females called workers, which normally lay no eggs, but gather the stores, keep the hive clean, feed the young, and do the other work of the hive. During part of the year there are also present some hundreds of males or drones (often removed or restricted in numbers by the bee keeper) whose only service is to mate with young queens. These three types are easily recognized, even by a novice. In nature the colony lives in a hollow tree or other cavity, but under manipulation thrives in the artificial hives provided. The combs which form their abode are composed of wax secreted by the workers. The hexagonal cells of the two vertical layers constituting each comb have interplaced ends on a common septum. In the cells of these combs are reared the developing bees, and here are stored honey and pollen for food.

The cells built naturally are not all of the same size, those used in rearing worker bees being about one-fifth of an inch across, and those used in rearing drones and in storing honey about one-fourth of an inch across (fig. 10). The storage cells are more irregular, and generally curve upward at the outer end. Under manipulation, the size of the cells is controlled by the bee keeper by the use of comb foundation—sheets of pure beeswax on which are impressed the bases of cells and on which the bees build the side walls.

In the North, when the activity of the spring begins, the normal colony consists of the queen and some thousands of workers. As the workers bring in early pollen and honey, the queen begins to lay eggs in the worker cells. These in time develop into white larvæ, which grow to fill the cells. They are then capped over and transform gradually into adult worker bees. As the weather grows warmer, and the colony increases in size by the emergence of the developing bees, the quantity of brood is increased. The workers continue to bring in pollen, and nectar to be made into honey. After a time the queen begins to lay eggs in the larger cells, and these develop into drones or males.

Continued increase of the colony would result in the formation of enormous colonies, and unless some division takes place no increase in the number of colonies will result. Finally, however, the workers begin to build queen cells over certain female larvæ. These are larger than any other cells in the hive and hang on the comb vertically. In size and shape they may be likened to a peanut and are also rough on

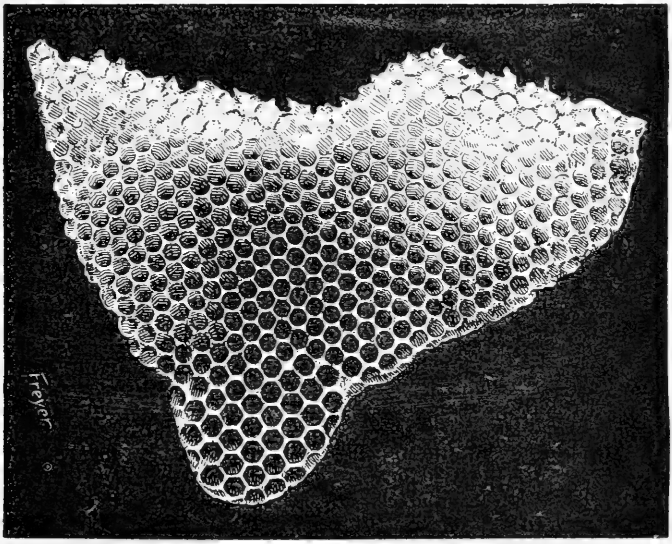

FIG. 10.—Piece of comb showing worker and drone cells with irregular transitions. Reduced.

the outside. When the larvæ in these cells have grown to full size they too are sealed up, and the colony is then ready for swarming.

Swarming consists of the exit from the hive of the original queen with part of the workers. They leave the hive to seek a new home and begin the building of combs, storing of honey and pollen, and rearing of brood in a new location. They leave behind the honey stores, except such as they can carry in their honey stomachs, and the brood, some workers, and no adult queen, but several queen cells from which will later emerge young queens. By this interesting process the original colony is divided into two.

The swarm finds a new location either in a hollow tree or, if cared for by the bee keeper, in a hive. The workers build new combs, the queen begins laying, and in a short time the colony is again in normal condition.

The colony on the old stand (parent colony) has the advantage of the bees which emerge from the brood. After a time (usually about nine days), the queens in their cells are ready to emerge. If the colony is only moderately strong the first queen to emerge is allowed by the workers to tear down the other queen cells and kill the queens not yet emerged, but if a "second swarm" is to be given off the queen cells are protected.

If the weather permits, after from five to eight days the young queen flies from the hive to mate with a drone. Mating usually occurs but once during the life of the queen and always takes place on the wing. In this single mating she receives enough spermatozoa to last throughout her life. She returns to the hive after mating, and in about two days begins egg laying. The queen never leaves the hive except at mating time or with a swarm, and her sole duty in the colony is to lay eggs to keep up the population.

When the flowers are in bloom which furnish most nectar, the bees usually gather more honey than they need for their own use, and this the bee keeper can safely remove. They continue the collection of honey and other activities until cold weather comes on in the fall, when brood rearing ceases; they then become relatively quiet, remaining in the hive all winter, except for short flights on warm days. When the main honey flow is over, the drones are usually driven from the hive. By that time the virgin queens have been mated and drones are of no further use. They are not usually stung to death, but are merely carried or driven from the hive by the workers and starve. A colony of bees which for any reason is without a queen does not expel the drones.

Many abnormal conditions may arise in the activity of a colony, and it is therefore necessary for the bee keeper to understand most of these, so that when they occur he may overcome them. If a virgin queen is prevented from mating she generally dies, but occasionally begins to lay eggs after about four weeks. In this event, however, all of the eggs which develop become males. Such a queen is commonly called a "drone-layer."

If the virgin queen is lost while on her flight or the colony at any other time is left queenless without means of rearing additional queens, it sometimes happens that some of the workers begin to lay eggs. These eggs also develop only into drones.

It also happens at times that when a queen becomes old her supply of spermatozoa is exhausted, at which time her eggs also develop only into drones. These facts are the basis of the theory that the drone of the bee is developed from an unfertilized egg or is parthenogenetic. A full discussion of this point is impossible at this time.

The work of the hive is very nicely apportioned among the inmates, so that there is little lost effort. As has been stated, the rearing of young is accomplished by having one individual to lay eggs and numerous others (immature females) to care for the larvæ. In like manner all work of the colony is apportioned. In general, it may be stated that all inside work—wax building, care of brood, and cleaning—is done by the younger workers, those less than 17 days old, while the outside work of collecting pollen and nectar to be made into honey is done by the older workers. This plan may be changed by special conditions. For example, if the colony has been queenless for a time and a queen is then given, old workers may begin the inside work of feeding larvæ and these may also secrete wax. Or, if the old workers are all removed, the younger bees may begin outside work. As a rule, however, the general plan of division of labor according to age is followed rather closely.

DIRECTIONS FOR GENERAL MANIPULATIONS.

Bees should be handled so that they will be little disturbed in their work. As much as possible, stings should be avoided during manipulation. This is true not so much because they are painful to the operator, but because the odor of poison which gets into the air irritates the other bees and makes them more difficult to manage. For this reason it is most advisable to wear a black veil (fig. 4) over a wide-brimmed hat and to have a good smoker (fig. 3). Experienced bee keepers often dispense with these, but the beginner should not. Gloves, however, are usually more an inconvenience than otherwise. Gauntlets or rubber bands around the cuffs keep the bees from crawling up the sleeve. It is best to avoid black clothing, since that color seems to excite bees; a black felt hat is especially to be avoided.

The bee keeper should manipulate without exhibiting fear. This is not because the bees recognize the fact that the operator is afraid of them, as some claim, but because superfluous quick movements tend to irritate the bees. The hive should not be jarred or disturbed any more than necessary. Rapid movements are objectionable, because with their peculiar eye structure bees probably perceive motion more readily than they do objects. Persons not accustomed to bees, on approaching a hive, often strike at bees which fly toward them or make some quick movement of the head or hand to avoid the sting which they fear is to follow. This is just what should not be done, for the rapid movement, even if not toward the bee, is far more likely to be followed by a sting than is remaining quiet.

The best time to handle bees is during the middle of warm days, particularly during a honey flow. Never handle bees at night or on cold, wet days unless absolutely necessary. The work of a beginner may be made much easier and more pleasant by keeping gentle bees. Caucasians, Carniolans, Banats, and some strains of Italians ordinarily do not sting much unless unusually provoked or except in bad weather. Common black bees or crosses of blacks with other races are more irritable. It may be well worth while for the beginner to procure gentle bees while gaining experience in manipulation. Later on, this is less important, for the bee keeper learns to handle bees with the least inconvenience to himself or to them.

Before opening a hive the smoker should be lighted and the veil put on. A few puffs of smoke directed into the entrance will cause the bees to fill themselves with honey and will drive back the guards. The hive cover should be raised gently, if necessary being pried loose with a screw-driver or special hive tool. As soon as a small opening is made, more smoke should be blown in on the tops of the frames, or if a mat covering for the frames is used, the cover should be entirely removed and one corner of the mat lifted to admit smoke. It is not desirable to use any more smoke than just enough to subdue the bees and keep them down on the frames. At any time during manipulation, if they become excited, more smoke may be used. Do not stand in front of the entrance, but at one side or the back.

After the frames are exposed they may be loosened by prying with the hive tool and crowded together a little so as to give room for the removal of one frame. In cool weather the propolis (bee glue) may be brittle. Care should be exercised not to loosen this with a jar. The first frame removed can be leaned against the hive, so that inside there will be more room for handling the others. During all manipulations bees must not be mashed or crowded, for that irritates the colony greatly and may make it necessary to discontinue operations. Undue crowding may also mash the queen. If bees crawl on the hands, they may be gently brushed off or thrown off.

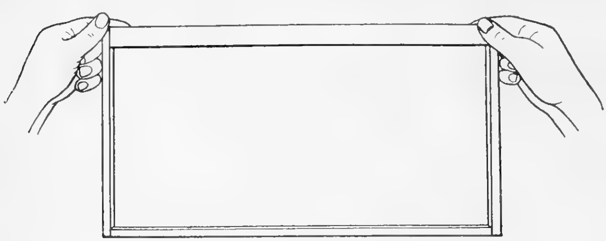

Fig. 11.—Handling the frame: First position.

In examining a frame always hold it over the hive, so that any bees or queen which fall may drop into it. Freshly gathered honey also often drops from the frame, and if it falls in the hive the bees can quickly clean it up, whereas if it drops outside it is untidy and may cause robbing. If a frame is temporarily leaned against the hive, it should be placed in a nearly upright position to prevent breakage and leaking of honey. The frame on which the queen is located should not be placed on the ground, for fear she may crawl away and be lost. It is best to lean the frame on the side of the hive away from the operator, so that bees will not crawl up the legs.

In handling frames the comb should always be held in a vertical position, especially if it contains much honey. When a frame is lifted from the hive by the top bar, one side is exposed to the operator with the comb placed vertically (fig. 11). To examine the reverse side, raise one end of the top bar until it is perpendicular (fig. 12), turn the frame on the top bar as an axis until the reverse side is in view, and then lower to a horizontal position with the top bar below (fig. 13). In this way there is no extra strain on the comb and the bees are not irritated. This care is not so necessary with wired combs, but it is a good habit to form in handling frames.

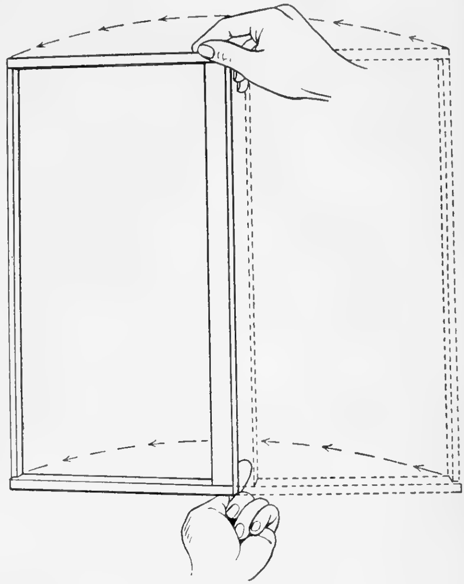

FIG. 12.—Handling the frame: Second position.

It is desirable to have combs all of worker cells to reduce the amount of drone brood. The use of full sheets of foundation will bring this about and is also of value in making the combs straight, so that bees are not mashed in removing the frame. It is extremely difficult to remove combs built crosswise in the hive, and this should never be allowed to occur. Such a hive is even worse than a plain box hive. Extra inside fixtures should be avoided, as they tend only to impede manipulation. The hive should also be placed so that the entrance is perfectly horizontal and a little lower than the back of the hive. The frames will then hang in a vertical position, and the outer ones will not be fastened to the hive body if properly spaced at the top.

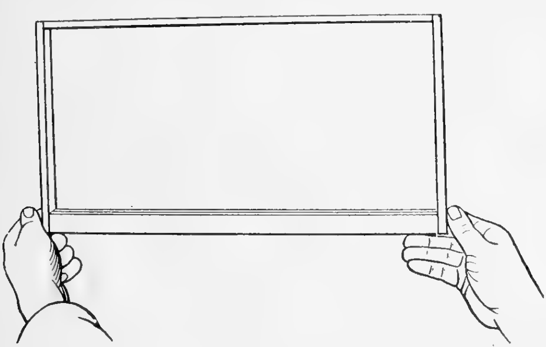

FIG. 13.—Handling the frame: Third position.

Various remedies for bee stings have been advocated, but they are all useless. The puncture made by the sting is so small that it closes when the sting is removed and liquids can not be expected to enter. The best thing to do when stung is to remove the sting as soon as possible without squeezing the poison sac, which is usually attached. This can be done by scraping it out with a knife or finger nail. After this is done the injured spot should be let alone and not rubbed with any liniment. The intense itching will soon disappear; any irritation only serves to increase the after swelling.

In placing frames in the hive great care should be exercised that they are properly spaced. Some frames are self-spacing, having projections on the side, so that when placed as close as possible they are the correct distance apart. These are good for beginners or persons who do not judge distances well and are preferred by many professional bee keepers. If unspaced frames are used, they should be $1\frac{3}{8}$ inches from center to center. A little practice will usually enable anyone to space quickly and accurately. Careful spacing is necessary to prevent the building of combs of irregular thickness and to retard the building of pieces of comb from one frame to another.

A beginner in bee keeping should by all means, if possible, visit some experienced bee keeper to get suggestions in handling bees. More can be learned in a short visit than in a considerably longer time in reading directions, and numerous short cuts which are acquired by experience will well repay the trouble or expense of such a visit. Not all professional bee keepers manipulate in the very best way, but later personal experience will correct any erroneous information. Above all, personal experimenting and a study of bee activity are absolute necessities in the practical handling of bees.

TRANSFERRING.

In increasing the apiary it is sometimes best to buy colonies in box hives on account of their smaller cost and to transfer them to hives with movable frames. This should be done as soon as possible, for box-hive colonies are of small value as producers. The best time to transfer is in the spring (during fruit bloom in the North) when the amount of honey and the population of the colony are at a minimum.

Transferring should not be delayed until spring merely because that season is best for the work. It may be done at any time during the active season, but, whenever possible, during a honey flow, to prevent robbing. If necessary, it may be done in a tent such as is often used in manipulating colonies. By choosing a time of the day when the largest number of bees are in the field the work will be lessened.

The box hive should be moved a few feet from its stand and in its place should be put a hive containing either full sheets of foundation or empty combs. The box hive should be turned upside down and a small, empty box fitted on it. By drumming continuously on the box hive for a considerable time the bees will be made to desert their combs and go to the upper box, and when most of them are clustered above the box may be carried to the new hive and the bees dumped in front of the entrance. The queen will usually be seen as the bees enter the hive, but, in case she has not left the old combs, more drumming will induce her to leave. It is necessary that the queen be in the hive before this manipulation is finished. The old box hive containing brood may now be placed right side up in a new location and in twenty-one days all of the worker brood will have emerged and probably some new queens will have been reared. These bees may then be drummed out and united with their former hive mates by smoking the colony and the drummed bees vigorously and allowing the latter to enter the hive through a perforated zinc to keep out the young queens. The wax in the box hive may then be melted up and any honey which it may contain used as the bee keeper sees fit. By this method good straight combs are obtained. If little honey is being gathered, the colony in the hive must be provided with food.

If, on the other hand, the operator desires to save the combs of the box hive, the bees may be drummed into a box and the brood combs and other fairly good combs cut to fit frames and tied in place or held with rubber bands, strings, or strips of wood until the bees can repair the damage and fill up the breaks. These frames can then be hung in a hive on the old stand and the bees allowed to go in. The cutting of combs containing brood with more or less bees on them is a disagreeable job and, since the combs so obtained are usually of little value in an apiary, the first method is recommended.

Colonies often take up their abode in walls of houses and it is often necessary to remove them to prevent damage from melting combs. If the cavity in which the combs are built can be reached, the method of procedure is like that of transferring, except that drumming is impractical and the bees must simply be subdued with smoke and the combs cut out with the bees on them.

Another method which is often better is to place a bee escape over the entrance to the cavity, so that the bees can come out, but can not return. A cone of wire cloth about 8 inches high with a hole at the apex just large enough for one bee to pass will serve as a bee escape, or a regular bee escape such as are sold by dealers may be used. A hive which they can enter is then placed beside the entrance. The queen is not obtained in this way and, of course, goes right on laying eggs, but as the colony is rapidly reduced in size the amount of brood decreases. As brood emerges, the younger bees leave the cavity and join the bees in the hive, until finally the queen is left practically alone. A new queen should be given to the bees in the hive as soon as possible, and in a short time they are fully established in their new quarters. After about four weeks, when all or nearly all of the brood in the cavity has emerged, the bee escape should be removed and as large a hole made at the entrance of the cavity as possible. The bees will then go in and rob out the honey and carry it to the hive, leaving only empty combs. The empty combs will probably do no damage, as moths usually soon destroy them and they may be left in the cavity and the old entrance carefully closed to prevent another swarm from taking up quarters there.

In transferring bees from a hollow tree the method will depend on the accessibility of the cavity. Usually it is difficult to drum out the bees and the combs can be cut out after subduing the colony with smoke.

UNITING.

Frequently colonies become queenless when it is not practicable to give them a new queen, and the best practice under such conditions is to unite the queenless bees to a normal colony. If any colonies are weak in the fall, even if they have a queen, safe wintering is better insured if two or more weak colonies are united, keeping the best queen. Under various other conditions which may arise the bee keeper may find it desirable to unite bees from different colonies. Some fundamental facts in bee behavior must be thoroughly understood to make this a success.

Every colony of bees has a distinctive colony odor and by this means bees recognize the entering of their hive by bees from other colonies and usually resent it. If, however, a bee comes heavily laden from the field and flies directly into the wrong hive without hesitation it is rarely molested. In uniting colonies, the separate colony odors must be hidden, and this is done by smoking each colony vigorously. It may at times be desirable to use tobacco smoke, which not only covers the colony odor but stupefies the bees somewhat. Care should be taken not to use too much tobacco, as it will completely overcome the bees. The queen to be saved should be caged for a day or two to prevent the strange bees from killing her in the first excitement.

Another fact which must be considered is that the bees of a colony carefully mark the location of their own hive and remember that location for some time after they are removed. If, therefore, two colonies in the apiary which are not close together are to be united, they should be moved gradually nearer, not more than a foot at a time, until they are side by side, so that the bees will not return to their original locations and be lost. As the hives are moved gradually the slight changes are noted and no such loss occurs. As a further precaution, a board should be placed in front of the entrance in a slanting position, or brush and weeds may be thrown down so that when the bees fly out they recognize the fact that there has been a change and accustom themselves to the new place. If uniting can be done during a honey flow, there is less danger of loss of bees by fighting, or if done in cool weather, when the bees are not actively rearing brood, the colony odors are diminished and the danger is reduced.

It is an easy matter to unite two or more weak swarms to make one strong one, for during swarming the bees have lost their memory of the old location, are full of honey, and are easily placed wherever the bee keeper wishes. They may simply be thrown together in front of a hive. Swarms may also be given to a newly established colony with little difficulty.

PREVENTING ROBBING IN THE APIARY.

When there is no honey flow bees are inclined to rob other colonies, and every precaution must be taken to prevent this. Feeding often attracts other bees, and, if there are indications of robbing, the sirup or honey should be given late in the day. As soon as robbing begins, manipulation of colonies should be discontinued, the hives closed, and, if necessary, the entrances contracted as far as the weather will permit. If brush is thrown in front of the entrance, robbers are less likely to attempt entering. At all times honey which has been removed from the hives should be kept where no bees can get at it, so as not to incite robbing.

FEEDING.

During spring manipulations, in preparing bees for winter, and at other times it may be necessary to feed bees for stimulation or to provide stores. *Honey from an unknown source should never be used*, for fear of introducing disease, and sirup made of granulated sugar is cheapest and best for this purpose. The cheaper grades of sugar or molasses should never be used for winter stores. The proportion of sugar to water depends on the season and the purpose of the feeding. For stimulation a proportion of one-fourth to one-third sugar by volume is enough, and for fall feeding, especially if rather late, a solution containing as much sugar as it will hold when cold is best. There seems to be little advantage in boiling the sirup. Tartaric acid in small quantity may be added for the purpose of changing part of the cane sugar to invert sugar, thus retarding granulation. The medication of sirup as a preventive or cure of brood disease is often practiced, but it has not been shown that such a procedure is of any value. If honey is fed, it should be diluted somewhat, the amount of dilution depending on the season. If robbing is likely to occur, feeding should be done in the evening.

Numerous feeders are on the market, adapted for different purposes and methods of manipulation (figs. 14, 15, 16). A simple feeder can be made of a tin pan filled with excelsior or shavings (fig. 17). This is filled with sirup and placed on top of the frames in a super or hive body. It is advisable to lean pieces of wood on the pan as runways for the bees, and to attract them first to the sirup, either by mixing in a little honey or by spilling a little sirup over the frames and sticks.

It may be stated positively that it does not pay financially, or in any other way, to feed sugar sirup to be stored in sections and sold as comb honey. Of course, such things have been tried, but the consumption of sugar during the storing makes the cost greater than the value of pure floral honey.

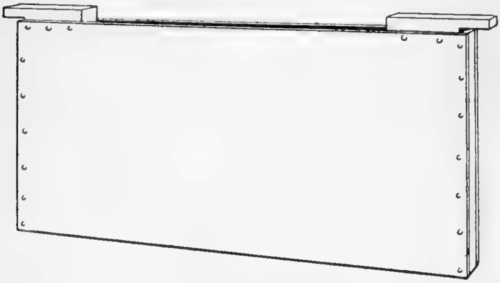

FIG. 14.—Division-board feeder to be hung in hive in place of frame.

SPRING MANAGEMENT.

The condition of a colony of bees in the early spring depends largely on care in the preceding autumn and in the method of wintering. If the colony has wintered well and has a good prolific queen, preferably young, the chances are that it will become strong in time to store a good surplus when the honey flow comes.

The bees which come through the winter, reared the previous autumn, are old and incapable of much work. As the season opens they go out to collect the early nectar and pollen, and also care for the brood which hatches from the eggs laid by the queen. The amount of brood is at first small, and as the new workers emerge they assist in the brood rearing so that the extent of the brood can be gradually increased until it reaches the maximum at the beginning of the summer. The old bees die off rapidly.

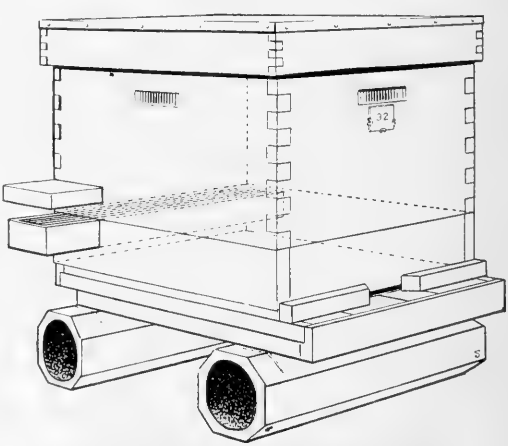

FIG. 15.—Feeder set in collar under hive body.

If brood rearing does not continue late in the fall, so that the colony goes into winter with a large percentage of young bees, the old bees may die off in the spring faster than they are replaced by emerging brood. This is known as "spring dwindling." A remedy for this may be applied by feeding, if necessary, the autumn before, or keeping up brood rearing by some other means as late as possible.

If spring dwindling begins, however, it can be diminished somewhat by keeping the colony warm and by stimulative feeding, so that all the energy of the old bees may be put to the best advantage in rearing brood to replace those dying off. The size of the brood chamber can also be reduced to conserve heat.

It sometimes happens that when a hive is examined in the spring the hive body and combs are spotted with brownish yellow excrement. This is an evidence of what is commonly called "dysentery." The cause of this trouble is long-continued confinement with a poor quality of honey for food. Honey-dew honey and some of the inferior floral honeys contain a relatively large percentage of material which bees can not digest, and, if they are not able to fly for some time, the intestines become clogged with fæcal matter and a diseased condition results. Bees never normally deposit their fæces in the hive. The obvious preventive for this is to provide the colony with good honey or sugar sirup the previous fall. "Dysentery" frequently entirely destroys colonies, but if the bees can pull through until warm days permit a cleansing flight they recover promptly.

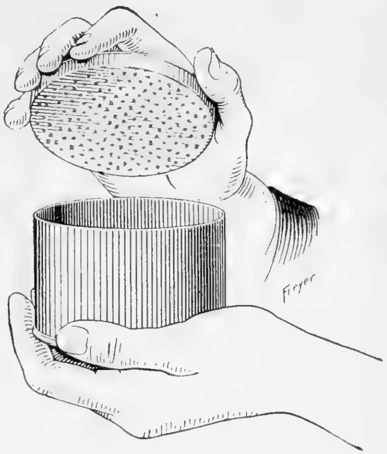

Fig. 16.—"Pepper-box" feeder for use on top of frames.

Bees should not be handled in the early spring any more than necessary, for to open a hive in cool weather wastes heat and may even kill the brood by chilling. The hive should be kept as warm as possible in early spring as an aid to brood rearing. It is a good practice to wrap hives in *black* tar paper in the spring, not only that it may aid in conserving the heat of the colony, but in holding the sun's heat rays as a help to the warmth of the hive. This wrapping should be put on as soon as an early examination has shown the colony to be in good condition, and there need be no hurry in taking it off. A black wrapping during the winter is not desirable, as it might induce brood rearing too early and waste the strength of the bees.

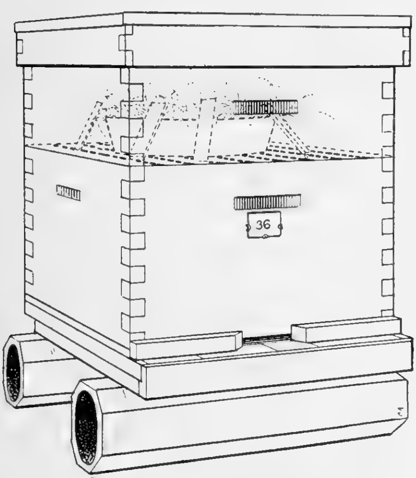

Fig. 17.—Pan in super arranged for feeding.

As a further stimulus to brood rearing, many bee keepers practice stimulative feeding of sugar sirup in early spring. This produces the same effect as a light honey flow does and the results are good. Others prefer to give the bees such a large supply of stores in the fall that when spring comes they will have an abundance for brood rearing, and it will not be necessary to disturb them in cool weather. Both ideas are good, but judicious stimulative feeding usually more than pays for the labor. Colonies should be fed late in the day, so that the bees will not fly as a result of it, and so that robbing will not be started. When the weather is warmer and more settled, the brood cluster may be artificially enlarged by spreading the frames so as to insert an empty comb in the middle. The bees will attempt to cover all the brood that they already had, and the queen will at once begin laying in the newly inserted comb, thus making a great increase in the brood. This practice is desirable when carefully done, but may lead to serious results if too much new brood is produced. A beginner had better leave the quantity of brood to the bees.

It is desirable early in the season, before any preparations are made for swarming, to go through the apiary and clip one wing of each queen so that if a swarm issues the queen can not fly and the bees can be easily returned to the old stand. This should be done before the hive becomes too populous. It is perhaps best to clip queens as they are introduced, but some colonies may rear new ones without the knowledge of the owner, and a spring examination will insure no escaping swarms.

Queens sometimes die during the winter and early spring, and since there is no brood from which the bees can replace them, the queenless colonies are "hopelessly queenless." Such colonies are usually restless and are not active in pollen gathering. If, on opening a colony, it is found to be without a queen and reduced in numbers, it should be united with another colony by smoking both vigorously and caging the queen in the queen-right colony for a day or two to prevent her being killed. A frame or two of brood may be added to a queenless colony, not only to increase its strength, but to provide young brood from which they can rear a queen. Bee keepers in the North can frequently buy queens from southern breeders early in the spring, and naturally this is better than leaving the colony without a queen until the bees can rear one, as it is important that there be no stoppage in brood rearing at this season.

SWARM MANAGEMENT AND INCREASE.

The excessive rearing of brood at the wrong season or increase in the number of colonies greatly reduces the surplus honey crop by consumption. The ideal to which all progressive bee keepers work, when operating simply for honey, is to stimulate brood rearing to prepare bees for gathering, to retard breeding when it is less desirable, and to prevent swarming. Formerly the measure of success in bee keeping was the amount of increase by swarming, but this is now recognized as being quite the contrary of success.

The stimulation of brood rearing in the spring, however, makes it more likely that swarming will occur; so that the operator must counteract that tendency. This is especially true in comb-honey production. Very few succeed in entirely preventing swarming, but by various methods the situation can be largely controlled.

When a swarm issues, it usually first settles on a limb of a tree or bush near the apiary. It was formerly common to make a noise by beating pans or ringing bells in the belief that this causes the swarm to settle. There is no foundation for such action on the part of the bee keeper. If the bees light on a small limb that can be spared, it may simply be sawed off and the bees carried to the hive and thrown on a sheet or hive cover in front of the entrance. If the limb can not be cut, the swarm can be shaken off into a box or basket on a pole and hived. If the bees light on the trunk of a tree or in some inaccessible place, they can first be attracted away by a comb, preferably containing unsealed brood. In these manipulations it is not necessary to get all the bees, but if the queen is not with those which are put in the hive the bees will go into the air again and join the cluster.

If a queen is clipped as recommended under "Spring management" (p. 24) the swarm will issue just the same, but the queen, not being able to fly, will simply wander about on the ground in front of the hive, where she can be caught and caged. The parent colony can then be removed to a new stand and a new hive put in its place. The bees will soon return and the queen can be freed among them as they enter. The field bees on returning will enter the new hive with the swarm, thus decreasing still more the parent colony and making a second swarm less probable. To make sure of this, however, all queen cells except one good one can be removed soon after the swarm issues. To hold a swarm it is desirable to put one frame containing unsealed brood in the new hive. The other frames may contain full sheets or starters of foundation or drawn combs. Usually comb-honey supers or surplus bodies for extracting frames will have been put on before swarming occurs. These are given to the swarm on the old stand and separated from the brood chamber by queen-excluding perforated zinc.

When clipping the queen's wing is not practiced, swarms may be prevented from leaving by the use of queen traps of perforated zinc (fig. 6). These allow the workers to pass out, but not drones or queens, which, on leaving the entrance, pass up to an upper compartment from which they can not return. These are also used for keeping undesirable drones from escaping, and the drones die of starvation. When a swarm issues from a hive provided with a queen trap, the queen goes to the upper compartment and remains there until released by the bee keeper. The workers soon return to the hive. When the operator discovers the queen outside, the colony may be artificially swarmed to prevent another attempt at natural swarming. A queen trap should not be kept on the hive all the time for fear the old queen may be superseded and the young queen prevented from flying out to mate.

ARTIFICIAL SWARMING.

If increase is desired, it is better to practice some method of artificial swarming and to forestall natural swarming rather than be compelled to await the whims of the colonies. The situation should be under the control of the bee keeper as much as possible. The bees, combs, and brood may be divided into two nearly equal parts and a queen provided for the queenless portion; or small colonies, called nuclei, may be made from the parent colony, so reducing its strength that swarming is not attempted. These plans are not as satisfactory as shaken swarms, since divided colonies lack the vigor of swarms.

A good method of artificially swarming a colony is to shake most of the bees from the combs into a new hive on the old stand with starters (narrow strips) of foundation. The hive containing the brood with some bees still adhering is then moved to a new location. If receptacles for surplus honey have been put on previously, as they generally should be, they should now be put over the artificial swarm separated from the brood compartment by perforated zinc.

This method of artificially swarming (usually called by bee keepers "shook" swarming) should not be practiced too early, since natural swarming may take place later. The colony should first have begun its preparations for swarming. The method is particularly useful in comb-honey production. The bees may be prevented from leaving the hive by the use of a drone trap (fig. 6) or by putting in one frame containing unsealed brood. Some bee keepers prefer using full sheets of foundation or even drawn combs for the artificial swarm, but narrow strips of foundation have some advantages. By using narrow strips the queen has no cells in which to lay eggs for a time, thus reducing brood rearing, but, since by the time artificial swarming is practiced the profitable brood rearing is over, this is no loss but rather a gain. There are also in the brood compartment no cells in which the gathering workers can deposit fresh honey, and they consequently put it above in the supers. Gradually the combs below are built out and brood rearing is increased. Later the colony is allowed to put honey in the brood combs for its winter supply. If no increase is desired, the bees which emerge from the removed brood combs may later be united with the artificial swarm and by that time there will usually be little danger of natural swarming.

PREVENTION OF SWARMING.

Unless increase is particularly desired, both natural and artificial swarming should be done away with as far as possible, so that the energy of the bees shall go into the gathering of honey. Since crowded and overheated hives are particularly conducive to swarming, this tendency may be largely overcome by giving plenty of ventilation and additional room in the hive. Shade is also a good preventive of swarming. Extra space in the hive may be furnished by adding more hive bodies and frames or by frequent extracting, so that there may be plenty of room for brood rearing and storage at all times. These manipulations are, of course, particularly applicable to extracted-honey production.

To curb the swarming impulse frequent examinations of the colonies (about every week or ten days during the swarming season) for the purpose of cutting out queen cells is a help, but this requires considerable work, and since some cells may be overlooked, and particularly since it frequently fails in spite of the greatest care, it is not usually practiced. Requeening with young queens early in the season, when possible, generally prevents swarming.

Swarming is largely due to crowded brood chambers, and since eggs laid immediately before and during the honey flow do not produce gatherers, several methods have been tried of reducing the brood. The queen may either be entirely removed or be caged in the hive to prevent her from laying. In either event the bees will usually build queen cells to replace her, and these must be kept cut out. These plans would answer the purpose very well were it not for the fact that queenless colonies often do not work vigorously. Under most circumstances these methods can not be recommended. A better method is to remove brood about swarming time and thus reduce the amount. There are generally colonies in the apiary to which frames of brood can be given to advantage.

In addition to these methods various nonswarming devices have been invented, and later a nonswarming hive so constructed that there is no opportunity for the bees to form a dense cluster. The breeding of bees by selecting colonies with less tendency to swarm has been suggested, but nothing has been accomplished along that line.

On the whole, the best methods are the giving of plenty of room, shade, and ventilation to colonies run for extracted honey; and ventilation, shade, and artificial swarming of colonies run for comb honey. Frequent requeening (about once in two years) is desirable for other reasons, and requeening before swarming time helps in the solution of that difficulty.

PREPARATION FOR THE HARVEST.

An essential in honey production is to have the hive overflowing with bees at the beginning of the honey flow, so that the field force will be large enough to gather more honey than the bees need for their own use. To accomplish this, the bee keeper must see to it that brood rearing is heavy some time before the harvest, and he must know accurately when the honey flows come, so that he may time his manipulations properly. Brood rearing during the honey flow usually produces bees which consume stores, while brood reared before the flow furnishes the surplus gatherers. The best methods of procedure may be illustrated by giving as an example the conditions in the white-clover region.

In the spring the bees gather pollen and nectar from various early flowers, and often a considerable quantity from fruit bloom and dandelions. During this time brood rearing is stimulated by the new honey, but afterwards there is usually a period of drought when brood rearing is normally diminished or not still more increased as it should be. This condition continues until the white-clover flow comes on, usually with a rush, when brood rearing is again augmented. If such a condition exists, the bee keeper should keep brood rearing at a maximum by stimulative feeding during the drought. When white clover comes in bloom he may even find it desirable to prevent brood rearing to turn the attention of his bees to gathering.

A worker bee emerges from its cell twenty-one days after the egg is laid, and it usually begins field work in from fourteen to seventeen days later. It is evident, therefore, that an egg must be laid five weeks before the honey flow to produce a gatherer. Since the flow continues for some time and since bees often go to the field earlier than fourteen days, egg laying should be pushed up to within two or three weeks of the opening of the honey flow. In addition to stimulative feeding, the care of the colony described under the heading of "Spring management" (p. 24) will increase brood production.

THE PRODUCTION OF HONEY.

The obtaining of honey from bees is generally the primary object of their culture. Bees gather nectar to make into honey for their own use as food, but generally store more than they need, and this surplus the bee keeper takes away. By managing colonies early in the spring as previously described, the surplus may be considerably increased. The secret of maximum crops is to "Keep all colonies strong."

Honey is gathered in the form of nectar secreted by various flowers, transformed by the bees, and stored in the comb. Bees also often gather a sweet liquid called "honeydew," produced by various scale insects and plant-lice, but the honeydew honey made from it is quite unlike floral honey and should not be sold for honey. It is usually unpalatable and should never be used as winter food for bees. When nectar or honeydew has been thickened by evaporation and otherwise changed, the honey is sealed in the cells with cappings of beeswax.

It is not profitable to cultivate any plant solely for the nectar which it will produce, but various plants, such as clovers, alfalfa, and buckwheat are excellent honey plants as well as valuable for other purposes; their cultivation is therefore a benefit to the bee keeper. It is often profitable to sow some plant on waste land; sweet clovers are often used in this way. The majority of honey-producing plants are wild, and the bee keeper must largely accept the locality as he finds it and manage his apiary so as to get the largest possible amount of the available nectar. Since bees often fly as far as 2 or 3 miles to obtain nectar, it is obvious that the bee keeper can rarely influence the nectar supply appreciably.

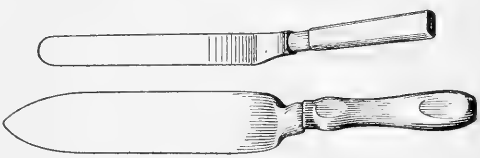

FIG. 18.—Knives for uncapping honey.

EXTRACTED HONEY.

Extracted honey is honey which has been removed by means of centrifugal force from the combs in which the bees stored it. In providing combs for the storage of honey to be extracted, the usual practice is to add to the top of the brood chamber one or more hive bodies just like the one in which brood is reared and fill these with frames. If preferred, shallower frames with bodies of proper size may be used, but most honey extractors are made for full-size frames. The surplus bodies should be put on in plenty of time to prevent the crowding of the brood chamber, and also to act as a preventive of swarming.

Honey for extracting should not be removed until it is well ripened and a large percentage of it capped. It is best, however, to remove the crop from each honey flow before another heavy producing plant comes into bloom, so that the different grades of honey may be kept separate.

The frames containing honey to be extracted are removed from the hive, the cappings cut off with a sharp, warm knife (fig. 18) made specially for this purpose, and the frames are then put into the baskets of the honey extractor (fig. 19). By revolving these rapidly the honey is thrown out of one side. The basket is then reversed and the honey from the other side is removed. The combs can then be returned to the bees to be refilled, or if the honey flow is over, they can be returned to the bees to be cleaned and then removed and stored until needed again. This method is much to be preferred to mashing the comb and straining out the honey, as was formerly done.

The extracted honey is then strained and run into vessels. It is advisable not to put it in bottles at once, but to let it settle in open vessels for a time, so that it can be skimmed. Most honeys will granulate and become quite hard if exposed to changes of temperature, and to liquefy granulated extracted honey it should be heated in a water bath. Never heat honey directly over a stove or flame, as the flavor is thereby injured. The honey should never be heated higher than 160° F. unless it is necessary to sterilize it because of contamination of disease.

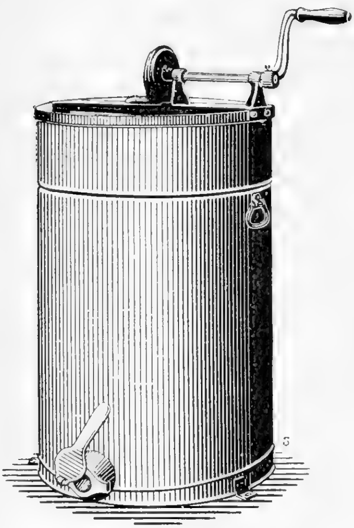

FIG. 19.—Honey extractor.

Extracted honey is put up in bottles or small tin cans for the retail trade, and in 5-gallon square tin cans or barrels for the wholesale market. Great care must be exercised if barrels are used, as honey will absorb moisture from the wood, if any is present, and cause leakage. The tin package is much to be preferred in most cases. In bottling honey for retail trade, it will well repay the bee keeper or bottler to go to considerable expense and trouble to make an attractive package, as the increased price obtained will more than make it up. Honey should be heated to 160° F. and kept there for a time before bottling, and the bottle should be filled as full as possible and sealed hermetically.[a]

COMB HONEY.

Comb honey is honey as stored in the comb by the bees, the size and shape being determined by the small wooden sections provided by the bee keeper. Instead of having comb in large frames in which to store surplus honey, the bees are compelled to build comb in the sections and to store honey there (fig. 2). A full section weighs about 1 pound; larger ones are rarely used. By the use of modern sections and foundation the comb honey now produced is a truly beautiful, very uni-

[a] For further discussion of the production and care of extracted honey, see Bulletin 75, Part I, Bureau of Entomology. It may be obtained from the Superintendent of Documents, Washington, D. C. Price 5c.

form product—so uniform in fact that it is often charged that it must be artificially manufactured. The purchaser of a section of comb honey may be absolutely certain, however, that he is obtaining a product of the bees, for never has anyone been able to imitate their work successfully. To show their confidence in the purity of comb honey, the National Bee Keepers' Association offers $1,000 for a single pound of artificial comb filled with an artificially prepared sirup.

There are several different styles of sections now in use, the usual sizes being $4\frac{1}{4}$ inches square and 4 inches by 5 inches. There are also two methods of spacing, so that there will be room for the passage of bees from the brood chamber into the sections and from one super of sections to another. This is done either by cutting "bee ways" in the sides of the sections and using plain flat separators or by using "no bee-way" or plain sections and using "fences"—separators with cleats fastened on each side, to provide the bee space. To describe all the different "supers" or bodies for holding sections would be impossible in a bulletin of this size, and the reader must be referred to catalogues of dealers in bee-keeping supplies. Instead of using regular comb-honey supers, some bee keepers use wide frames to hold two tiers of sections. It is better, however, to have the supers smaller, so that the bees may be crowded more to produce full sections. To overcome this difficulty, shallow wide frames holding one tier of sections may be used. The majority of bee keepers find it advisable to use special comb-honey supers.

In producing comb honey it is even more necessary to know the plants which produce surplus honey and just when they come in bloom than it is in extracted honey production. The colony should be so manipulated that the maximum field force is ready for the beginning of the flow. This requires care in spring management, and above all the prevention of swarming. Supers should be put on just before the heavy flow begins. A good indication of the need of supers is the whitening of the brood combs at the top. If the bees are in two-hive bodies they should generally be reduced to one, and the frames should be filled with brood and honey so that as the new crop comes in the bees will carry it immediately to the sections. If large hives are used for the brood chamber it is often advisable to remove some of the frames and use a division board to crowd the bees above. To prevent the queen from going into the sections to lay, a sheet of perforated zinc (fig. 20) may be put between the brood chamber and the super (fig. 2).

It is often difficult to get bees to begin work in the small sections, but this should be brought about as soon as possible to prevent loss of honey. If there are at hand some sections which have been partly drawn the previous year, these may be put in the super with the new sections as "bait." Another good plan is to put a shallow extracting frame on either side of the sections. If a few colonies in the apiary that are strong enough to go above still refuse, lift supers from some colonies that have started to work above and give them to the slow colonies. The super should generally be shaded somewhat to keep it from getting too hot. Artificial swarming will quickly force bees into the supers.

To produce the finest quality of comb honey full sheets of foundation should be used in the sections. Some bee keepers use nearly a full sheet hung from the top of the section and a narrow bottom starter. The use of foundation of worker-cell size is much preferred.

When one super becomes half full or more and there are indications that there will be honey enough to fill others, the first one should be raised and an empty one put on the hive under it. This tiering up can be continued as long as necessary, but it is advisable to remove filled sections as soon as possible after they are nicely capped, for they soon become discolored and less attractive. Honey removed immediately after capping finds a better market, but if left on the hive even until the end of the summer the quality of the honey is improved. A careful watch must be kept on the honey flow, so as to give the bees only enough sections to store the crop. If this is not done a lot of unfinished sections will be left at the end of the flow. Honeys from different sources should never be mixed in the sections, as it gives the comb a bad appearance.

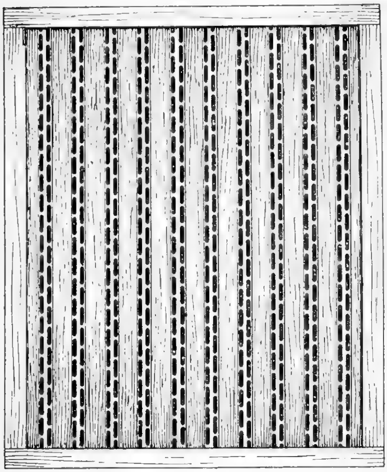

FIG. 20.—Perforated zinc queen excluder.

To remove bees from sections, the super may be put over a bee escape so that the bees can pass down but can not return, or the supers may be removed and covered with a wire-cloth-cone bee escape.

After sections are removed the wood should be scraped free of propolis (bee glue) and then packed in shipping cases (fig. 21) for the market. Shipping cases to hold 12, 24, or 48 sections, in which the various styles of sections fit exactly, are manufactured by dealers in supplies. In shipping these cases, several of them should be put in a box or crate packed in straw and paper and handles provided to reduce the chances of breakage. When loaded in a freight car the combs should be parallel with the length of the car.

In preparing comb honey for market it should be carefully graded, so that the sections in each shipping case are as uniform as possible. Nothing will more likely cause wholesale purchasers to cut the price than to find the first row of sections in a case fancy and those behind of inferior grade. Grading rules have been adopted by various bee keepers' associations or drawn up by honey dealers. The following sets of rules are in general use:

Eastern Grading Rules for Comb Honey.

Fancy.—All sections well filled; combs straight; firmly attached to all four sides; the combs unsoiled by travel, stain, or otherwise; all the cells sealed except an occasional one; the outside surface of the wood well scraped of propolis.

A No. 1.—All sections well filled except the row of cells next to the wood; combs straight; one-eighth part of comb surface soiled, or the entire surface slightly soiled; the outside surface of the wood well scraped of propolis.

No. 1.—All sections well filled except the row of cells next to the wood; combs comparatively even; one-eighth part of comb surface soiled, or the entire surface slightly soiled.

No. 2.—Three-fourths of the total surface must be filled and sealed.

No. 3.—Must weigh at least half as much as a full-weight section.

In addition to this the honey is to be classified according to color, using the terms white, amber, and dark; that is, there will be "Fancy White," "No. 1 Dark," etc.

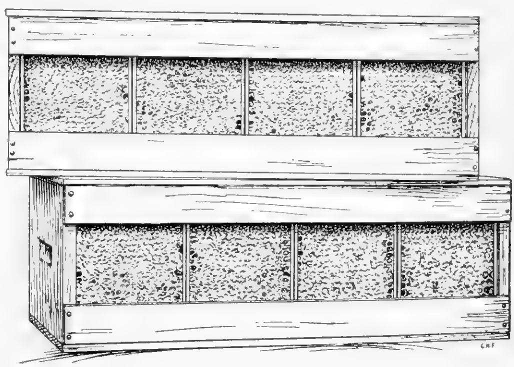

Fig. 21.—Shipping cases for comb honey.

New Comb-Honey Grading Rules Adopted by the Colorado State Bee Keepers' Association.

No. 1 White.—Sections to be well filled and evenly capped, except the outside row, next to the wood; honey white or slightly amber, comb and cappings white, and not projecting beyond the wood; wood to be well cleaned; cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections

No. 1 Light Amber.—Sections to be well filled and evenly capped, except the outside row, next to the wood; honey white or light amber; comb and cappings from white to off color, but not dark; comb not projecting beyond the wood; wood to be well cleaned. Cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections.

No. 2.—This includes all white honey, and amber honey not included in the above grades; sections to be fairly well filled and capped, no more than 25 uncapped cells, exclusive of outside row, permitted in this grade; wood to be well cleaned; no section in this grade to weigh less than 12 ounces. Cases of separatored honey to average not less than 19 pounds net. Cases of half-separatored honey to average not less than 20 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 21 pounds net per case of 24 sections.

THE PRODUCTION OF WAX.

Beeswax, which is secreted by the bees and used by them for building their combs, is an important commercial product. There are times in almost every apiary when there are combs to be melted up, and it pays to take care of even scraps of comb and the cappings taken off in extracting. A common method of taking out the wax is to melt the combs in a solar wax extractor. This is perhaps the most feasible method where little wax is produced, but considerable wax still remains in old brood combs after such heating. Various wax presses are on the market, or one can be made at home. If much wax is produced, the bee keeper should make a careful study of the methods of wax extraction, as there is usually much wax wasted even after pressing.

PREPARATIONS FOR WINTERING.

After the main honey flow is over the management must depend on what may be expected later in the season from minor honey flows. If no crop is to be expected, the colony may well be kept only moderately strong, so that there will not be so many consumers in the hive.

In localities where winters are severe and breeding is suspended for several months great care should be taken that brood-rearing is rather active during the late summer, so that the colony may go into winter with plenty of young bees. In case any queens show lack of vitality they should be replaced early, so that the bees will not become queenless during the winter.

The important considerations in wintering are plenty of young bees, a good queen, plenty of stores of good quality, sound hives, and proper protection from cold and dampness.

If, as cold weather approaches, the bees do not have stores enough, they must be fed. Every colony should have from 25 to 50 pounds, depending on the length of winter and the methods of wintering. It is better to have too much honey than not enough, for what is left is good next season. If feeding is practiced, honey may be used, but sirup made of granulated sugar is just as good and is perfectly safe. If honey is purchased for feeding, great care should be taken that it comes from a healthy apiary, otherwise the apiary may be ruined by disease. *Never feed honey bought on the open market.* The bees should be provided with stores early enough so that it will not be necessary to feed or to open the colonies after cold weather comes on. Honeydew honey should not be left in the hives, as it produces "dysentery." Some honeys are also not ideal for winter stores. Those which show a high percentage of gums (most tree honeys) are not so desirable, but will usually cause no trouble.

In wintering out of doors the amount of protection depends on the severity of the winter. In the South no packing is necessary, and even in very cold climates good colonies with plenty of stores can often pass the winter with little protection, but packing and protection make it necessary for the bees to generate less heat, and consequently they consume less stores and their vitality is not reduced. Dampness is probably harder for bees to withstand than cold, and when it is considered that bees give off considerable moisture, precautions should be taken that as it condenses it does not get on the cluster. An opening at the top would allow the moisture to pass out, but it would also waste heat, so it is better to put a mat of burlap or other absorbent material on top of the frames. The hive may also be packed in chaff, leaves, or other similar dry material to keep out the cold. Some hives are made with double walls, the space being filled with chaff; these are good for outdoor wintering. The hive entrance should be lower than any other part of the hive, so that any condensed moisture may run out. The hives should be sound and the covers tight and waterproof.

Entrances should be contracted in cold weather not only to keep out cold wind, but to prevent mice from entering. There should always be enough room, however, for bees to pass in and out if warmer weather permits a flight.

In the hands of experienced bee keepers cellar wintering is very successful, but this method requires careful study. The cellar must be dry and so protected that the temperature never varies more than from 40 to 45° F.; 43° F. seems to be the optimum temperature. The ventilation must be good or the bees become fretful. Light should not be admitted to the cellar, and consequently some means of indirect ventilation is necessary.

Cellar wintering requires the consumption of less honey to maintain the proper temperature in the cluster and is therefore economical. Bees so wintered do not have an opportunity for a cleansing flight, often for several months, but the low consumption makes this less necessary. Some bee keepers advocate carrying the colonies out a few times on warm days, but it is not fully established whether this is entirely beneficial and is usually not practiced.

The time for putting colonies in the cellar is a point of dispute, and practice in this regard varies considerably. They should certainly be put in before the weather becomes severe and as soon as they have ceased brood rearing. The time chosen may be at night when they are all in the hive, or on some chilly day.

The hives may be piled one on top of the other, the lower tier raised a little from the floor. The entrances should not be contracted unless the colony is comparatively weak. It is usually not considered good policy to close the entrances with wire cloth, as the dead bees which accumulate more or less on the bottom board may cut off ventilation, and the entrance should be free so that these may be cleaned out.

The time of removing bees from the cellar is less easily determined than that of putting them in. The colonies may be removed early and wrapped in *black* tar paper or left until the weather is settled. If the weather is very warm and the bees become fretful, the cellar must either be cooled or the bees removed. Some bee keepers prefer to remove bees at night, so that they can recover from the excitement and fly from the hive normally in the morning. One of the chief difficulties is to prevent the bees from getting into the wrong hives after their first flights. They often "drift" badly with the wind, and sometimes an outside row will become abnormally strong, leaving other colonies weak.

DISEASES AND ENEMIES.

There are two infectious diseases of the brood of bees which cause great losses to the bee-keeping industry of the United States. These are known as American foul brood and European foul brood. Both of these diseases destroy colonies by killing the brood, so that there are not enough young bees emerging to take the place of the old adult bees as these die from natural causes. The adult bees are not attacked by either disease. In the hands of careful bee keepers both diseases may be controlled, and this requires careful study and constant watching. In view of the fact that these diseases are now widely distributed throughout the United States, every bee keeper should read the available literature on the subject, so that if disease enters his apiary he may be able to recognize it before it gets a start. The symptoms and the treatment recommended by this Department are given in another publication which will be sent free on request.[a]

It is difficult for a bee keeper to keep his apiary free from disease if others about him have diseased colonies which are not properly treated. The only way to keep disease under control is for the bee keepers in the neighborhood to cooperate in doing everything possible to stamp out disease as soon as it appears in a single colony. The progressive bee keeper who learns of disease in his neighborhood should see to it that the other bee keepers around him are supplied

[a] Circular 79, Bureau of Entomology, U. S. Dept. of Agriculture. The Brood Diseases of Bees.

with literature describing symptoms and treatment, and should also try to induce them to unite in eradicating the malady. Since it is so often impossible to get all of the bee keepers in a community to treat infected colonies properly and promptly, it is desirable that the States pass laws providing for the inspection of apiaries and granting to the inspector the power to compel negligent bee keepers to treat diseased colonies so that the property of others may not be endangered and destroyed. This has been done in a number of States, but there are still some where the need is great and in which no such provision has been made. When no inspection is provided, bee keepers should unite in asking for such protection, so that the danger to the industry may be lessened.

In case there is an inspector for the State or county, he should be notified as soon as disease is suspected in the neighborhood. Some bee keepers hesitate to report disease through fear that the inspector will destroy their bees or because they feel that it is a disgrace to have disease in the apiary. There is no disgrace in having colonies become diseased; the discredit is in not treating them promptly. The inspectors are usually, if not universally, good practical bee keepers who from a wide experience are able to tell what should be done in individual cases to give the best results with the least cost in material and labor. They do not destroy colonies needlessly, and, in fact, they all advocate and teach treatment.

The brood diseases are frequently introduced into a locality by the shipping in of diseased colonies; or, more often, the bees get honey from infected colonies which is fed to them, or which they rob, from discarded honey cans. It is decidedly dangerous to purchase honey on the market, with no knowledge of its source, to be used in feeding bees. Many outbreaks of disease can be traced to this practice (see "Feeding," p. 23). It is difficult to prevent bees from getting contaminated honey accidentally. If colonies are purchased, great care should be taken that there is no disease present. Whenever possible, colonies should be purchased near at home, unless disease is already present in the neighborhood.

There are other diseased conditions of the brood, known to bee keepers as pickled brood, but these can usually be distinguished from the two diseases previously mentioned. The so-called "pickled brood" is not contagious and no treatment is necessary. Bees also suffer from "dysentery," which is discussed in the earlier part of this bulletin, and from the so-called "paralysis," a disease of adult bees. No treatment for the latter disease can as yet be recommended as reliable. The sprinkling of powdered sulphur on the top bars of frames or at the entrance is sometimes claimed to be effective, but under what circumstances it is beneficial is unknown.

A number of insects, birds, and mammals must be classed as enemies of bees, but of these the two wax moths, and ants, are the only ones of importance. There are two species of moth, the larger wax moth (*Galleria mellonella* L.,) and the lesser wax moth (*Achroia grisella* Fab.), the larvæ of which destroy combs by burrowing through them.[a] Reports are frequently received in the Department that the larvæ of these moths (usually the larger species) are destroying colonies of bees. It may be stated positively that moths do not destroy strong healthy colonies in good hives, and if it is supposed that they are causing damage the bee keeper should carefully study his colonies to see what other trouble has weakened them enough for the moths to enter. Queenlessness, lack of stores, or some such trouble may be the condition favorable to the entrance of the pest, but a careful examination should be made of the brood to see whether there is any evidence of disease. This is the most frequent cause of the cases of moth depredation reported to this Department. Black bees are less capable of driving moth larvæ out, but, even with these bees, strong colonies rarely allow them to remain. The observance of the golden rule of bee keeping, "Keep all colonies strong," will solve the moth question unless disease appears.

Moth larvæ often destroy combs stored outside the hive. To prevent this the combs may be fumigated with sulphur fumes or bisulphid of carbon in tiers of hives or in tight rooms. If bisulphid of carbon is used, great care should be taken not to bring it near a flame, as it is highly inflammable. Combs should be stored in a dry, well-ventilated, light room.

In the warmer parts of the country ants are often a serious pest. They may enter the hive for protection against changes of temperature, or to prey on the honey stores or the brood. The usual method of keeping them out is to put the hive on a stand, the legs of which rest in vessels containing water or creosote. Another method is to wrap a tape soaked in corrosive sublimate around the bottom board.

GENERAL INFORMATION.

For the purpose of answering numerous questions which are asked of this Department the following brief topics are included.

BREEDERS OF QUEENS.

There are a large number of bee keepers who make a business of rearing queens of good stock for sale. The queens are usually sent by mail. If poor stock is all that can be obtained locally, it is recommended that such colonies be purchased and the queens removed and

[a] Bee keepers refer to these insects as "moths," "wax moths," "bee moths," "millers," "wax worms," "honey moths," "moth worms," "moth millers," and "grubs." The last six terms are not correct.

replaced with those obtained from a good breeder. This Department can supply names of breeders, nearest the applicant, of any race raised in this country.

INTRODUCING QUEENS.

When queens are shipped by mail they usually come in cages which can be used for introducing. If the colony to receive the new queen has one, she must be removed and the cage inserted between the frames. The small hole leading into the candy compartment is uncovered, and the bees gradually eat through and release the queen. If queens are reared at home, a similar cage may be used for introducing.

In view of the fact that disease may be transmitted in mailing cages, it is always a wise precaution to remove the new queen and destroy the accompanying workers and the cage and its contents. The queen may then be put into a clean cage without worker bees with candy known to be free from contamination (made from honey from healthy hives) and introduced in the regular way. Queens sold by breeders are always mated unless otherwise specified, and consequently the colony in which they are introduced has no effect on the offspring. During the active season the bees in the colony are all the offspring of the new queen in about nine weeks. Three weeks is required for the previous brood to emerge (if the colony has not been queenless), and in six weeks after all the old brood emerges most of the workers from it will have died.

DEALERS IN BEE KEEPERS' SUPPLIES.

There are several manufacturers of supplies in this country who can furnish almost anything desired by the bee keeper. Some of them have agents in various parts of the country from whom supplies may be purchased, thus saving considerable in freight.

BEE KEEPERS' ASSOCIATIONS.

There are a large number of associations of bee keepers in all parts of the country, formed for the betterment of the industry and a few associations which are organized to aid the members in purchasing supplies and in selling the crops. Of these the National Beekeepers' Association is the largest. It helps its members in obtaining their legal rights, and aids in securing legislation for the furtherance of the industry. The annual conventions are held in different parts of the country, and copies of the proceedings are sent to the members. There are also numerous state, county, and town associations, some of which publish proceedings. The names of officers of the nearest associations or of the National Beekeepers' Association will be sent on request from this Department.

LAWS AFFECTING BEE KEEPING.

Disease inspection.—Various States have passed laws providing for the state or county inspection of apiaries for bee-disease control, and every bee keeper should get in touch with an inspector when disease is suspected, if one is provided. The inspectors are practical bee keepers who fully understand how to control the diseases, and are of great help in giving directions in this matter. The name of the inspector of any locality can usually be furnished, and this department is glad to aid bee keepers in reaching the proper officers.

Laws against spraying fruit trees while in bloom.—The spraying of fruit trees while in bloom is not now advised by economic entomologists, and to prevent the practice some States have passed laws making it a misdemeanor. Such spraying not only kills off honeybees, causing a loss to the bee keeper, but interferes with the proper pollination of the blossoms and is thus a detriment to the fruit grower. Bee keepers should do everything in their power to prevent the practice.

Laws against the adulteration of honey.—The National Food and Drugs Act of 1906, and various state pure food laws, are a great aid to the bee keeper in preventing the sale of adulterated extracted honey as pure honey. Bee keepers can often aid in this work by reporting to the proper officials infringements of these laws which come to their notice.

When bees are a nuisance.—Some cities have passed ordinances prohibiting the keeping of bees in certain areas, but so far none have been able to enforce them. If bees are a nuisance in individual cases, the owner may be compelled to remove them. The National Beekeepers' Association will help any of its members in such cases, if they are in the right, as well as in cases where bees sting horses. Bee keepers should be careful not to locate bees where they can cause any trouble of this kind.

SUPPOSED INJURY OF CROPS BY BEES.

Bee keepers are often compelled to combat the idea that bees cause damage to fruit or other crops by sucking the nectar from the flower. This is not only untrue, but in many cases the bees are a great benefit in pollinating the flowers, making a good crop possible. A more frequent complaint is that bees puncture fruit and suck the juices. Bees never puncture sound fruit, but if the skin is broken by some other means bees will often suck the fruit dry. In doing it, however, they are sucking fruit which is already damaged. These and similar charges against the honeybee are prompted by a lack of information concerning their activities. Bees may, of course, become a nuisance to others through their stinging propensities, but bee keepers should not be criticised for things which their bees do not do.

JOURNALS AND BOOKS ON BEE KEEPING.

The progressive bee keeper will find it to his profit to subscribe for at least one journal devoted to bee keeping. Several of these are published in the United States. The names and addresses of such journals may usually be obtained from a subscription agent for periodicals, or from a supply dealer.

It will also be advantageous to read and study books on bee keeping, of which several are published in this country. These are advertised in journals devoted to bee keeping, or may usually be obtained through the local book dealer or through dealers in bee keepers' supplies.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE ON BEE KEEPING.[a]

There are several publications of this Department which are of interest to bee keepers, and new ones are added as fast as the different lines of investigation are completed.

The following publications relating to bee culture, prepared in the Bureau of Entomology, are for free distribution and may be obtained by addressing the Secretary of Agriculture:

Farmers' Bulletin No. 59, "Bee Keeping." By Frank Benton. 1905. 48 pp., 19 figs. Superseded by Farmers' Bulletin No. 397.

Farmers' Bulletin No. 397, "Bees." By E. F. Phillips, Ph. D. 1910. 44 pp., 21 figs. A general account of the management of bees.

Circular No. 79, "The Brood Diseases of Bees." By E. F. Phillips, Ph. D. 1906. 5 pp.

This publication gives briefly the symptoms of the various brood diseases, with directions for treatment.

Circular No. 94, "The Cause of American Foul Brood." By G. F. White, Ph. D. 1907. 4 pp.

This publication contains a brief account of the investigations which demonstrated for the first time the cause of one of the brood diseases of bees, American foul brood.

The following publications are not for free distribution, but may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at the prices indicated. All remittances should be made payable to him and not to the Department of Agriculture, and should be sent by postal money order or by New York exchange. If currency is sent it is at the sender's risk; such remittances, however, usually arrive safely. Stamps, personal checks, or foreign money will not be accepted in any case.

BUREAU OF ENTOMOLOGY.

Bulletin No. 1, "The Honey Bee." By Frank Benton. 1899. 118 pp., 76 figs., 12 plates.

[This bulletin has been discontinued owing to the fact that later investigations have shown the error of certain portions which, when the bulletin was prepared, were generally accepted as correct. The subjects treated are discussed in the various later publications of the Bureau.]

Bulletin No. 55, "The Rearing of Queen Bees." By E. F. Phillips, Ph. D. 1905. 32 pp., 17 figs. Price 5c.

A general account of the methods used in queen rearing. Several methods are given, so that the bee keeper may choose those best suited to his individual needs.

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[a] List revised to April 1, 1910. (VI.)

Bulletin No. 70, "Report of the Meeting of Inspectors of Apiaries, San Antonio, Tex., November 12, 1906." 1907. 79 pp., 1 plate. Price 15c.

Contains an account of the history of bee-disease investigations, the relationship of bacteria to bee diseases, and a discussion of treatment by various inspectors of apiaries and other practical bee keepers who are familiar with diseases of bees.

Bulletin No. 75, Part I, "Production and Care of Extracted Honey." By E. F. Phillips, Ph. D. "Methods of Honey Testing for Bee Keepers." By C. A. Browne, Ph. D. 1907. 18 pp. Price 5c.

The methods of producing extracted honey, with special reference to the care of honey after it is taken from the bees, so that its value may not be decreased by improper handling. The second portion of the publication gives some simple tests for adulteration.

Bulletin No. 75, Part II, "Wax Moths and American Foul Brood." By E. F. Phillips, Ph. D. 1907. Pp. 19–22, 3 plates. Price 5c.

An account of the behavior of the two species of wax moths on combs containing American foul brood, showing that moths do not clean up the disease-carrying scales.

Bulletin No. 75, Part III, "Bee Diseases in Massachusetts." By Burton N. Gates. 1908. Pp. 23–32, map. Price 5c.

An account of the distribution of the brood diseases of bees in the State, with brief directions for controlling them.

Bulletin No. 75, Part IV, "The Relation of the Etiology (Cause) of Bee Diseases to the Treatment." By G. F. White, Ph. D. 1908. Pp. 33–42. Price 5c.

The necessity for a knowledge of the cause of bee diseases before rational treatment is possible is pointed out. The present state of our knowledge of the causes of disease is summarized.

Bulletin No. 75, Part V, "A Brief Survey of Hawaiian Bee Keeping." By E. F. Phillips, Ph. D. 1909. Pp. 43–58, 6 plates. Price 15c.

An account of the bee-keeping methods used in a tropical country and a comparison with mainland conditions. Some new manipulations are recommended.

Bulletin No. 75, Part VI, "The Status of Apiculture in the United States." By E. F. Phillips, Ph. D. 1909. Pp. 59–80. Price 5c.

A survey of present-day bee keeping in the United States, with suggestions as to the work yet to be done before apiculture will have reached its fullest development.

Bulletin No. 75, Part VII, "Bee Keeping in Massachusetts." By Burton N. Gates. 1909. Pp. 81–109, 2 figs. Price 5c.

An account of a detailed study of the apicultural conditions in Massachusetts. The object of this paper is to find out what are the actual conditions and needs of bee keeping in New England.

Bulletin No. 75, 7 parts. A table of contents and index to the entire bulletin will be issued soon, after which the seven parts with contents and index will be published under one cover.

Technical Series, No. 14, "The Bacteria of the Apiary, with Special Reference to Bee Diseases." By G. F. White, Ph. D. 1906. 50 pp. Price 10c.

A technical study of the bacteria found under normal conditions, with special attention to those found in diseased brood.

Technical Series, No. 18, "The Anatomy of the Honey Bee." By R. E. Snodgrass. 1910. 162 pp., 57 figs. Price 20c.

An account of the structure of the bee, with technical terms omitted as far as possible. Practically all of the illustrations are new, and the various parts are interpreted according to the best usage in comparative anatomy of insects. A brief discussion of the physiology of the various organs is included.

BUREAU OF CHEMISTRY.

Bulletin No. 110, "Chemical Analysis and Composition of American Honeys." By C. A. Browne. Including "A Microscopical Study of Honey Pollen." By W. J. Young. 1908. 93 pp, 1 fig., 6 plates. Price 20c.

A very comprehensive study of the chemical composition of American honeys. This publication is technical in nature and will perhaps be little used by practical bee keepers, but it is an important contribution to apicultural literature. By means of this work the detection of honey adulteration is much aided.

Applications for the following publication may be addressed to the Secretary of Agriculture:

HAWAII AGRICULTURAL EXPERIMENTAL STATION, HONOLULU, HAWAII.

Bulletin No. 17, "Hawaiian Honeys." By D. L. Van Dine and Alice R. Thompson. 1908. 21 pp., 1 plate.

A study of the source and composition of the honeys of Hawaii. The peculiar conditions found on these islands are dealt with.

Issued March 27, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 440.

SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB, AND CURCULIO.

BY

W. M. SCOTT,
OF THE BUREAU OF PLANT INDUSTRY,

AND

A. L. QUAINTANCE,
OF THE BUREAU OF ENTOMOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Washington, D. C., February 18, 1911.

Sir: We have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "Spraying Peaches for the Control of Brown-Rot, Scab, and Curculio," by W. M. Scott, of the Bureau of Plant Industry, and A. L. Quaintance, of the Bureau of Entomology.

The loss to the peach growers of the United States from brown-rot, scab, and curculio amounts to millions of dollars annually, and until recently there has been no effective means of preventing this great shrinkage. Experiments conducted by this department during the past four years, however, have abundantly demonstrated that these troubles can be thoroughly controlled at a small cost. The results of experiments and demonstrations conducted during 1910 and instructions for the application of the treatment are contained in the accompanying manuscript.

Respectfully,

Wm. A. Taylor,
Acting Chief, Bureau of Plant Industry.
L. O. Howard,
Chief, Bureau of Entomology.

Hon. James Wilson,
Secretary of Agriculture.

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SPRAYING PEACHES FOR THE CONTROL OF BROWN-ROT, SCAB, AND CURCULIO.

INTRODUCTION.

The peach-growing industry in the United States at the present time has become a very important one, being second in extent among fruits only to the cultivation of the apple. According to the 1900 census there were in the territory east of the Rocky Mountains, which is subject to the troubles treated in this bulletin, approximately 91,000,000 bearing peach trees. Since that time the number of bearing trees has increased by perhaps one-fourth, making a possible total of 113,750,000 trees. Careful estimates indicate that the quantity of fruit annually harvested by peach growers in this territory is not less than 10,000,000 bushels. Thus the crop for 1910, although an unusually large one, was for the territory mentioned, probably not less than 12,000 000 bushels, with a gross valuation of about $12,000,000 to $16,000,000.

Although many insects and parasitic fungi occur on the peach, comparatively few are of much economic importance. Of the diseases of the peach, the brown-rot (*Sclerotinia fructigena* (Pers.) Schröt.) and scab, or black-spot (*Cladosporium carpophilum* Thüm.), are responsible for practically all of the damage to the fruit crop and the insect injury is limited almost entirely to the attack of one species, the plum curculio (*Conotrachelus nenuphar* Herbst.).

The brown-rot probably causes more loss to peach growers than all other maladies of the peach combined, with perhaps the exception of "yellows," which kills the trees outright. In the South the brown-rot often causes the destruction of half or even practically all of the crop, and throughout the territory under consideration the annual shrinkage in yield is perhaps 25 to 35 per cent of the crop, representing a valuation of about $3,000,000 to $4,000,000. Although the brown-rot is always present in the peach orchards of humid sections, causing a rotting of a certain proportion of the fruit, it becomes notably destructive only under certain weather conditions, when within a period of 10 days or two weeks it will spread so rapidly as to result in the destruction of practically the entire crop. Such disastrous outbreaks are likely to occur during moist, humid weather as the fruit begins to ripen. The brilliant prospects of the orchardists are thus within a few days obliterated as if by fire.

The peach scab is the only other destructive disease of the fruit in the eastern United States, and, while it does not occur in such sudden and disastrous outbreaks, the sum total of the injuries caused by it are very important, resulting in a shrinkage in crop values of perhaps $1,000,000 annually. This disease occurs all over humid America where the peach is grown and is especially troublesome east of the Allegheny Mountains. It not only renders much of the fruit unfit for market, but so mars the appearance of the marketed fruit as to reduce its value.

The plum curculio is of scarcely less importance in its relation to the successful production of the peach than the diseases above mentioned. By its punctures of the fruit in feeding and egg laying and the injury resulting from the larvæ, or grubs, within the fruit it brings about a reduction in yield of a valuation amounting to perhaps not less than $3,750,000 annually. The puncturing of the fruit also greatly favors the brown-rot, and curculio control is a prime essential in preventing losses from this malady. Although the plum curculio is very generally distributed eastward of the Rocky Mountains, it is especially abundant in the Middle and Southern States. During years of full fruit crops its injuries are less important, simply more or less thinning the fruit; but when the crop is light little fruit may escape its ravages.

The troubles mentioned have more than kept pace with the development of the peach-growing industry, and the cultivation of this crop, especially in the South, has become more and more hazardous. Practical means for their control have, therefore, been most urgently needed, and much attention has been given by investigators of the Department of Agriculture and of the various agricultural experiment stations to supply this want. While it has been possible by the use of certain sprays, such as Bordeaux mixture and Paris green, to effectively reduce these troubles, the sensitiveness of the foliage and fruit of the peach has practically prevented their employment, and the peach grower has been almost helpless against them. A spray effective in the control of these troubles and which at the same time may be used with perfect safety on the trees and fruit has been the most important requirement to place the industry on a reasonably secure foundation.

Experiments begun by the Bureau of Plant Industry some three or four years ago and carried out under varying climatic and other conditions in different parts of the eastern United States have established beyond question the effectiveness of the self-boiled lime-sulphur wash for the control of the fungous troubles mentioned. Earlier experiments by the Bureau of Entomology had already shown that by the proper use of arsenate of lead the curculio could be largely controlled, though on account of danger of foliage injury its use had not been unqualifiedly recommended. Cooperative experiments between the two bureaus have shown that the fungicide and arsenical may be used as a combined spray with satisfactory results in controlling these troubles and without injury to the fruit and foliage of the peach. Hence, there is now available a satisfactory method for the control of these three serious obstacles to successful peach culture.

In the following pages the brown-rot, peach scab, and curculio are treated with reference to their occurrence on the peach, and results are given of experiments and demonstrations in their control conducted jointly by the Bureau of Plant Industry and the Bureau of Entomology during 1910. The writers were assisted in this work by E. L. Jenne and E. W. Scott, of the Bureau of Entomology, and by Leslie Pierce and G. W. Keitt, of the Bureau of Plant Industry.

BROWN-ROT.

NATURE AND CAUSE OF THE DISEASE.

Brown-rot is a fungous disease which affects the stone fruits, such as the peach, plum, and cherry, and to a less extent some of the pome fruits, such as the apple, pear, and quince, producing a so-called rot of the fruit and blight of the twigs. It is caused by a fungus known to botanists as *Sclerotinia fructigena* (Pers.) Schröt. Brown-rot is the common name usually applied to the disease, but monilia, the generic name of the imperfect stage of the fungus, is often used by some of the older fruit growers.

The disease appears on the fruit as a small circular brown spot, which under moist, warm conditions enlarges rapidly, soon involving the entire fruit in decay (fig. 1). The spots do not usually become sunken, and the fruit remains plump until almost entirely decayed. The fungus growing in the tissues of the fruit breaks through the skin, forming small, grayish tufts of spore-bearing threads. These tufts, although few on young spots, soon become so numerous as to give the diseased area a grayish, moldy appearance, which is responsible for the term "peach mold" sometimes applied to the disease. The spores which are produced in great abundance by these fungous tufts are blown by the wind and carried by insects and birds from fruit to fruit, tree to tree, and orchard to orchard. Finding lodgment on the fruit under favorable conditions of temperature and moisture, these spores germinate, producing a fungous growth, which ramifies and kills the tissues. These dead tissues turn brown, and the fungus breaks through the surface, producing another crop of spores. The process is very rapid, only a few days intervening between one generation of spores and another.

DAMAGE TO THE PEACH.

Although the young fruits soon after the petals are shed may become affected, as a rule no marked outbreak occurs until the fruit is half grown or larger, and the greatest destruction is wrought at harvest time. The fruit crop may reach maturity in perfect condition and yet be destroyed before it can be picked. Moreover, the fruit may become affected in transit or after reaching the market. It is no uncommon experience among peach growers to have a carload of peaches leave the orchard in apparently good condition and

FIG. 1.—Peaches entirely destroyed by brown-rot, showing gray masses of spores of the fungus.

arrive on the market specked and practically worthless, owing to the brown-rot fungus. Through handling by pickers and packers some fruit in every package may become contaminated with spores from a few diseased fruits in the orchard. Enough moisture usually develops in the car to germinate the spores, and if the refrigeration is poor the fruit is likely to go down in partial or total decay before reaching the consumer.

The fungus also attacks the blossoms and extends from these into the fruit-bearing twigs, often girdling them. In a wet spring the fruit crop may thus be materially reduced, although this form of attack is only occasionally serious. In like manner the fungus may extend from diseased fruits into the twigs. Following an outbreak of brown-rot on the fruit, these twig infections may become so severe as to give the trees a blighted appearance.

WINTER STAGE AND SOURCE OF INFECTION.

The affected fruits largely drop to the ground, although many of them hang on the trees for months. They become dried and shriveled, and at this stage are known as brown-rot mummies. The fungus passes the winter in these mummies, which form the chief source of infection for the new fruit crop. When moistened by spring rains, the mummified fruits on the trees and on the ground become covered with fruiting tufts of the fungus, producing countless numbers of spores.

After 18 months, or at the end of the second winter, about the time peach trees are in bloom, there arise from the mummies on the ground, partly or entirely covered with soil, fruiting bodies representing the perfect stage of the fungus. These are dark-brown somewhat bell-shaped disks, resembling toadstools. In them are produced an abundance of ascospores, which rise in the air and are wafted by the wind. These, as well as the summer spores (conidia), serve to infect the blossoms and young fruits. The propagation of the fungus being thus so abundantly provided for, it is not surprising that a crop of fruit may be destroyed without much warning.

INFLUENCE OF THE WEATHER AND INSECTS.

In sections where the brown-rot is prevalent the spores are practically omnipresent, and only favorable conditions for their germination and the rapid growth of the fungus are required to start an outbreak of the disease. The most important factor is excessive moisture in the form of rain, which not only favors the production and germination of the spores and the growth of the fungus, but renders the fruit soft and watery, and therefore more susceptible to the disease. High temperatures also favor the disease, although the fungus grows readily in mild summer temperatures. Prolonged cloudy weather with frequent light showers is more dangerous than a hard rain followed by clearing. Warm, muggy weather, when the fruit is maturing, is often disastrous to the crop.

Insects, especially the curculio and certain plant bugs, play an important part in the distribution of the spores and the infection of the fruit. Although the fungus under favorable conditions is apparently able to pass readily through the unbroken skin of the fruit, it is greatly aided by insect abrasions. In the process of feeding and egg laying, the curculio punctures the skin of the fruit, opening the way for the fungus and in many cases perhaps actually inserting the spores. This insect may render spraying for brown-rot partially ineffective by breaking the sprayed skin of the fruit, thus exposing the flesh to attack. In the treatment of the disease it is, therefore, important to combine an insecticide with the fungicide so as to destroy the beetles.

TREATMENT.

Experiments conducted by the Bureau of Plant Industry during the past four years have shown conclusively that this disease can be controlled by the use of self-boiled lime-sulphur mixture.[1]

A schedule of applications for the combined treatment of brown-rot, scab, and curculio is given on pages 38–40 of this bulletin.

PEACH SCAB.

ECONOMIC IMPORTANCE OF THE DISEASE.

Of the diseases affecting the fruit of the peach, scab is second only to brown-rot in economic importance; in fact, it is more destructive

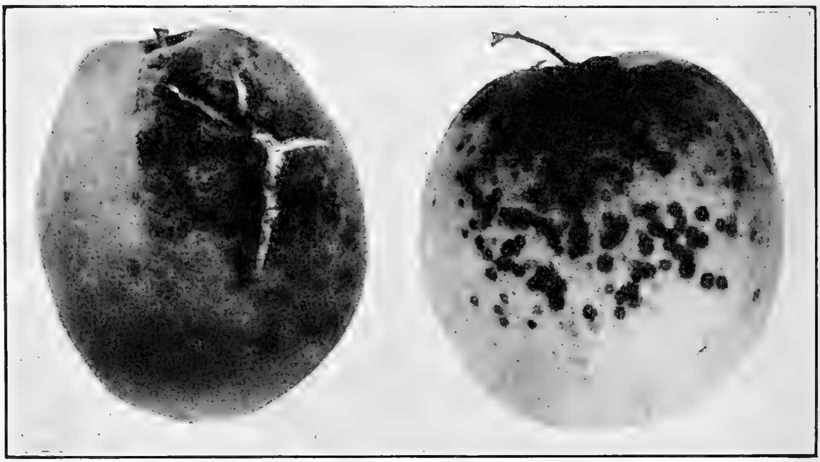

FIG. 2.—Peach scab on Elberta peaches, showing spots and cracks caused by the disease.

than brown-rot in some of the mountain districts. It dwarfs the fruit and causes premature dropping, thereby reducing the yield; it ruptures the skin, opening the way for brown-rot attacks; and it mars the appearance of the fruit, thus lowering the grade and reducing its market value. The disease is common wherever peaches are grown east of the Rocky Mountains, scarcely an orchard being entirely free from it. In some cases, especially in a dry season, only a small percentage of the fruit may become affected and with only a few small harmless spots, while in other cases the entire crop may become so badly affected as to be unmarketable. If the loss in the orchard

[1] Circulars 1 and 27 and Bulletin 174, Bureau of Plant Industry, U. S. Dept. of Agriculture.

and the reduction in market value are both considered, it seems evident that a loss of 10 per cent of the total value of the peach crop in the eastern United States is caused by peach scab.

THE NATURE AND CAUSE OF THE DISEASE.

The name commonly applied to this disease is "peach scab," but it is also known as "black spot" and "freckles" and in some districts it is often improperly called "mildew." It is caused by the fungus *Cladosporium carpophilum* Thüm., which grows in the skin of the fruit, producing small, circular dark-brown spots. When numerous, these spots give the fruit a smutty or blackened appearance and cause the skin to crack (fig. 2). Fruit badly affected does not reach normal size and often drops prematurely.

The fungus also attacks the twigs, producing brown spots, in which it passes the winter. These spots are very common in peach orchards,

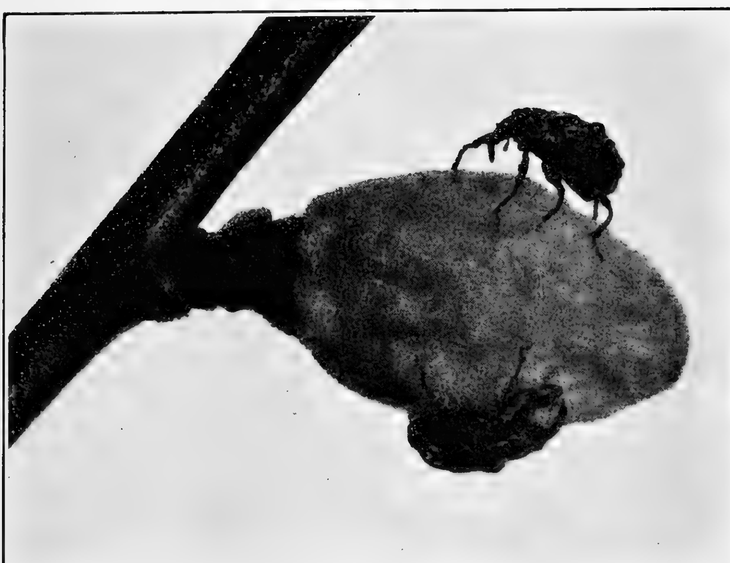

FIG. 3.—Two adult curculios on a young peach. (Considerably enlarged.)

but they apparently do little damage to the twigs. During the spring or early summer the fungus growing in the spots produces olive-brown spores which serve to infect the young peaches. Similar spores are also produced on the fruit spots.

THE SUSCEPTIBILITY OF VARIETIES.

There is a considerable difference in varieties as to their susceptibility to peach scab. In general, the late varieties are much more susceptible than the early varieties. This is due, in part at least, to the fact that the fruit of the late-maturing varieties is exposed to infection over a longer period and the opportunity for the development of the disease is greater. Of the commercial varieties, the Heath is perhaps the most susceptible; in fact, the disease has almost prohibited the growing of this variety except in a small way. The Bilyeu variety is also badly affected and the disease has restricted its culture to high, well-drained locations. The Salway, Smock, and most of the other varieties that ripen after the Elberta usually

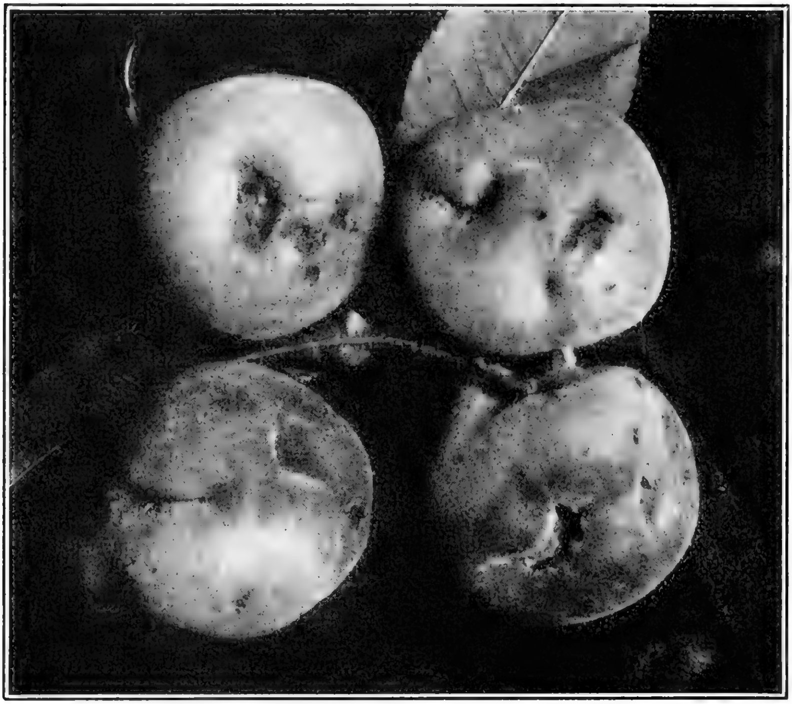

FIG. 4.—Deformed ripe peaches resulting from feeding and egg-laying punctures.

suffer rather severely from this disease, while the Elberta may be considered somewhat less affected, although the crop of this variety often becomes badly diseased. The varieties that ripen earlier than Elberta are as a rule only slightly or moderately affected. This is especially true of the Carman, Hiley, Champion, and Belle. On the other hand, the Mountain Rose and Early Rivers are quite susceptible to the disease.

TREATMENT.

The development of the self-boiled lime-sulphur mixture as a fungicide has made possible the control of the scab without injury to the fruit or foliage. The injury produced by this disease may be almost entirely prevented at a small cost. This has been abundantly demonstrated through experiments conducted by the Bureau of Plant Industry during the past three or four years.[1] The schedule of applications for the control of this disease, together with the brown-rot and curculio, is given on pages 38–40 of this bulletin.

THE PLUM CURCULIO.

WHAT THE CURCULIO IS.

The curculio is a small snout beetle of the family Curculionidæ, which contains many species of economic importance. The adult

FIG. 5.—Peaches showing the exudation of gum from curculio punctures.

insects vary somewhat in size, but will average about three-sixteenths of an inch in length. Figure 3 illustrates two beetles on a newly set peach, all considerably enlarged. In the course of its growth the insect passes through four stages, namely, the egg, larva, pupa, and adult. The larva, or grub, is the small whitish worm frequently found in ripe peaches, plums, and cherries and is well known to lovers of these fruits.

There are many common names for this insect, such as the "plum curculio," "plum weevil," "peach curculio," "peach worm," "fruit

[1] Circulars 1 and 27 and Bulletin 174, Bureau of Plant Industry, U. S. Dept. of Agriculture.

weevil," "little Turk," "curculio," etc. The name here used, however, is perhaps best fixed in literature on economic entomology and has been adopted for this species by the American Association of Economic Entomologists.

The plum curculio is a native American insect and fed originally, as it feeds at the present time, on wild plums and other wild fruits, especially Crataegus. Its injuries were noted as long ago as 1736, and it was the subject of an extended article published in 1804. Our early horticultural literature abounds with references to its depredations, especially to plums, which were apparently grown with the greatest difficulty.

FIG. 6.—Peach infested with curculio larva, or grub.

So far as is known, the plum curculio is still confined to North America, ranging from southern Canada south to Florida and Texas and west to about the one hundredth meridian. It appears to be restricted in its westward spread by the more arid climate of the Great Plains region. It is probably present throughout its entire area of distribution, but is especially abundant in the Central and Southern States.

FOOD PLANTS AND CHARACTER OF INJURY.

Practically all stone and pome fruits, such as peaches, plums, apricots, nectarines, cherries, apples, pears, etc., are used by the curculio for feeding and egg-laying purposes. Injury is done by both the adult and larva. The former punctures the fruit in feeding and in egg laying, and the grubs live within the fruit and spoil it for market or other purposes. The character and extent of injury vary with different fruits, and while the present paper deals with the insect as an enemy of the peach the statements here made are fairly applicable to other stone fruits, such as plums, cherries, apricots, and nectarines.

Most of the peaches punctured while small soon fall from the effect of the injury or on account of the presence of the developing grubs. After a peach is of some size, about one third grown, most of the larvæ apparently are unable to develop successfully in it, owing to its vigorous growth. There is a considerable period, therefore, when the curculio is able to inflict but little damage to vigorous-growing peaches, though the fruit may be more or less scarred by the feeding and egg punctures, from which gum may exude, especially during moist weather (figs. 4 and 5). As stated elsewhere, these punctures and the exudation of gum greatly favor the brown-rot, forming a nidus for spores of the fungus and furnishing an easy point of infection. After the period of rapid growth of peaches has passed and the ripening process has begun, the curculio larva is able to develop readily in the fruit and, as the beetles are still ovipositing when early and midsummer varieties are ripening, wormy ripe peaches are often to be noted at picking time. The loss caused by worminess of fruit (fig. 6), while often quite important, is perhaps less so than that resulting from the "stings" which deform and scar the fruit. Wormy fruit and that which is scarred to any extent ripen prematurely, as a rule, and in untreated orchards may constitute a considerable proportion of the crop.

LIFE HISTORY AND HABITS.

How the curculio passes the winter.—The curculio passes the winter in the adult or beetle stage under trash in orchards, along fences, terraces, etc., but especially in woods adjacent to orchards. The beetles come out of hibernation in the spring at about the blooming period of the peach, feeding at first upon the buds and foliage and later also upon the fruit.

Occurrence in orchards.—The invasion by the beetles of orchards in spring and the effect on their abundance of neighboring woods have been several times investigated. Much may be done to reduce their number by keeping the orchards and surroundings free from trash. Where practicable, it will be desirable to burn over in early spring woods adjacent to orchards in order to destroy the beetles hibernating there. Jarring records of considerable areas of peach orchards have been made which show the occurrence of the curculio first in large numbers adjacent to woods, terraces, or other favoring places. Table I shows the results of a jarring record made by Messrs. E. W. Scott and E. L. Jenne, at Barnesville, Ga., during 1910. Figure 7 illustrates the arrangement of the trees with respect to their surroundings.

Considering the results of the jarring records for the individual rows, the influence of the woods is very evident. A total of 476 beetles was taken from rows 1 and 2, adjacent to woods, up to March 23, as compared with a total of 61 beetles from the remaining eight rows. Fifteen days after the emergence from hibernation of the beetles began, namely, by March 25, their diffusion had become quite general all over the orchard, though the first one or two rows always showed on a given date a greater number of individuals than any other row. During the season a total of 3,197 beetles was taken from row 1, or 42.64 per cent of all captured. The first three rows adjacent to the woods gave for the season 4,813 beetles, or 64.19 per cent of the total for the entire plat. Between rows 9 and 10, as shown in the diagram, there was a terrace covered with grass and trash, and its influence on the abundance of the insects is also to be

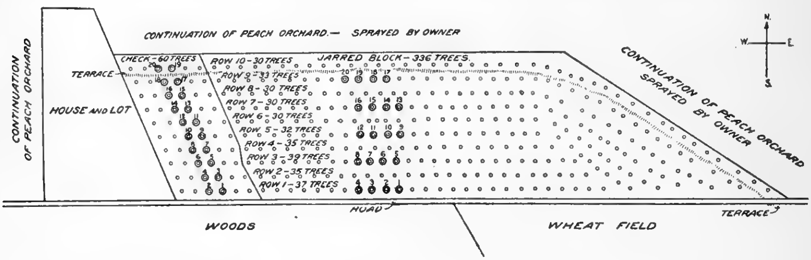

FIG. 7.—Plan of a block of peach trees jarred for the curculio, showing the arrangement of the trees.

noted, more individuals being taken on these respective rows than from any one of the rows 4 to 8, inclusive.

The Georgia record also shows that beetles were out in maximum numbers from March 25 to April 3, or about 10 days to 2 weeks after the trees were in bloom. During this period, 4,108 individuals were captured, or 54.79 per cent of the catch for the season. However, during all of May and June the beetles were fairly abundant, but they diminished perceptibly during July and August. The increase in numbers, evident with the third week in August, is perhaps due to the appearance of beetles developing from ripe peaches or those of a second generation, for the development of which some evidence was obtained under laboratory conditions. Apparently all of the beetles had left the trees for hibernation by October 11, as after this date no more individuals were captured.

TABLE I.—*Jarring record for the plum curculio on the peach, Barnesville, Ga., 1910.*

Dates of jarring.	Number of curculio caught, by rows and dates.										Total.
	Row 1.	Row 2.	Row 3.	Row 4.	Row 5.	Row 6.	Row 7.	Row 8.	Row 9.	Row 10.	
Mar. 10	16	0	2	0	0	0	0	1	0	0	19
14	5	1	0	0	1	0	0	0	1	1	9
16	0	1	0	0	0	0	0	0	0	0	1
18	3	1	0	0	0	0	0	0	0	1	5
21	15	1	1	1	0	1	0	0	0	1	20
23	406	27	10	6	0	6	7	1	5	15	483
25	460	140	56	45	32	13	14	15	16	49	840
28	550	125	95	58	38	33	30	33	35	74	1,071
30	206	77	57	36	21	24	29	21	38	54	563
Apr. 1	186	74	54	33	18	19	23	18	54	55	534
4	92	38	45	39	32	29	37	21	45	49	427
6	93	36	38	17	10	3	2	6	10	28	243
8	71	23	21	5	3	4	3	6	9	21	166
11	54	30	16	6	9	10	13	7	7	17	169
13	34	13	14	4	3	2	5	3	6	11	95
15	31	8	8	3	0	3	3	1	3	9	69
18	22	10	8	4	3	3	5	2	5	10	72
20	5	2	0	1	0	0	0	0	0	4	12
22	9	11	5	5	2	2	1	3	7	8	53
25	5	0	1	3	1	0	0	1	2	2	15
27	3	4	1	1	0	3	2	0	1	1	16
29	23	8	9	4	2	2	2	4	10	26	90
May 2	41	21	13	3	7	3	7	6	10	14	125
4	33	5	5	4	4	2	6	2	6	15	82
6	12	3	5	1	3	3	0	2	10	13	52
9	7	5	1	2	0	1	0	0	8	5	29
11	39	14	3	6	4	2	8	8	9	8	101
13	13	3	1	0	1	1	1	0	5	6	31
16	4	1	3	0	1	0	1	0	0	0	10
18	6	1	0	2	0	0	2	1	2	4	18
20	37	11	9	5	2	4	6	4	9	11	98
23	23	6	6	3	3	1	2	1	4	12	61
25	18	2	3	4	3	0	1	2	4	4	41
27	15	10	3	3	2	3	1	2	4	6	49
30	17	10	2	4	3	2	3	2	8	7	58
June 1	4	1	0	2	2	1	0	0	2	3	15
4	10	1	1	1	0	2	3	0	6	5	29
7	81	46	14	7	8	7	8	8	16	36	231
9	55	14	17	10	6	3	12	11	30	31	189
11	21	11	6	7	2	4	2	3	3	4	63
14	44	17	8	2	5	6	5	8	15	17	127
16	36	25	13	7	4	4	3	4	16	19	131
18	35	21	9	8	4	7	6	5	21	6	122
20	15	6	7	2	2	1	4	1	8	8	54
22	8	2	3	1	2	2	0	0	8	8	34
24	16	7	2	4	2	3	2	2	8	3	49
27	16	5	5	4	2	3	3	3	2	8	51
29	6	7	3	1	3	0	0	1	0	8	29
July 2	4	3	2	1	1	0	2	1	2	1	17
5	13	3	2	2	0	1	0	1	0	2	24
8	6	4	0	0	0	1	0	1	0	4	16
11	4	3	1	4	2	0	3	1	0	5	23
25	13	5	3	3	2	0	0	1	3	4	34
29	12	6	5	3	0	0	0	0	2	1	29
Aug. 2	10	2	1	1	1	0	0	1	5	3	24
5	1	3	2	0	0	0	0	0	0	2	8
8	5	2	2	0	0	0	0	0	0	1	10
Sept. 2	65	10	4	8	1	1	3	0	2	25	119
5	36	13	8	3	1	2	2	0	5	8	78
10	7	1	3	0	1	0	2	0	0	4	18
12	32	3	4	0	4	1	1	1	2	9	57
16	14	4	2	0	1	0	0	1	0	2	24
23	16	5	4	1	2	0	0	0	1	3	32
27	3	3	1	0	0	0	0	0	0	2	9
30	8	0	1	1	0	0	0	0	0	1	11
Oct. 4	1	2	0	0	0	0	0	0	1	0	4
7	3	1	0	0	0	0	0	0	0	1	5
11	13	2	1	0	2	0	0	0	1	2	21
15	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0
Total.	3,197	975	641	393	269	229	275	227	503	788	7,497

Egg-laying habits.—Peaches are less suitable for the egg-laying purposes of the curculio than smooth-skinned fruits, such as plums, apples, etc. Observations by Mr. Jenne indicate that the fuzz may be so copious on young peaches as to prevent the puncturing of the skin by the beetle. He observed that eggs were frequently deposited at the bottom of a tubular boring excavated down in the fuzz as far as the skin of the peach, which was usually scraped somewhat, later resulting in a russet spot on the fruit. In older fruit, however, the female is able to place her eggs under the skin in about the usual manner. In ovipositing, a hole is first excavated through the skin and into the flesh, about as deep as her snout will reach. Turning around, an egg is inserted by means of the ovipositor. Once more turning around, the snout is used to push the egg into the egg cavity and to fill it with bits of surrounding tissue. The next step is to cut the characteristic crescent slit at one side of the egg cavity, the excavation extending back under the egg to prevent its being crushed by the rapid growth of the fruit. Egg and feeding punctures on a newly set plum are shown in figure 8, much enlarged.

Fig. 8.—Egg and feeding punctures of the curculio on a young plum.

Period of oviposition and number of eggs laid.—Egg laying begins as soon as the young fruit is of sufficient size and may continue for several months, depending upon the vitality of the individual beetles. Most of the eggs, however, are laid during the first six or eight weeks after egg laying begins. Many records of the number of eggs deposited by the curculio in plums, peaches, apples, etc., have been made in different localities. Some of these data are shown in Table II. A total of 12,602 eggs is shown from the seven localities.

Table II.—*Combined weekly egg-laying records of the plum curculio for various localities and the percentage of eggs deposited within two, four, six, and eight weeks from confinement.*

Locality.	Number of beetles ovipositing.	Total number of eggs laid each week by all beetles of the respective localities.								
		First week.	Second week.	Third week.	Fourth week.	Fifth week.	Sixth week.	Seventh week.	Eighth week.	For remainder of period.
College Park, Md.	9	496	700	414	289	192	98	46	23	153
Youngstown, N. Y.	8	192	186	201	234	204	140	68	37	32
North East, Pa.	10	81	183	197	94	54	48	18	66	46
Washington, D. C.	4	232	213	242	153	128	108	.81	21	46
Myrtle, Ga.	9	58	62	41	176	50	83	48	40	130
Siloam Springs, Ark.	29	254	300	343	673	619	545	536	350	1,104
Douglas, Mich.	18	72	259	329	423	229	89	13	....	....
Total	87	1,385	1,963	1,767	2,042	1,476	1,111	810	537	1,511

Table II.—*Combined weekly egg-laying records of the plum curculio for various localities and the percentage of eggs deposited within two, four, six, and eight weeks from confinement*—Continued.

Locality.	Total number of eggs.	Number of eggs per individual.			Percentage of total eggs deposited by end of—			
		Maximum.	Minimum.	Average.	Second week.	Fourth week.	Sixth week.	Eighth week.
College Park, Md.	2,471	436	62	274.56	50.83	79.28	91.02	93.81
Youngstown, N. Y.	1,294	257	72	161.75	29.21	62.83	89.40	97.53
North East, Pa.	787	122	48	78.70	33.55	70.65	83.48	94.17
Washington, D. C.	1,224	557	126	306.00	36.36	68.63	87.91	96.24
Myrtle, Ga.	688	154	1	76.44	17.44	48.98	68.31	81.10
Siloam Springs, Ark.	4,724	388	4	162.97	11.73	33.23	57.88	76.63
Douglas, Mich.	1,414	201	25	78.56	23.41	76.59	99.08	100.00
Total	12,602							
Average for all localities				144.85	26.57	56.79	77.32	88.01

At College Park, Md., the greatest number deposited by any one female was 426 and the minimum 62, with an average of 274.56 eggs for the individuals under observation. At Youngstown, N. Y., the maximum is 257 and the minimum 72, with an average of 161.75 eggs. At Washington, D. C., under laboratory conditions, a single individual deposited 557 eggs, which is the highest of all records thus far obtained for this insect; the lowest number deposited was 126 and the average for the 4 beetles under observation was 306. At Myrtle, Ga., this range was from 154 as a maximum to a minimum of 1, with an average of 76.44 per individual. At Siloam Springs, Ark., the records include an unusually large number of eggs, namely, 4,724, from 29 beetles. These records show a maximum of 388 and a minimum of 4 eggs, with an average for all pairs of 162.97 eggs. At Douglas, Mich., the records show a range from 201 to 25, with an average for the 18 individuals of 78.56 eggs. The final average number of eggs per female for all localities above mentioned is 144.85, with a range of from 1 to 557.

As shown under the heading "Percentage of total eggs deposited by end of second, fourth, sixth, and eighth week," the proportion deposited by a given time varies for the different localities. There is, however, a general agreement in that the great majority of the eggs have been placed by the end of eight weeks. Approximately, one-fourth of the total eggs are deposited during the first two weeks; one-half have been deposited by the close of the first month; three-fourths within six weeks; and about 88 per cent of the total within eight weeks after the oviposition begins.

Time spent in the fruit.—Records of the time spent in the fruit as the egg and larva have been determined for many individuals and in various localities, including Illinois, District of Columbia, western New York, Georgia, Arkansas, and Michigan.

In all localities the majority of the larvæ emerged within three weeks after the eggs were laid, and, with one exception, emergence had practically ceased by the close of the fourth week.

Time spent in the soil.—When full grown the larva deserts the fruit and burrows below the surface of the soil. Practically none of the larvæ go deeper than 3 inches and the great majority penetrate not more than 2 inches. A small cell is made where the pupal stage is passed and where transformation to the adult or beetle occurs. Some days are spent in the soil by the larva before changing to the pupa, and the newly formed adult may not emerge for several days or even weeks, especially if the ground be dry. The effect of a shower, however, is to bring the new-generation beetles out in numbers.

A large number of observations have also been made on the length of time spent in the soil by different individuals, including a total of several thousand and from about the same localities as already mentioned. All of these observations go to show that comparatively few insects complete their underground transformations in less than three weeks from the time of entering the soil as larvæ. In from four to five weeks, however, the great majority of the beetles are out and by the close of the sixth week emergence has practically ceased.

Time required for transformation from egg to adult.—The average time spent in the fruit for the numerous localities investigated proved to be 19.48 days, and the average time spent in the ground was found to be 30.89 days, giving an average life-cycle period for the insect of 50.27 days.

Complete life-cycle observations were also made on a total of 597 individuals from many parts of the country, which gave a final average for the period per individual of 50.71 days, differing only a fraction of a day from the time determined in an essentially different manner. Approximately 50 days would therefore appear to be the average life-cycle period for the plum curculio for the country as a whole. The range though, will vary considerably and as actually determined in the case of the individual records was from 37 to 58.45 days.

Habits of beetles from emergence until hibernation.—After emergence, beetles of the new generation feed upon various fruits and plants until fall, when they enter hibernation quarters, appearing the following spring, as already stated. While there is some evidence to indicate that there may be a small second generation in the South, this will be comparatively insignificant and for practical purposes the insect produces but one generation annually. The beetles which develop one summer live over the following winter, ovipositing during the spring and summer, and gradually die off, until by early fall practically all of them have disappeared. The life of the more hardy beetles is thus seen to be some 12 or 14 months

RESULTS OF SPRAYING EXPERIMENTS AND DEMONSTRATIONS DURING 1910.

During the season of 1910 the same experiments were carried out as during 1909, which were reported in Circular 120 of the Bureau of Entomology and in Bulletin 174 of the Bureau of Plant Industry, and in addition the recommendations given in these publications were put in effect on a commercial scale to serve as an object lesson for growers. During 1909 the experiments made in the Hale orchard at Fort Valley, Ga., included the treatment of 1,100 Elberta trees for the control of peach scab, brown-rot, and curculio. The self-boiled lime-sulphur mixture (8–8–50) plus 2 pounds of arsenate of lead was used.

This combined treatment gave the following results: At picking time 95.5 per cent of the fruit on the sprayed block was free from brown-rot, 93.5 per cent free from scab, and 72.5 per cent free from curculio. On the unsprayed block only 37 per cent of the fruit was free from brown-rot, 1 per cent free from scab, and 2.5 per cent free from curculio injury. In packing the fruit for market it was found that the yield of merchantable fruit on the sprayed block was ten times as great as from the unsprayed block containing the same number of trees.

During the season of 1910 neither the brown-rot nor the plum curculio was so abundant in Georgia as the year previous, and the contrast between the sprayed and unsprayed blocks was, therefore, not so striking. Nevertheless, the very satisfactory results obtained fully substantiated the conclusions previously reached as to the value of spraying.

The work in Georgia was carried out at Fort Valley, Barnesville, and at Baldwin. At Fort Valley a block of 1,064 nine-year-old Elberta trees was treated in the orchard of the United Orchard Company. In addition to numerous experiments planned to show the effect of treatments at different times and with different mixtures, the demonstration treatment was put in effect on a block of 848 Elberta trees, a similar number being left unsprayed for purposes of comparison. The trees were sprayed (1) as the calyxes were shedding, April 1, with 2 pounds of arsenate of lead and 3 pounds of lime in each 50 gallons of water; (2) two to three weeks later, April 19 and 20, with 8–8–50 self-boiled lime-sulphur and 2 pounds of arsenate of lead; (3) on June 17, about a month before the fruit ripened, with self-boiled lime-sulphur alone.

In order to determine the effect of the treatments, the fruit at picking time (July 12 to 15) was gathered from 68 trees in the sprayed block and from 63 trees in the unsprayed block. This fruit was carefully graded into "merchantable" and "culls," with the results shown in Table III.

TABLE III.—*Results of demonstration spraying in the peach orchard of the United Orchard Company, Fort Valley, Ga., 1910.*

Plat.	Yield.	Merchantable fruit.	Culls.	Fruit affected with brown-rot.
	Bushels.	*Per cent.*	*Per cent.*	*Per cent.*
68 trees (sprayed)	101	86.2	13.7	5.3
63 trees (not sprayed)	92	54.6	46.4	20.0

It will be noted that from the 68 sprayed trees there was a total yield of 101 bushels, of which 86.2 per cent was merchantable and 13.7 per cent was culls. On the unsprayed block of 63 trees there was a total yield of 92 bushels of fruit, of which 54.6 per cent was merchantable and 46.4 per cent was culls, a gain in merchantable fruit due to the treatments of 31.6 per cent.

In the orchard of Mr. S. H. Bassett, also at Fort Valley, Ga., a block of 700 seven-year-old Elberta trees was sprayed as a demonstration and a like number of trees left unsprayed for comparison. The trees were sprayed as the calyxes were shedding, April 5, with 2 pounds of arsenate of lead to each 50 gallons of water and again on April 22 with self-boiled lime-sulphur (8–8–50) and 2 pounds of arsenate of lead. Owing to the difficulty of getting water, this block received no further treatment. On July 7, when the first picking of the crop was being made, the sprayed and unsprayed blocks were carefully examined for the purpose of making an estimate of the results of the treatment. The fruit on the sprayed block was highly colored and practically free from scab, brown-rot, and curculio. No specimens of fruit affected with these troubles could be found in a search of two hours throughout the block. The crop was decidedly heavier on the sprayed trees than on the unsprayed, the fruit from the latter having dropped from the effect of these combined troubles. In looking over the unsprayed block, it was estimated that 50 to 60 per cent of the crop had been destroyed or rendered unmerchantable by curculio, brown-rot, and scab.

In the operations at Barnesville, Ga., the same plan of spraying was carried out on a commercial scale in two different orchards. The improved condition of the fruit on the sprayed blocks in both of these orchards was a matter of much comment by the fruit growers in that section.

Owing to the almost complete absence of the curculio and the small amount of brown-rot in these orchards, the results were not as well marked as those obtained elsewhere. The peach scab, however, was quite abundant on the unsprayed fruit and practically absent on the sprayed blocks.

In the orchard of Mr. S. M. Marshburn, the demonstration treatment was given to 926 Elberta trees, 212 trees being left untreated for comparison.

From the sprayed trees the yield was 209 crates of extra fancy fruit, 587 crates of fancy fruit, with 51¾ bushels, or 96 crates, of culls, the total merchantable fruit being 92.02 per cent.

On the unsprayed trees the yield was 15¾ crates of extra fancy fruit, 135¼ crates of fancy fruit, with 21½ bushels, or 28⅔ crates, of culls, the percentage merchantable being 84.02.

In the A. O. Murphy orchard, the yield from 485 sprayed Elberta trees was 211 crates of extra fancy fruit, 272 crates of fancy fruit, with 68½ bushels, or 91⅓ crates, of culls, the total percentage merchantable being 84.09.

On the 110 unsprayed Elbertas in this orchard the yield was 8½ crates of extra fancy fruit, 109 crates of fancy fruit, and 45¼ bushels, or 60⅓ crates, of culls, the percentage merchantable being 66.07.

In the orchard of Mr. A. M. Kitchen, at Baldwin, Ga., experiments and demonstrations were conducted on the Carman, Hiley, Elberta, and Summerour, or Atlanta, varieties, 2,000 trees in all being treated and a similar block left untreated. The trees were 7 years old and bore a fair crop of fruit, although the crop was rather light in portions of the orchard. The Elberta and Summerour varieties were sprayed (1) as the calyxes were shedding, April 7 and 8, with arsenate of lead, 2 pounds to 50 gallons of water; (2) on April 27 and 28, with 8–8–50 self-boiled lime-sulphur and 2 pounds of arsenate of lead; and (3) on June 17 and 18, about a month before the fruit ripened, with 8–8–50 self-boiled lime-sulphur. The Carman and Hiley varieties received the same treatment, with the omission of the third application. At picking time the fruit from 5 to 11 sprayed trees and a like number of unsprayed trees in each variety was sorted and the results are shown in Table IV.

TABLE IV.—*Results from spraying the Carman, Hiley, Elberta, and Summerour varieties of peaches at Baldwin, Ga., 1910.*

Varieties and dates of spraying.	Total fruits.	Fruit affected with brown-rot.	Fruit affected with scab.	Fruit badly affected with scab.	Merchantable fruit.	Culls.
Sprayed.	*Number.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Carman, Apr. 7 and 27	1,884	0.1	15.9	0.00	97.6	2.4
Hiley, Apr. 7 and 27	1,446	.2	28.0	.00	96.3	3.7
Elberta, Apr. 7, 27, and June 17	3,443	.7	41.4	.03	97.7	2.3
Summerour, Apr. 7, 27, and June 17	4,360	9.3	[1] 7.7	.80	82.6	17.4
Unsprayed:						
Carman	1,417	31.8	92.9	16.40	40.2	59.8
Hiley	739	28.1	99.4	19.00	51.5	48.5
Elberta	1,291	70.0	100.0	16.00	16.9	83.1
Summerour	5,308	54.8	[1] 91.7	72.50	7.5	92.5

[1] In sorting this variety, fruits that showed only a few inconspicuous spots were not counted as scabby, while all the affected fruit of the other varieties was counted.

It will be seen from Table IV that the brown-rot was thoroughly controlled, even where 70 per cent of the unsprayed fruit rotted, as was the case with the Elberta. The scab was also held down so that it was commercially negligible. The Summerour is particularly susceptible to scab, and has been unprofitable in Mr. Kitchen's orchard on account of this disease. On the unsprayed trees 72.5 per cent of the fruit was badly affected with scab, while less than 1 per cent of the sprayed fruit was badly affected. By referring to the column showing the percentage of merchantable fruit in Table IV it will be seen that from 82.6 to 97.7 per cent of the sprayed fruit was merchantable and from 7.5 to 51.5 per cent of the unsprayed fruit was merchantable. The difference between these two sets of figures represents the difference between success and failure.

In Table V are shown the results from 12 sprayed and 12 unsprayed Elberta trees in the same orchard and given the same treatment as those considered in Table IV, but located in a different section of the orchard. The fruit was picked from July 26 to August 1 and sorted with reference to brown-rot, scab, and curculio. To determine the presence or absence of the curculio all the fruit was sliced into several pieces.

Table V.—*Results from 12 sprayed and 12 unsprayed Elberta peach trees at Baldwin, Ga., 1910.*

Plats.	Total fruits.	Fruit affected with scab.	Fruit badly affected with scab.	Fruit affected with brown-rot.	Fruit affected with curculio.	Merchantable fruit.	Culls.
	No.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Sprayed	5,197	39.26	0.03	0.90	13.15	97.61	2.39
Unsprayed	3,907	100.00	9.29	18.04	51.19	46.49	53.51

It will be seen from Table V that 0.9 per cent of the sprayed fruit was affected with brown-rot, 39.26 per cent with scab (practically none of which was bad), and 13.15 per cent with curculio, while 18.04 per cent of the unsprayed fruit was affected with brown-rot, 100 per cent with scab, and 51.19 per cent with curculio. It is also shown that 97.61 per cent of the sprayed fruit was merchantable, as against 46.49 per cent of the unsprayed fruit. Had all the fruit infested with curculio been thrown out the percentage of merchantable fruit from both the sprayed and the unsprayed trees would not have been quite so high. Much of the infestation consisted of young worms just hatched, and in such cases the market value of the fruit had not been materially affected. In addition to these 12 trees the crop from a block of 70 sprayed and 70 unsprayed Elberta trees was sorted and packed for the market. It was found that 97.04 per cent of the fruit of the sprayed block was merchantable, leaving 2.96 per cent as culls. From the unsprayed block only 54.11 per cent of the crop was merchantable and 45.89 per cent unmerchantable, a gain of 42.93 per cent.

A block of 1,000 Summerour trees, which is a late-maturing variety, ripening at Baldwin last season, August 27 to 31, was given the same treatment received by the Elbertas. In order to determine the commercial results the crop from 70 sprayed trees and the same number of unsprayed trees was graded at the packing house. It was found that 85 per cent of the sprayed fruit was merchantable, leaving 14.98 per cent unmerchantable. Only 6.49 per cent of the unsprayed fruit from 70 trees was merchantable, 93.51 per cent being totally unfit for market. This shows a gain from spraying of 78.53 per cent. This great loss was due to the combined effect of the curculio, brown-rot, and scab, although the latter was the most prominent trouble. These commercial results show conclusively that even under severe conditions the combination treatment will effectually control these troubles.

It will be understood that the combination treatment for these diseases and curculio is in effect a compromise. Considered only from the insect standpoint, an additional application of arsenate of lead would be desirable, but a third application of the poison is as a rule unsafe. Nevertheless, the benefits from two applications of arsenate of lead has been very marked. In order to show more in detail the effect of two such treatments on the curculio, Table VI is presented, showing the results of an examination for curculio infestation of the dropped fruits during the season, as well as those on the trees at picking time, 12 trees in the sprayed block and 12 trees in the unsprayed block being examined.

TABLE VI.—*Results of spraying Elberta peaches for plum curculio, Baldwin, Ga., 1910.*

Plat No.	Treatment.	Tree No.	Fruit from ground.		Fruit from tree.		Total number of fruits.	Total number of fruit infested.	Sound fruit.[1]
			Total number.	Number infested.	Total number.	Number infested.			
									Per cent.
1	First application, Apr. 7-8, arsenate of lead, 2 pounds to 50 gallons of water; second application, 2 pounds of arsenate of lead in self-boiled lime-sulphur wash (8-8-50), Apr. 27-28; third application, lime-sulphur wash only (8-8-50), June 17-18.	1	447	7	589	26	1,036	33	96.81
		2	119	8	465	45	584	53	90.92
		3	177	10	388	65	565	75	86.72
		4	363	24	606	76	969	100	88.63
		5	161	10	335	61	496	71	85.68
		6	96	12	409	26	505	38	92.47
		7	99	2	358	38	457	40	91.23
		8	222	22	293	33	515	55	89.32
		9	702	25	412	123	1,114	148	86.71
		10	224	6	476	83	700	89	87.28
		11	68	7	410	50	478	57	88.07
		12	348	17	456	58	804	75	90.67
		Total.	3,026	150	5,197	684	8,223	834	....
2	Untreated..................	1	188	115	324	178	512	293	42.77
		2	187	83	385	132	572	215	62.41
		3	147	85	280	155	427	240	43.79
		4	839	114	648	239	1,487	353	76.26
		5	76	56	129	79	205	135	34.14
		6	605	165	471	189	1,076	354	67.10
		7	192	71	177	94	369	165	55.28
		8	318	55	299	147	617	202	67.26
		9	68	67	388	251	456	318	30.26
		10	143	67	176	137	319	204	36.05
		11	214	110	347	231	561	341	39.21
		12	274	100	283	168	557	268	51.88
		Total.	3,251	1,088	3,907	2,000	7,158	3,088	....

[1] The average of sound fruit on treated trees was 89.85 per cent; on untreated trees, 56.85 per cent.

In the sprayed block 8,223 fruits were obtained, of which 834, or 10.15 per cent, were infested. From the unsprayed block there was a total of 7,158 fruits, of which 3,088 were infested, the percentage of sound fruit being 56.85, a gain in yield of 33 per cent of fruit free from curculio infestation.

EXPERIMENTS IN WEST VIRGINIA, 1910.

In order to demonstrate the control of peach scab and to determine how much spraying is required on late varieties, an experiment was conducted in the orchard of L. P. Miller & Bros., at Okonoko, W. Va., during 1910. There are about 600 acres of 12-year-old trees in this orchard, and it is composed of a large number of varieties, beginning with Southern Early and ending with Bilyeu. Until summer spraying was undertaken in 1908 the peach scab had been most disastrous to the crops in this orchard, about one-half of the fruit being lost every year. Spraying, however, largely overcame the trouble, and in 1910 the loss was comparatively small, notwithstanding the difficulty of thoroughly spraying such a large orchard at the proper time.

The spraying experiments were confined to the Elberta, Salway, and Bilyeu, and about 500 trees each of these varieties were used. The Bilyeu set a good crop, while the crop of Elberta and Salway was only medium to light, but ample for an experiment. For the most part the weather was unfavorable for good work. During the time the first and second applications were being made it was cloudy and showery and the day following the second application it rained rather hard all day. The Elberta trees were sprayed according to the following plan:

Plat 1.—Self-boiled lime-sulphur and arsenate of lead, one month after petals fell, May 11.

Plat 2.—Self-boiled lime-sulphur with arsenate of lead, one month after petals fell, and self-boiled lime-sulphur alone, one month later, May 11 and June 15.

Plat 3.—Self-boiled lime-sulphur, one month after petals fell and one month later, May 11 and June 15.

Plat 5.—Self-boiled lime-sulphur six weeks after petals fell and one month later, May 26 and June 28.

Plat 6.—Commercial lime-sulphur, 1 to 100 with arsenate of lead and lime, one month after petals fell, and with lime only one month later.

Plat 0.—Check; untreated.

At picking time, August 22 to 26, the crop, including windfalls, from four trees in each sprayed plat and six unsprayed trees was sorted to determine the percentage of fruit affected with scab and the percentage of merchantable fruit. The results are shown in Table VII.

TABLE VII.—*Results of treatment for peach scab on the Elberta variety, Okonoko, W. Va., 1910.*

Plats.	Total fruits.	Fruit affected with scab.	Fruit badly affected with scab.	Merchantable fruit.	Culls.
	Number.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	1,322	65.2	3.0	86.1	13.9
2	1,566	20.9	0.1	95.5	4.5
3	2,277	20.2	1.4	93.1	6.9
5	1,819	55.8	0.9	93.6	6.4
6	1,924	49.3	1.5	93.9	6.1
Check	2,918	99.6	41.1	53.7	46.3

The third column of the above table shows the percentage of fruit affected with scab, including fruit so slightly affected that its market value was not materially reduced, while the fourth column shows the percentage of badly affected, unmerchantable fruit. The fifth column shows the percentage of good, merchantable fruit obtained from each plat, while the sixth column shows the percentage of culls due to scab, brown-rot, curculio, and other causes.

Plat 1 received only one application, and the results were all that could be expected in a wet season, such as last spring. Although 65.2 per cent of the fruit was affected with scab, only 3 per cent of it was badly affected.

Plats 2 and 3, which were sprayed twice, gave the best results, only a little more than 20 per cent of the fruit in each being affected with scab. Most of this scab infection was commercially negligible, the spots being small and rather inconspicuous. In plat 2 less than 1 per cent of the fruit was badly affected, and in plat 3 only 1.4 per cent was so affected. The only difference in the treatment received by these two plats was the use of arsenate of lead with the self-boiled lime-sulphur in the first application on plat 2. This made no difference in the control of scab. It apparently raised the percentage of merchantable fruit, plat 2 having 95.5 per cent and plat 3 having 93.1 per cent. This difference would certainly have been greater had there been more curculio in the orchard.

The good results obtained from the treatment of these two plats may be better appreciated by comparing them with the results from the unsprayed trees. Practically all (99.6 per cent) of the unsprayed fruit was affected with scab and 41.1 per cent of it was badly affected. Only 53.7 per cent of the fruit was suitable for market, leaving 46.3 per cent of culls.

Plat 5 received the same treatment as plat 3, except that both applications were delayed two weeks. The results indicate that one month after the petals fall is a better time to begin spraying for scab than two weeks later.

Plat 6, which was sprayed with commercial lime-sulphur solution, 1 gallon to 100 gallons of water, had only 1.5 per cent of fruit badly affected with scab, although 49.3 per cent of it was affected more or less. These results indicate that the scab can be held in check by a very dilute solution of the lime-sulphur solution. It burned the foliage considerably and caused some of the leaves to drop, but the injury almost disappeared as the season advanced and the fruit matured in good condition.

A similar test was made on the Salway variety, which ripens some four weeks later than the Elberta. There were four sprayed plats, consisting of about 80 trees each, and 17 trees were left untreated for the purpose of comparison. The self-boiled lime-sulphur (8–8–50) was used in each application, and arsenate of lead at the rate of 2 pounds to each 50 gallons was added in the first application only.

On September 22 and 23 the crop from four trees in each plat was sorted for scab and brown-rot, and the results are shown in Table VIII. In this case the classification of scabby fruit was made on a commercial basis; that is, the fruit having only a few small specks of scab, which did not materially detract from its market value, was not classed as scabby. The figures given in the table therefore represent the percentage of fruit so badly affected as to have but little value on the market.

TABLE VIII.—*Results of spraying on the Salway variety in the Miller orchard, Okonoko, W. Va., 1910.*

Plat No.	Dates of spraying.	Total fruits.	Scabby fruit.	Rotted fruit.
		Number.	*Per cent.*	*Per cent.*
8	(1) One month after petals fell, May 12; (2) June 17; (3) July 15	1,557	5.5	2.5
9	(1) One month after petals fell, May 12; (2) June 17	1,599	5.3	1.9
10	(1) One month after petals fell, May 12	1,132	27.2	6.8
11	(1) Six weeks after petals fell, May 26; (2) June 28	1,065	5.8	1.3
12	Check; not sprayed	2,349	87.5	37.6

It will be observed that the results from plat 8, which had three applications, are about the same as those from plat 9, which had two applications, the scab and brown-rot having been almost completely controlled in both cases. The results of the treatment of plat 9 are shown in figures 9 and 11. The superiority of two treatments over one may be seen by comparing plats 9 and 10. The latter received only one application and 27.2 per cent of the fruit became affected with scab, while only 5.3 per cent of the crop on plat 9 was affected. Plat 11 received the same treatment as plat 9, except that the applications on plat 11 were delayed two weeks, the object being to determine the best time to begin the spraying. In this case there was very little difference in the results from the two plats.

Of the fruit from the unsprayed trees, 87.5 per cent was rather badly affected with scab and 37.6 per cent was affected with brown-rot, as shown in figures 10 and 12. In other words, the unsprayed crop was almost a total loss.

The Bilyeu variety was given the same treatment as that applied to Salway and the results were about the same. In this case the fruit was not sorted and counted, but at picking time comparative notes were made, attempting to show the estimated percentages of brown-rot and scab. Fully 50 per cent of the unsprayed fruit was lost on account of these diseases, while there was a loss of only about 5 per cent of the fruit sprayed twice, although much of it showed some

FIG. 9.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Scabby fruit in single basket on the left; remainder of the crop sound.

slight spotting with scab. On the plat sprayed three times the scab was almost entirely prevented. In most cases three treatments will be necessary for the best results against scab on late-maturing varieties like the Bilyeu.

EXPERIENCE OF FRUIT GROWERS.

Following the recommendations of the United States Department of Agriculture, a considerable number of fruit growers have adopted the combination treatment, and in Georgia during 1910 perhaps not less than one-fourth of the peach orchards were sprayed for the curculio, brown-rot, and scab. In connection with the department's experiments at Fort Valley, Barnesville, and Baldwin, Ga., an effort was made to give personal instruction to as many orchardists as possible in order to start them in the work, and by visits and by correspondence assistance was rendered to growers in other parts of the State. Thus at Fort Valley the Hale Georgia Orchard Co. sprayed three times its entire bearing orchard of about 100,000 trees. The same schedule of treatments was also adopted by Mr. W. C. Wright in his orchard of 60,000 trees and by others in the immediate neighborhood. Also at Marshallville, Ga., the treatment was adopted by Mr. S. H. Rumph and other leading growers, the total number of trees sprayed in this general section aggregating about a million.

At Barnesville, Ga., practically all of the large orchardists used the combined spray, aggregating not less than 500,000 trees. At Baldwin, Ga., some of the leading growers sprayed not less than 100,000

FIG. 10.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Sound fruit in three baskets on the left; remainder of the crop scabby.

trees. Messrs. Stranahan Bros., of Warm Springs, Ga., have been spraying for the past three years and were among the first large peach orchardists to adopt the lime-sulphur treatment even before it was out of its experimental stage. Also around Adairsville and at numerous other points in Georgia spraying was adopted by the leading growers, at least 2,000,000 trees for the State as a whole being sprayed. Considering all of the Southeastern States it is probable that in this territory 3,000,000 trees were sprayed during 1910.

Considerable spraying has also been done by peach orchardists in West Virginia, western Maryland, and Pennsylvania, including a total of perhaps 1,000,000 trees. The treatment has also been adopted by some growers in Illinois, Missouri, and Arkansas, aggregating about

500,000 trees, making on a conservative estimate a grand total of 4,500,000 to 5,000,000 trees sprayed during 1910 with the self-boiled lime-sulphur wash and arsenate of lead.

We have been able to personally examine some of these orchards, and have had reports from many of the orchardists regarding the results of the treatment. So far as it has been possible to determine, the results have been uniformly satisfactory and the slight injury from the spray comparatively unimportant. It seems rather remarkable that so many growers in different parts of the country should be so successful in using a new treatment for the first time. This may be taken to indicate the entire practicability of the recommendations.

EFFECT OF SPRAYING ON THE QUALITY OF THE FRUIT.

The good results from the treatment do not end with the control of the curculio, scab, and brown-rot. The sprayed fruit is as a rule

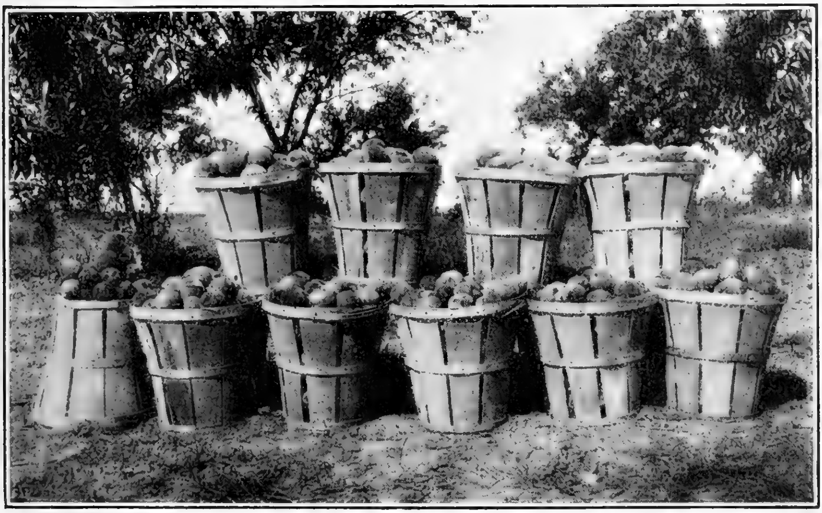

Fig. 11.—Crop from four Salway trees sprayed twice, Okonoko, W. Va. Rotten fruit in upturned basket on the left; remainder free from rot.

somewhat larger, much more highly colored, and firmer than unsprayed fruit. It keeps longer, carries to the market in better condition, and brings better prices. A carload of Elberta peaches shipped from Baldwin, Ga., on July 29 contained 166 crates of sprayed fruit and 324 crates of unsprayed fruit. This fruit was sold on the New York market on August 2, the 166 crates of sprayed fruit bringing $2.50 per crate, while the 324 crates of unsprayed fruit brought an average of $1.75 per crate, a difference of 75 cents per crate in favor of the sprayed fruit.

The effect of the treatments is to fairly clean the fruit from disease and to put it in a more or less sterilized condition, adding greatly to its keeping quality. This superiority of sprayed as against unsprayed fruit is one of the marked benefits and has been noted by all growers who have adopted the treatment.

On July 14 sprayed and unsprayed Elberta fruit in the Hale orchard at Fort Valley, Ga., was picked and packed for a shipping test, but owing to a car shortage was not shipped. There were 64 crates of unsprayed fruit and 400 crates of sprayed fruit. This fruit was stacked out on the ground where it remained in the sun and during occasional showers of rain until July 18 (4 days) and then 6 crates of each lot

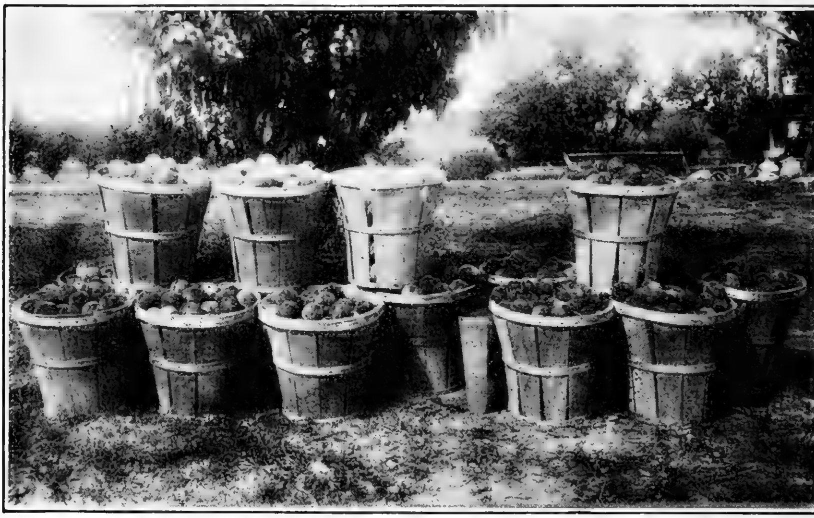

FIG. 12.—Crop from four unsprayed Salway trees, Okonoko, W. Va. Fruit in six baskets on the right affected with brown-rot; the remainder free from rot, but scabby.

were examined for brown-rot. It was found that 62.7 per cent of the unsprayed fruit had rotted, while only 8 per cent of the sprayed fruit was so affected, showing conclusively the better keeping quality of the latter.

EFFECT OF THE SELF-BOILED LIME-SULPHUR WASH ON SCALE INSECTS.

Observations and experiments go to show that, when used as a summer spray, the effect of the self-boiled lime-sulphur wash on the control of scale insects which may be present on the trees, especially the San Jose scale, is important. While to secure the best results in the control of scale insects it would be desirable to coat the limbs and twigs more thoroughly than is accomplished in ordinary summer spraying, nevertheless in the course of the work as practiced against the curculio, brown-rot, and scab noticeable good is accomplished. Although the spray is not strong enough to kill many of the adult scale insects, it is effective to an important extent in bringing about the death of the young scales. Experiments made by the Bureau of Entomology in the use of the self-boiled lime-sulphur wash as a summer spray for the San Jose scale[1] have shown that two or three applications will result in a marked improvement in the condition of the trees by fall. The effect of the wash is to prevent the settling of the young scales upon the twigs and branches, so that by the close of the season the trees are largely free from the insects.

Further observations are necessary to determine just how much benefit will result from these applications in the control of scale insects, but it seems probable in peach orchards regularly sprayed for the curculio and for scab and brown-rot that the usual winter treatments for the San Jose scale may be reduced to perhaps one application every two or three years. Any observant orchardist should be able to determine for himself the necessity for winter treatments, depending upon the abundance of the scale insects. The lime-sulphur wash is furthermore effective against numerous other sucking insects, especially plant lice, which may be present on the trees.

PREPARATION AND USE OF THE SPRAY.

Spraying for the brown-rot, scab, and curculio does not differ in principle from the usual spraying practices. It is essential that an efficient spraying outfit be employed, so that the work may be done expeditiously and with thoroughness. Where the orchard interest is at all important it will be desirable to employ a power sprayer, such as a gasoline or compressed-air outfit. Excellent work, however, may be done with the ordinary barrel sprayer, which is suitable for orchards of a few hundred trees. In applying the spray, all parts of the tree should be reached. This is especially important in the first application, which is directed principally against the plum curculio. The purpose should be to coat thoroughly the foliage, twigs, and young fruit to insure to the fullest extent possible the poisoning of the beetles. The same precautions as to poisoning the foliage, fruit, and buds are also essential in making the second application, as the beetles are still very numerous, feeding and ovipositing freely. (See Table II.) This is also the most important application for the prevention of scab infection, which is prevented only by thoroughly coating the young fruits. In subsequent applications the efforts should be directed more to coating the fruit with the spray to protect it from brown-rot infection, especially as it begins to ripen.

[1] Reported in the Journal of Economic Entomology, vol. 2, p. 130

The schedule of applications (pp. 38–40) takes account of the ripening period of the principal commercial varieties of peaches. Applications made later than a month or six weeks before picking time are likely to result in the fruit being more or less spotted with the spray when harvested, somewhat marring its appearance for market purposes. This danger can be largely avoided by using nozzles which throw a mistlike spray, coating the fruit with very fine dots rather than with large blotches.

DIRECTIONS FOR THE PREPARATION OF SELF-BOILED LIME-SULPHUR WASH.

The standard self-boiled lime-sulphur mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur to 50 gallons of water. In mild cases of brown-rot and scab a weaker mixture containing 6 pounds of each ingredient to 50 gallons of water may be used with satisfactory results. The materials cost so little, however, that one should not economize in this direction where a valuable fruit crop is at stake. Any finely powdered sulphur (flowers, flour, or "commercial ground" sulphur) may be used in the preparation of the mixture.

In order to secure the best action from the lime, the mixture should be prepared in rather large quantities, at least enough for 200 gallons of spray, using 32 pounds of lime and 32 pounds of sulphur. The lime should be placed in a barrel and enough water (about 6 gallons) poured on to almost 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, if any are present. The mixture should be constantly stirred and more water (3 or 4 gallons) added as needed to form at first a thick paste 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 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.

The stage at which cold water should be poured on to stop the cooking varies with different limes. 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 for 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 the strainer.

DIRECTIONS FOR USING ARSENATE OF LEAD.

Many experiments have shown that well-made arsenate of lead is much the safest of all available arsenicals for use on the peach. Arsenate of lead is to be found on the market both as a powder and as a putty-like paste, which latter must be worked free in water before it is added to the lime-sulphur mixture. The paste form of the poison is largely used at the rate of about 2 pounds to each 50 gallons of the lime-sulphur wash and is added, after it has been well worked free in water, to the lime-sulphur spray previously prepared. As there are numerous brands of arsenate of lead upon the market, the grower should be careful to purchase from reliable firms. A decided change in color will result when the arsenate of lead is added to the lime-sulphur mixture, due to certain chemical changes which, in the experience of the writers, do not injuriously affect the fungicidal and insecticidal properties of the spray or result in injury to the foliage.

In large spraying operations it will be more convenient to prepare in advance a stock mixture of arsenate of lead, as follows: Place 100 pounds of arsenate of lead in a barrel, with sufficient water to work into a thin paste, diluting finally with water to exactly 25 gallons. When thoroughly stirred, each gallon of the stock solution will thus contain 4 pounds of arsenate of lead, the amount necessary for 100 gallons of spray. In smaller spraying operations the proper quantity of arsenate of lead may be weighed out as needed, and thinned with water. In all cases the arsenate of lead solution should be strained before or as it is poured into the spray tank. The necessary care should be exercised to keep the poison out of the reach of domestic and other animals.

DANGER OF INJURY FROM SPRAYING.

As stated elsewhere in this bulletin, the foliage of the peach is extremely sensitive to injury from such sprays as Bordeaux mixture and arsenicals, such as Paris green, arsenate of lead, etc. This sensitiveness has been the sole reason why it has been impracticable to spray peach orchards with fungicides and insecticides such as Bordeaux mixture or Paris green, as has for years been the custom in the case of apples, grapes, and other deciduous fruits.

Of the various arsenicals available for use, well-made arsenate of lead has proved to be the safest. Shortly after the development of this comparatively new insecticide, it was at once extensively experimented with on peaches by numerous entomologists and it was tried to a limited extent by peach growers. A single application of arsenate of lead in water did not result in injury so important as to prevent its use. However, when two or three applications were made, as is necessary in the control of the curculio, serious shot-holing and falling of the leaves and even burning of the fruit resulted, the latter, in extreme cases, falling to the ground. The use of lime with arsenate of lead lessened the danger of injury considerably, but used even in this way for two or three treatments, especially under certain weather conditions, resulted in extensive injury to foliage and fruit.

When it was established that the self-boiled lime-sulphur wash was an effective fungicide and entirely safe as a spray for the peach, one of the interesting questions presented was whether arsenate of lead might be safely used with it to effect a combination spray for both insects and diseases. While on chemical grounds it appeared that the addition of arsenate of lead to the self-boiled lime-sulphur mixture would result in an important decomposition of the spray and greatly add to its probable injurious character, in practice the combined spray was found to be entirely safe. Observations extending over three seasons have failed to show any serious injury resulting from the use of this spray, even when as many as three applications were made. Thus, in the test of numerous brands of arsenate of lead at Barnesville, Ga., during 1910, carried out by Mr. E. W. Scott, of the Bureau of Entomology, peach trees were given three thorough applications: (1) With arsenate of lead in limewater at the rate of 2 pounds to 50 gallons, and (2) in the self-boiled lime-sulphur wash used at the same strength. In all cases very serious injury resulted to fruit and foliage on the plats sprayed with the arsenate of lead in limewater, whereas there was no discernible injury on the plats treated with arsenate of lead in the self-boiled lime-sulphur wash. It is not understood why the arsenate of lead apparently loses its injurious properties when used in the self-boiled lime-sulphur wash, though its safe employment in this way is most fortunate.

In the schedule of applications only two arsenate of lead treatments are recommended, as these will measurably control the curculio and a third treatment would considerably increase the danger of injury. Where the curculio is very destructive, however, the grower should use his judgment as to whether a third application of the poison would be advantageous.

The effect of the arsenate of lead upon the fruit is to increase its color notably. This increase in color from two applications in self-boiled lime-sulphur wash improves the appearance of the fruit. Three or even two applications of the poison alone or in limewater, however, result in a very excessive reddening, especially on the side exposed to the sun, on which later may appear brown, sunken spots of variable size, accompanied with more or less extensive cracking of the skin. This condition of the fruit is shown in figure 13.

The self-boiled lime-sulphur mixture when properly prepared according to directions does not injure the fruit or foliage, but if allowed to remain hot in concentrated form before dilution enough sulphur may go into solution to produce injury to the foliage. Users of this spray should therefore follow carefully the directions given for its preparation, bearing in mind that a good mechanical mixture of the sulphur and lime suspended in water and only slightly combined is desired rather than to dissolve any considerable quantity of the sulphur.

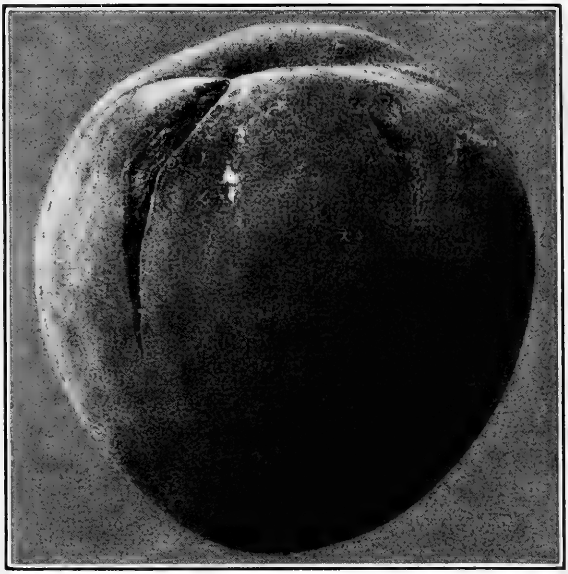

FIG. 13.—Elberta peach sprayed three times with arsenate of lead, showing the browning and cracking effect of the poison.

During the application of the spray, it is very important that the mixture be kept well agitated to insure its uniform distribution. As both the self-boiled lime-sulphur wash and the arsenate of lead quickly settle when the spray is left undisturbed, an excessive amount may be applied to some trees, while others receive an insufficient quantity. While most spraying equipments are supplied with adequate agitating apparatus, the orchardist should assure himself that the spray is being properly stirred in the tank during its application. Under conditions of imperfect agitation and consequent settling, the ingredients of the spray may be applied so strong that serious injury will result. This has been observed to be the case, especially following the employment of compressed-air sprayers with inefficient agitators.

COST OF TREATMENT.

The cost of the combined treatment for the control of brown-rot, scab, and curculio is insignificant when compared with the resulting benefits. The trees at Baldwin, Ga., were sprayed with a good hand outfit, and 3 men were able to spray 1,000 trees a day. With labor at 75 cents a day (the wages paid in that section), arsenate of lead at 10 cents a pound, sulphur at 2½ cents a pound, and lime at $1.10 a barrel, the cost for three treatments was $27.60 a thousand, or a little less than 3 cents a tree. At Fort Valley, Ga., a gasoline-power sprayer was used. The trees there were larger and the water was not so convenient, making the cost somewhat higher than at Baldwin. In this case the cost of three treatments was $32 a thousand, or a little more than 3 cents a tree. Where wages are higher the cost will be somewhat greater. For three treatments, the first with arsenate of lead alone, the second with self-boiled lime-sulphur and arsenate of lead, and the third with self-boiled lime-sulphur alone, the cost will range from 3 to 5 cents per tree, depending upon the labor conditions, the size of the trees, the convenience of the water supply, and the equipment used. For average-sized 7-year-old trees, as a rule 1 gallon of spray per tree will be required for each application. In the first application not quite so much will be required, owing to scant foliage at that time, while a little more will be required for the second treatment. The third application should be lighter than the second, using finer nozzles so as to avoid staining the fruit with blotches of lime.

From the experience of the writers it seems safe to conclude that in most of the peach orchards of the eastern United States an increase per tree of at least one-half bushel of good merchantable fruit, worth about 50 cents, may be obtained from spraying at a cost of 3 to 5 cents. Spraying, therefore, is the most profitable of all the orchard operations.

SCHEDULE OF APPLICATIONS.

Most of the peach orchards in the eastern half of the United States should be given the combined treatment for brown-rot, scab, and curculio. This is particularly true of the southern orchards, where all these troubles are prevalent. In some of the more northern orchards the curculio is not very troublesome, but as a rule it will probably pay to add the arsenate of lead in at least the first lime-sulphur application.

The self-boiled lime-sulphur mixture referred to in the following outlines of treatment should be made of a strength of 8 pounds of lime and 8 pounds of sulphur to each 50 gallons of water, and the arsenate of lead should be used at the rate of 2 pounds to each 50 gallons of the mixture or of water. When the poison is used in water there should be added the milk of lime made from slaking 2 to 3 pounds of good stone lime. When used in the lime-sulphur mixture additional lime will not be necessary.

Midseason varieties.—The midseason varieties of peaches, such as Reeves, Belle, Early Crawford, Elberta, Late Crawford, Chairs, Fox, and Beers Smock, should be sprayed as follows:

(1) With arsenate of lead alone, about 10 days after the petals fall, or at the time the calyxes are shedding. (Fig. 14.)

FIG. 14.—Young peaches, showing the earliest and latest stages at which the first arsenate of lead treatment should be made.

(2) With self-boiled lime-sulphur and arsenate of lead, two weeks later, or four to five weeks after the petals have been shed.

(3) With self-boiled lime-sulphur alone, four to five weeks before the fruit ripens.

Late varieties.—The Salway, Heath, Bilyeu, and varieties with a similar ripening period should be given the same treatment prescribed for midseason varieties, with an additional treatment of self-boiled lime-sulphur alone, to be applied three or four weeks after the second application.

Early varieties.—The Greensboro, Carman, Hiley, Mountain Rose, and varieties having the same ripening period should receive the first and second applications prescribed for midseason varieties.

Where the curculio is not particularly bad, as in Connecticut, western New York, and Michigan, the first treatment, which is for this insect only, may be omitted. Also for numerous orchards throughout the Middle States where the insect, especially in the younger orchards, is not yet very troublesome, orchardists should use their judgment as to whether the first application may be safely omitted. Where peach scab is the chief trouble, and brown-rot and curculio are of only minor importance, as may be the case in some of the Allegheny Mountain districts, satisfactory results may be had from two applications, namely, the first with self-boiled lime-sulphur and arsenate of lead four to five weeks after the petals fall, and the second treatment of the above schedule with self-boiled lime-sulphur alone three to four weeks later. These two treatments, if thoroughly applied, will control the scab and brown-rot, especially on the early and midseason varieties, and will materially reduce curculio injuries. Even one application of the combined spray made about five weeks after the petals fall would pay well, although this is recommended only for conditions where it is not feasible to do more.

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FARMERS' BULLETIN 442.

THE TREATMENT OF BEE DISEASES.

BY

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1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., February 24, 1911.

Sir: I have the honor to transmit herewith a manuscript entitled "The Treatment of Bee Diseases," by E. F. Phillips, Ph. D., in charge of bee culture in this bureau. In the preparation of this paper, which is intended to supersede Circular 79, of this bureau, the aim has been to give briefly the information needed by the beekeeper who has disease in his apiary. No discussion of the cause or distribution of these diseases has been included. I recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

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THE TREATMENT OF BEE DISEASES.

INTRODUCTION.

The diseases which attack the honey bee may be divided into two classes, namely, those affecting the brood and those to which the adult bees are subject. The diseases of adult bees have not been investigated sufficiently to make it possible at the present time to recommend methods for their treatment. In the present bulletin, therefore, only a brief statement concerning these diseases will be made, mainly for the purpose of indicating the present state of knowledge on these subjects. Concerning the diseases of the brood more is known, and this is particularly fortunate since they are far more destructive in American apiaries than are the diseases of the adult bees.

The causes of bee diseases will not be discussed here. For information on this phase of the subject the reader is referred to other publications of the Bureau of Entomology, which are listed at the end of this bulletin. The aim of this bulletin is to give information that can be used by the practical beekeeper in combating bee diseases.

THE BROOD DISEASES OF BEES.

The brood diseases of the honey bee are already widely distributed in the United States and seem to be spreading rather rapidly. The loss to the beekeepers of the country, owing to the actual death of colonies by disease, is estimated conservatively at $1,000,000 annually. This does not include the loss of crops, resulting from the destruction of colonies, or the discouragement to the beekeeper which often causes him to give up the business. A considerable part of this loss is due to the indifference of the beekeepers to these diseases and a lack of knowledge concerning them.

It frequently happens that colonies in an apiary become infected before the owner realizes that disease is present. He may erroneously attribute the losses observed to some other cause. In this way the disease gets a start which makes eradication difficult when once the cause of the loss has been discovered. In view of the widespread distribution of these diseases, it is most desirable that all beekeepers learn to distinguish the diseases when they appear and to know how to keep them under control.

It is often a matter of surprise to beekeepers to learn that bees are subject to disease. The most frequent source of confusion is the placing of the blame for loss of colonies on some cause other than disease. The poorer class of beekeepers attribute their losses simply to "bad luck," but even well-informed beekeepers err in this matter.

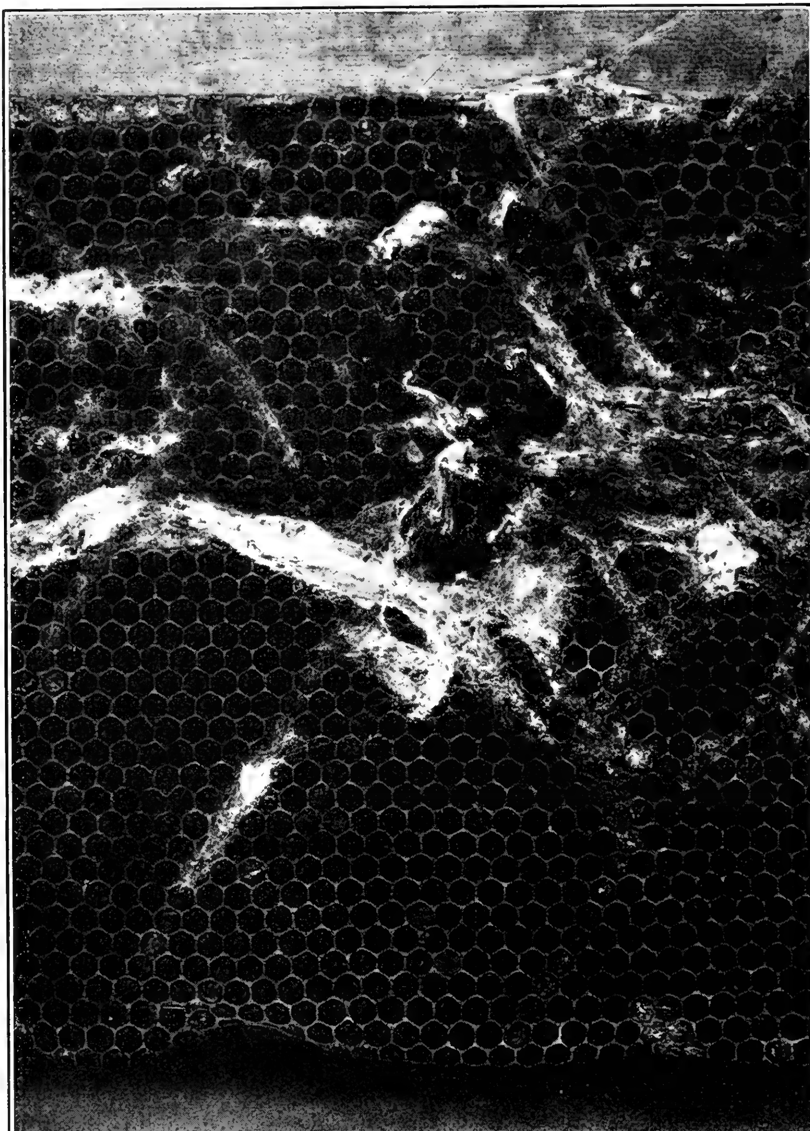


FIG. 1.—Work of the larger wax moth in a brood comb. (Original.)

The wax moths (see fig. 1) are most frequently blamed for the death of colonies, whereas they do no damage to strong, healthy colonies, properly cared for, but enter only when the colony is weakened by queenlessness, lack of stores, disease, or some other cause. In the majority of the reports of wax-moth depredations received by this department which can be investigated it is found that the trouble is actually an outbreak of a brood disease.

The spraying of fruit trees while in bloom is possibly injurious to bees, and there exists among beekeepers a strong feeling against the practice. Since no entomologist now recommends that fruit trees be sprayed during the blooming period, this is probably rarely done by progressive fruit growers. However, it is frequently reported by beekeepers that they are losing bees by poisoning due to spraying. A number of cases of the death of colonies, reported as caused by poisoning due to spraying while trees were in bloom, have been found to be in reality outbreaks of European foul brood, which is particularly prevalent in the spring and early summer.

Other circumstances to which is often attributed the death of brood or of the colony are chilling, fumes from coke ovens, and malicious poisoning. The wise attitude on the part of the beekeeper is first to suspect diseases as being the cause of any losses which he may sustain, and to be sure that there is no infectious disease present before looking elsewhere for a cause.

NATURE OF THE DISEASES.

There are two recognized infectious diseases of the brood of bees, now known as American foul brood and European foul brood. Both diseases weaken colonies by reducing the number of emerging bees needed to replace the old adult bees which die from natural or other causes. In neither case are adult bees affected, so far as known. The means used by the beekeeper in deciding which disease is present is the difference in the appearance of the larvæ dead of the two diseases. That the diseases are entirely distinct can not now be doubted, since they show certain differences in the age of the larvæ affected, in their response to treatment, and in the appearance of the dead larvæ. This is made still more certain by a study of the bacteria present in the dead larvæ. Reports are sometimes received that a colony is infected with both diseases at the same time. While this is possible, it is not by any means the rule, and such cases are usually not authentically reported. There is no evidence that chilled or starved brood develops into an infectious disease or that dead brood favors the development of a disease.

NAMES OF THE DISEASES.

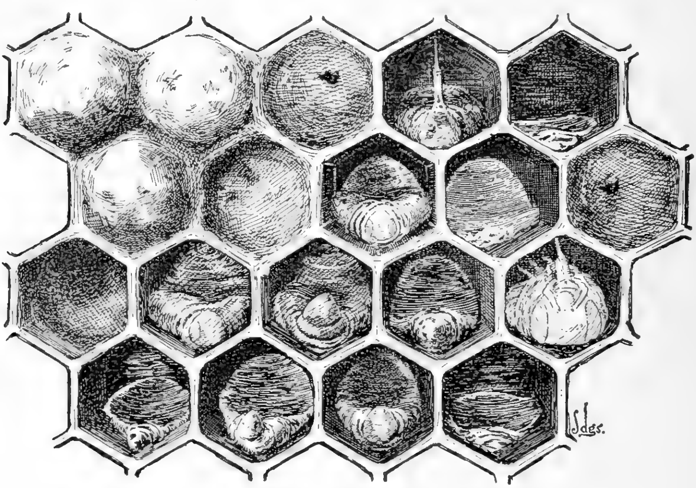
The names American foul brood and European foul brood were applied to these diseases by the Bureau of Entomology, of this department, to clear up the confusion in names which formerly existed. By retaining the words "foul brood" in each name the disease-inspection laws then in force could be interpreted as applying to both diseases. These names were in no way intended to designate geographical distribution, since both diseases did exist and do now exist in both Europe and America, but were chosen primarily because they were convenient and easily remembered names. Their only significance is in indicating where the diseases were first seriously investigated. It was particularly desirable to change the name of the disease now known as European foul brood, since "black brood" entirely fails to be descriptive and is misleading.

SYMPTOMS.

The presence of a particular disease in a colony of bees can be ascertained most reliably by a bacteriological examination, since the symptoms are somewhat variable. It is possible, however, to describe the usual manifestations of the diseases, and the usual differences, so that the beekeeper can in most cases tell which disease is present.

American Foul Brood.

American foul brood is frequently called simply "foul brood." It usually shows itself in the larva just about the time that the larva fills the cell and after it has ceased feeding and has begun pupation.



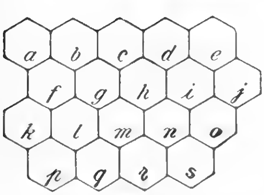


Fig. 2.—American foul brood: *a, b, f,* normal sealed cells; *c, j,* sunken cappings, showing perforations; *g,* sunken capping not perforated; *h, l, m, n, q, r,* larvæ affected by disease; *e, i, p, s,* scales formed from dried-down larvæ; *d, o,* pupæ affected by disease. Three times natural size. (Original.)

At this time it is sealed over in the comb (fig. 2, *a, b, f*). The first indication of the infection is a slight brownish discoloration and the loss of the well-rounded appearance of the normal larva (fig. 2, *l*). At this stage the disease is not usually recognized by the beekeeper. The larva gradually sinks down in the cell and becomes darker in color (fig. 2, *h*, *m*), and the posterior end lies against the bottom of the cell. Frequently the segmentation of the larva is clearly marked. By the time it has partially dried down and has became quite dark brown (coffee colored) the most typical characteristic of this disease manifests itself. If a match stick or tooth-pick is inserted into the decaying mass and withdrawn the larval remains adhere to it and are drawn out in a thread (fig. 3), which sometimes extends for several inches before breaking. This ropiness is the chief characteristic used by the bee-keeper in diagnosing this disease. The larva continues to dry down and gradually loses its ropiness until it finally becomes merely a scale on the lower side wall and base of the cell (fig. 2, *e*, *p*, *s*). The scale formed by the dried-down larva adheres tightly to the cell and can be removed with difficulty from the cell wall. The scales can best be observed when the comb is held with the top inclined toward the observer so that a bright light strikes the lower side wall (fig. 4).

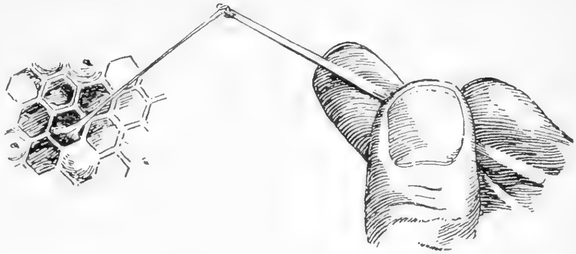


FIG. 3.—The ropiness of American foul brood. (Original.)

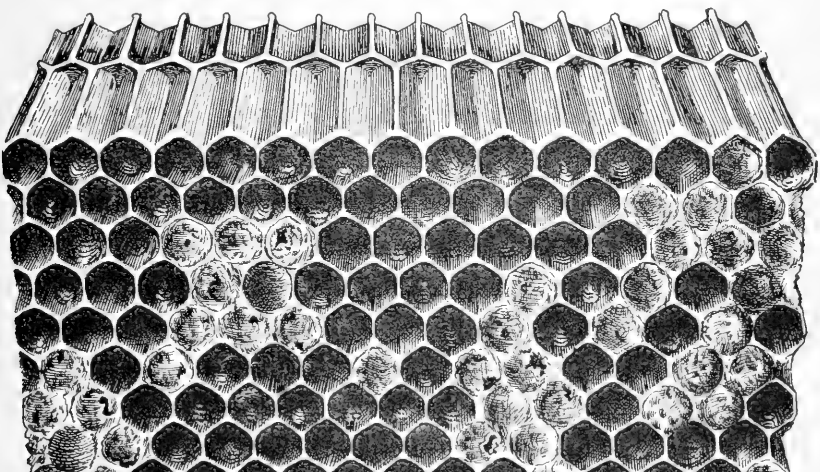


FIG. 4.—American foul-brood comb, showing irregular patches of sunken cappings and scales. The position of the comb indicates the best way to view the scales. (Original.)

A very characteristic and usually penetrating odor is often noticeable in the decaying larvæ. This can perhaps best be likened to the odor of heated glue.

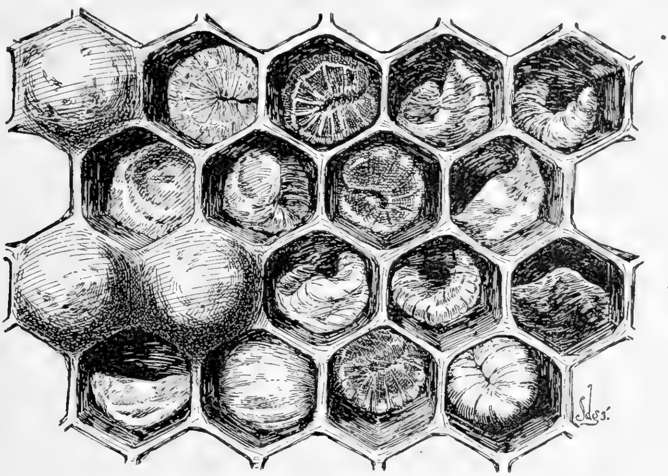
The majority of the larvæ which die of this disease are attacked after being sealed in the cells. The cappings are often entirely removed by the bees, but when they are left they usually become sunken (fig. 2, *g*, *c*, *j*) and frequently perforated (fig. 2, *c*, *j*). As the healthy brood emerges the comb shows the scattered sunken cappings covering dead larvæ (fig. 4), giving it a characteristic appearance.

Pupæ also may die of this disease, in which case they, too, dry down (fig. 2, *o*, *d*), become ropy, and have the characteristic odor and color. The tongue frequently adheres to the upper side wall and often remains there even after the pupa has dried down to a scale. Younger unsealed larvæ are sometimes affected. Usually the disease attacks only worker brood, but occasional cases are found in which queen and drone brood are diseased. It is not certain that race of bees, season, or climate have any effect on the virulence of this disease, except that in warmer climates, where the breeding season is prolonged, the rapidity of devastation is more marked.

European Foul Brood.

European foul brood was formerly called "black brood" or "New York bee disease." The name "black brood" was a poor one, for the color of the dead brood is rarely black or even very dark brown. European foul brood usually attacks the larva at an earlier stage of its development than American foul brood and while it is still curled up at the base of the cell (fig. 5, *r*). A small percentage of larvæ dies after capping, but sometimes quite young larvæ are attacked (fig. 5, *e*, *m*). Sunken and perforated cappings are sometimes observed just as in American foul brood (fig. 2, *c*, *g*, *j*). The earliest indication of the disease is a slight yellow or gray discoloration and uneasy movement of the larva in the cell. The larva loses its well-rounded, opaque appearance and becomes slightly translucent, so that the tracheæ may become prominent (fig. 5, *b*), giving the larvæ a clearly segmented appearance. The larva is usually flattened against the base of the cell, but may turn so that the ends of the larva are to the rear of the cell (fig. 5, *p*), or may fall away from the base (fig. 5, *e*, *g*, *l*). Later the color changes to a decided yellow or gray and the translucency is lost (fig. 5, *q*, *h*). The yellow color may be taken as the chief characteristic of this disease. The dead larva appears as a moist, somewhat collapsed mass, giving the appearance of being melted. When the remains have become almost dry (fig. 5, *c*) the tracheæ sometimes become conspicuous again, this time by retaining their shape, while the rest of the body content dries around them. Finally all that is left of the larva is a grayish-brown scale against the base of the cell (fig. 5, *f*, *h*), or a shapeless mass on the lower side wall if the larva did not retain its normal position (fig. 5, *n*, *o*). Very few scales are black. The scales are not adhesive, but are easily removed, and the bees carry out a great many in their efforts to clean house.

Decaying larvæ which have died of this disease are usually not ropy as in American foul brood, but a slight ropiness is sometimes observed. There is usually little odor in European foul brood, but sometimes a sour odor is present, which reminds one of yeast fermentation. This disease attacks drone and queen larvæ[1] almost as quickly as those of the workers.



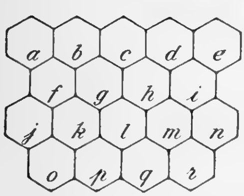


FIG. 5.—European foul brood: *a*, *j*, *k*, normal sealed cells; *b*, *c*, *d*, *e*, *g*, *i*, *l*, *m*, *p*, *q*, larvæ affected by disease; *r*, narmal larva at age attacked by disease; *f*, *h*, *n*, *o*, dried-down larvæ or scales. Three times natural size. (Original.)

European foul brood is more destructive during the spring and early summer than at other times, often entirely disappearing during late summer and autumn, or during a heavy honey flow. Italian bees seem to be better able to resist the ravages of this disease than any other race. The disease at times spreads with startling rapidity and is most destructive. Where it is prevalent a considerably larger percentage of colonies is affected than is usual for American foul brood. This disease is very variable in its symptoms and other manifestations and is often a puzzle to the beekeeper.

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[1] The tendency of this disease to attack queen larvæ is a serious drawback in treatment. Frequently the bees of a diseased colony attempt to supersede their queen, but the larvæ in the queen cells often die, leaving the colony hopelessly queenless. The colony is thus depleted very rapidly.

The So-Called "Pickle Brood."

In addition to the two infectious diseases just described, brood dead from other causes is often observed. The most common disease of this kind is what is known among beekeepers as "pickle brood." This name is seemingly applied to a great many different appearances and nothing is known of the cause or methods of spread. The most typical form kills the larva when it has extended itself in the cell. The larva usually lies on its back with the head turned upward. The color varies, but is frequently light yellow or brown, and the head is often almost black. The body is swollen and the contents watery, and the head may be quite hard. There is no ropiness. In case the larvæ are sealed before dying the cappings are usually normal. The name usually applied to this condition was unwisely chosen, and for the present and until more is known concerning the disease it is spoken of as the "so-called pickle brood."

This trouble does not appear to be infectious and is usually not serious, except that in the aggregate it may cause loss by weakening colonies. No treatment is necessary, as the trouble usually soon disappears. The most serious aspect of this disease is that it is often mistaken for one of the infectious diseases, and the colony is needlessly treated.

Brood dead of other causes.

Many different external factors may cause brood to die. If brood is killed by chilling in the spring or fall, or by overheating in extremely hot weather, or in shipping colonies of bees, or by starvation, the loss is often mistakenly attributed to an infectious disease. Such dead brood is soon removed by the bees. When the cause is removed the trouble then soon disappears. When a considerable quantity of brood is killed a disagreeable odor is usually present.

"Bald-headed brood."

It sometimes happens that unsealed or only partially sealed pupæ, known as "bald-headed brood," are observed in the hive, and frequently beginners mistake such a condition for disease. The partially built capping is often mistaken for the punctured capping of American foul brood. If, on examination, the pupæ are normal no fear need be entertained.

METHODS OF SPREAD.

Both American foul brood and European foul brood spread from colony to colony and from apiary to apiary in much the same way. The common means of carrying the virus is in honey which has become contaminated. The disease may be carried when bees rob a hive in which a colony has died of disease or may be transmitted by the use of honey from diseased colonies for feeding bees. It is not always necessary that bees be intentionally fed for them to get disease from contaminated honey. Discarded honey receptacles which have contained honey from a contaminated colony, if not thoroughly cleaned, may contain enough honey to carry disease to a healthy apiary. This may occur in the vicinity of bakeries or confectionery shops, or may even occur when empty honey bottles are thrown out from private houses. It is also possible to introduce disease into a colony in introducing queen bees purchased from a distance, probably due to the use of contaminated honey in making the candy to supply the queen cages.

Precautionary Measures.

In combating diseases it is much better to prevent disease from getting a foothold than it is to eradicate it after it has begun its work. All beekeepers, wherever located, should practice the following precautionary measures:

(1) If a colony becomes weak from any cause, or if disease is suspected, contract the entrance to prevent robbing, and if robbing is imminent close the entrance entirely.

(2) *Never feed honey purchased on the open market.* In case of doubt as to the source of honey feed sugar sirup.

(3) If within the range of possibility, see that no honey that comes from diseased apiaries is sold in the neighborhood. This may sometimes be accomplished by cultivating the home market so that there will be no incentive for bringing in other honey.

(4) In introducing purchased queens, transfer them to clean cages provided with candy known to be free from contamination, and destroy the old cage, candy, and accompanying workers. Of course, if it is certain that the queen comes from a healthy apiary this is not necessary.

(5) Colonies of bees should never be purchased unless it is certain that they are free from disease.

(6) The purchase of old combs or second-hand supplies is dangerous, unless it is certain that they came from healthy apiaries.

TREATMENT FOR BOTH INFECTIOUS DISEASES.

The treatment of an infectious bee disease consists primarily in the elimination or removal of the cause of the disease. It is definitely known that American foul brood is caused by a bacillus named *Bacillus larvæ*. In treating this disease, therefore, the aim of the manipulation is to remove or destroy all of the bacteria of this species. It should be remembered that the effort is not to save the larvæ that are already dead or dying, but to stop the further devastation of the disease by removing all material capable of transmitting the cause of the trouble.

The cause of European foul brood is not definitely known, but the same principles of treatment doubtless apply in this disease also. In all of the operations great pains should be taken not to spread the disease through carelessness. After handling a diseased colony the hands of the operator should be washed with water to remove any honey that may be on them. It does not pay to treat colonies that are considerably weakened by disease. In case there are several such colonies they should be united to form strong, vigorous colonies before or during treatment.

In discussing treatment it is assumed that hives with movable frames are in use. Box hives are a menace in regions where disease is present. These may be treated for disease by drumming the colony into another box and then hiving it like a swarm in a hive, but box hives are not profitable and are especially to be condemned where disease is present on account of the difficulty in inspecting and treating.

Shaking Treatment.

The shaking treatment consists essentially in the removal of all infected material from the colony, and in compelling the colony to take a fresh start by building new combs and gathering fresh stores. This is done by shaking the bees from the old combs into a clean hive on clean frames.

Time of treatment.—The shaking treatment should be given during a flow of honey, so that other bees in the apiary will not be inclined to rob. If this is not possible the operation may be performed under a tent made of mosquito netting. The best time is during the middle of a clear day when a large number of bees are in the field. It is sometimes recommended that shaking be done in the evening, but this is impossible if many colonies are to be treated. The colony can be handled more quickly when the field force is out of the hive.

Preparation.—All implements that will be needed, such as queen and drone trap, hive tool, and lighted smoker, should be in readiness before the operation is begun. A complete clean hive with frames is provided, as well as a tightly closed hive body in which to put the contaminated combs after shaking. An extra hive cover or some similar apparatus should be provided to serve as a runway for the bees as they enter the new hive. The new frames should contain strips of comb foundation from one-fourth to 1 inch wide. Full sheets are not desirable, and if combs built on full sheets of foundation are desired they may be built later.

Operation.—The old hive containing the diseased colony (fig. 6, *A*) is now lifted to one side out of the flight of returning field bees and the clean hive (*B*) set exactly in its place. The cover (*G*) is now taken off and a few frames (E) removed from the center of the hive. If unspaced frames are used, those remaining in the hive should be pushed tightly to either side of the hive, thus making a barrier beyond which the bees can not crawl as they move to the top of the hive after shaking. This largely prevents them from getting on the outside of the hive. If self-spacing frames are used, a couple of thin boards laid on the top bars on either side will accomplish the same result. The runway (D) is put in place in front of the entrance. The old hive is now opened for the first time. The frames are removed one at a time, lowered part way into the new hive, and with a quick downward shake the bees are dislodged. The frames are then put into the extra hive body (C) and immediately covered to prevent robbing. After all the frames are shaken the bees remaining on the sides of the old hive (A) are shaken out.

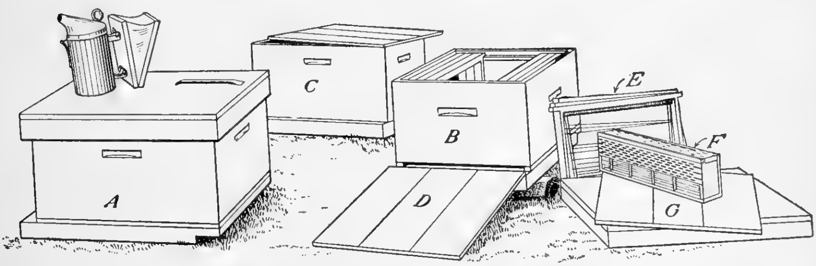

FIG. 6.—Apparatus for the shaking treatment: *A*, Hive containing diseased colony (formerly in position of *B*); *B*, clean hive; *C*, empty hive to receive combs after shaking; *D*, hive cover used as runway; *E*, frames removed from *B* to give room for shaking; *F*, queen and drone trap; *G*, cover for clean hive, *B*. (Original.)

If honey is coming in freely, so that thin honey is shaken out of the combs, cover the runway (D) with newspapers and shake the bees in front of the new hive (B), leaving all frames in place and the cover on. After the operation the soiled newspapers should be destroyed. In shaking in front of the entrance the first one or two frames should be so shaken that the bees are thrown against the entrance, where they can locate the hive quickly. They then fan their wings and the others follow them into the hive. If this is not done the bees may wander about and get under the hive or in some other undesirable place.

After the bees are mostly in the new hive a queen and drone trap (F) or a strip of perforated zinc is placed over the entrance to prevent the colony from deserting the hive. The queen can not pass through the openings in the perforated zinc and the workers will not leave without her. By the time that new combs are built and new brood is ready to be fed, any contaminated honey carried by the bees into their new hive will have been consumed and the disease will rarely reappear. If it should, a repetition of the treatment will be necessary.

Saving the healthy brood.—The old combs are now quickly removed. If several colonies are being treated at one time it may pay to stack several hive bodies containing contaminated combs over a weak diseased colony to allow most of the healthy brood to emerge, thereby strengthening the weak colony. After 10 or 12 days this colony is treated in turn and all the combs rendered into wax. If only one or two colonies in a large apiary are being treated it will not pay to do this.

Saving the wax.—Any but a very small apiary should have included in its equipment a wax press for removing wax from old combs. After the contaminated frames are taken to the honey house the combs should be kept carefully covered, so that no bees can reach them until the wax can be rendered. This should not be delayed very long or the combs may be ruined by wax moths. The slumgum or refuse remaining after the wax is removed should be burned. Contaminated combs should not be put into a solar wax extractor for fear of spreading the disease. The wax from contaminated combs may safely be used for the manufacture of comb foundation.

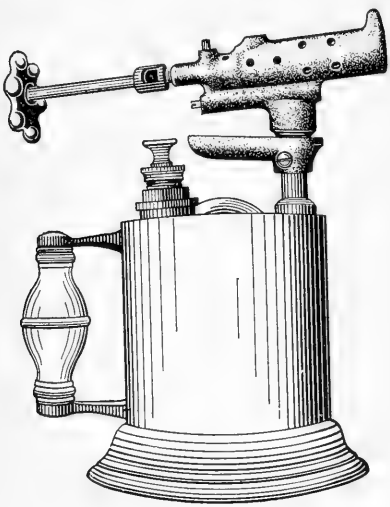

FIG. 7.—Gasoline torch. (Original.)

Cleaning the hive.—The hive which has contained the diseased colony should be thoroughly cleaned of all wax and honey, and it is desirable that it be carefully disinfected by burning out the inside with a gasoline blue-flame torch (fig. 7). If this piece of apparatus is not available several hive bodies may be piled together on a hive bottom and some gasoline or kerosene poured on the sides and on some straw or excelsior at the bottom. This is then ignited and after burning for a few seconds a close-fitting hive cover is placed on top of the pile to extinguish the flames. The inside of the hive bodies should be charred to a light brown. The careful cleaning and disinfection of frames always costs considerably more in labor than new frames would cost, but these also may be carefully cleaned and used again. Frames may be cleaned by boiling in water for about half an hour, but this frequently causes them to warp badly. The disinfection of hives and frames with chemicals is not recommended, as the ordinary strengths used are valueless for the purpose.

Disposal of the honey.—If there is a considerable quantity of honey in the contaminated combs it may be extracted. This honey is not safe to feed to bees without boiling, but it is absolutely safe for human consumption. If there is a comparatively small quantity it may be consumed in the beekeeper's family, care being taken that none of it is placed so that the bees can ever get it.

To put such honey on the market is contrary to law in some States. There is always danger that an emptied receptacle will be thrown out where bees can have access to it, thus causing a new outbreak of disease. It can be safely used for feeding to bees, provided it is diluted with at least an equal volume of water to prevent burning, and boiled in a closed vessel for not less than one-half hour, counting from the time that the diluted honey first boils vigorously. The honey will not be sterilized if it is heated in a vessel set inside of another containing boiling water. Boiled honey can not be sold as honey. It is good only as a food for bees, and even then should never be used for winter stores, as it will probably cause dysentery.

The second shake.—Some beekeepers prefer to shake the bees first onto frames containing strips of foundation as above described, and in four days to shake the colony a second time onto full sheets of foundation, destroying all comb built after the first treatment. This insures better combs than the use of strips of foundation, but is a severe drain on the strength of the colony. Since it is desirable to have combs built on full sheets, the best policy is to replace any irregular combs with full sheets of foundation or good combs later in the season.

The cost of shaking.—If the treatment just described is given at the beginning of a good honey flow, it is practically equivalent to artificial swarming and results in an actual increase in the surplus honey, especially in the case of comb-honey production. The wax rendered from the combs will sell for enough to pay for the foundation used if full sheets of foundation are employed. Since a colony so treated actually appears to work with greater vigor than a colony not so manipulated, the cost of treatment is small. If treatment must be given at some other time, so that the colony must be fed, the cost is materially increased. In feeding, it is best to use sugar sirup, or honey that is known to have come from healthy colonies.

Treatment with Bee Escape.

As a substitute for the shaking treatment just described, the bees may be removed from their old combs by means of a bee escape. The old hive is moved to one side and in its place is set a clean hive with clean frames and foundation. The queen is at once transferred to the new hive and the field bees fly there on their return from the field. The infected hive is now placed on top of or close beside the clean hive and a bee escape placed over the entrance, so that the younger bees and those which later emerge from the cells may leave the contaminated hive but can not return. They therefore join the colony in the new hive. If desired, the infected hive may be placed above the clean hive and a tin tube about 1 inch in diameter placed from the old entrance so that the lower end is just above the open entrance of the new hive. The bees follow down this tube and on their return enter the new hive. When all of the healthy brood has emerged from the infected combs the old hive is removed. This treatment induces less excitement in the apiary and is preferred by many experienced beekeepers. Care should be taken that the old hive is absolutely tight to prevent robbing. The old hive and its contents of honey and wax are treated as indicated under the shaking treatment.

Fall Treatment.

If it is necessary to treat a colony so late in the fall that it would be impossible for the bees to prepare for winter, the treatment may be modified by shaking the bees onto combs entirely full of honey so that there is no place for any brood to be reared. This will usually be satisfactory only after brood rearing has entirely ceased. Unless a colony is quite strong it does not pay to treat in the fall, but it should be destroyed or united to another colony. In case a diseased colony dies outdoors in the winter there is danger that other bees may have opportunity to rob the hive before the beekeepers can close the entrance. In case bees are wintered in the cellar it is more advisable to risk wintering before treatment, for if the colony does die the hive will not be robbed.

Drugs.

Many European writers have in the past advocated the use of various drugs for feeding, in sugar sirup, to diseased colonies, or the fumigation of contaminated combs. In the case of American foul brood, of which the cause is known, it has been found that the drugs recommended are not of the slightest value and no time should be wasted in their use.

TREATMENT FOR EUROPEAN FOUL BROOD.

European foul brood is a very peculiar disease and its cause has not yet been satisfactorily determined. It is, therefore, impossible to discuss the treatment of this disease as definitely as that of American foul brood. From the experience of many careful beekeepers it is, however, possible to suggest some additional manipulations which may be tried by experienced beekeepers. The treatments given previously are strongly recommended for this disease.

Introduction of Italian Stock.

Since, as stated previously (p. 11), Italian bees seem to be better able to withstand European foul brood than are other races, it is recommended that apiaries in regions where this disease is prevalent be requeened with young, vigorous Italian queens of good stock. This should be done whether or not the shaking treatment is given.

Dequeening.

It has been found that the removal of the queen and the keeping of the colony queenless for a period often results in the disappearance of European foul brood. The length of time that this should be done is in dispute. Mr. E. W. Alexander, who advocated this method,[1] recommended that the colony be kept queenless (by cutting out all queen cells at the end of 9 days) for a period of 20 days, at which time a cell containing a queen of Italian stock ready to emerge is to be given the colony. The young queen will thus begin to lay in about 27 days after the old queen has been removed, or in at least 3 days after the last of the drone brood has emerged. Other writers have advocated a shorter time.

The dequeening treatment is not always successful, and it is therefore recommended that care be exercised in trying it. Since there is a considerable percentage of successful results, this would indicate that there is an important principle involved. It should not be forgotten, however, that European foul brood often disappears in the late summer of its own accord if the case is not severe (p. 11), and it is probable that in many of the cases of dequeening reported as successful the disease would have disappeared without the treatment. This treatment is suggested only for the experienced beekeeper.

INSPECTION OF APIARIES.

Several States have passed laws providing for the inspection of apiaries for contagious disease and creating the office of apiary inspector. The men holding these offices are usually practical beekeepers, capable of giving excellent advice regarding disease, and it is desirable, when disease exists in a community, that the owners of apiaries take steps to learn who the inspector is and to notify him of the existence of disease. The Bureau of Entomology of this department can usually give information concerning the inspector and is always glad to be of service in bringing the beekeepers and inspectors in touch with one another.

Apiary inspection has proved beneficial to the beekeeping industry in spreading information concerning the nature, symptoms, and

[1] Alexander, E. W.—How to rid your apiary of black brood. Gleanings in Bee Culture, vol. 33, pp. 1125–1127, 1905.

treatment of the contagious diseases and particularly in compelling negligent and careless beekeepers to treat their diseased colonies. It is quite possible for the individual beekeeper to clean up his own apiary by following the directions given in this bulletin, but unless all of the beekeepers in the neighborhood do the same thing there will probably be a recurrence of the trouble due to infection from outside apiaries. It is therefore manifestly to the advantage of the beekeepers that they cooperate with the inspectors in the fight against diseases.

EXAMINATION OF SAMPLES OF DISEASED BROOD.

The Bureau of Entomology of this department is prepared to assist in the diagnosis of disease in cases where the beekeeper is unable to tell whether or not disease is present, or to determine which disease is in his apiary. Samples of brood comb about 5 inches square containing diseased or dead larvæ should be sent by mail in a strong wooden or tin box. The comb should not be wrapped in paper or cotton, but should be cut to fit the box closely. It is not possible to diagnose from empty combs, and no honey should be included in the sample, as it is valueless in diagnosis and will probably spoil the sample as well as other mail matter. The name of the sender must always appear on the package, and any available data should be sent in a separate letter. Never inclose a letter in the box with the sample.

THE DISEASES OF ADULT BEES.

The diseases affecting adult bees are but imperfectly known. At present four are known to beekeepers by name. Whether these are entirely distinct or whether under each name one or more diseases are included is not known. As stated in the introduction, these diseases have not been sufficiently investigated to give much help to the practical beekeeper.

DYSENTERY.

Dysentery affects bees only in the winter and is manifested by a distension of the abdomen, due to an accumulation of fecal matter in the intestine. When a day warm enough for flight occurs the bees fly from the hive to cleanse themselves, and the hive and surroundings are spotted with yellow excreta. After a good cleansing flight the trouble usually disappears, but if the bees are unable to fly they often die in great numbers. It is generally believed that dysentery is due to improper winter stores, the honey containing too high a percentage of indigestible matter. Honeydew honey almost always produces dysentery, while bees wintered on high-class honey or sugar sirup are not affected. From the wide experience of many beekeepers in this matter it is safe to assume that this explanation of the disease is the correct one, and consequently great care should be exercised that the colonies are provided with good stores for winter.

Recently it has been claimed that there are two types of dysentery, one form as above described and another form which is infectious. American beekeepers are not familiar with an infectious dysentery, and in practical manipulations it is necessary to consider only the type above described.

THE SO-CALLED PARALYSIS.

It is quite possible that under the name "paralysis" are included several distinct diseases. This is indicated by the variety of symptoms reported by beekeepers and the number of different seasons and conditions under which the disease is supposed to occur. The usual manifestation described is that the worker bees are seen crawling in front of the hive with their abdomens trembling. The abdomens are also frequently distended. The bees often climb grass blades and on attempting to fly from the top fall again to the ground. Frequently the bees so affected are almost hairless. The same trembling motion may often be observed on opening the hive. The colony is often depleted very rapidly. There is no evidence that the disease is infectious.

The cause of this peculiar trouble is unknown, and no remedy can be recommended. It is claimed by some writers that a salt-water spray applied to the combs or salt or sulphur sprinkled on the top bars or entrance is sometimes an effective remedy.

ISLE OF WIGHT DISEASE.

Recently a supposedly infectious disease of adult bees has decimated the bees on the Isle of Wight and is said to be spreading in England. It resembles somewhat the so-called paralysis. No treatment other than destruction to prevent the spread of the disease has been recommended. So far as is known no trouble of this kind has been experienced in America.

SPRING DWINDLING.

It sometimes happens that the adult bees in a colony die off in the spring more rapidly than they are replaced by emerging brood. This dwindling may be diminished somewhat by keeping the colony warm and by stimulative feeding, so that all of the energy of the old bees may be used to the best advantage. This condition is probably due to the fact that the colony goes into winter with too large a percentage of old worn-out bees. To prevent this, brood rearing should be continued as late as possible in the fall; if necessary, by stimulative feeding.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE ON BEE DISEASES.

There are several other publications of the Bureau of Entomology of this department which deal with bee diseases. They may be obtained on request to the Editor and Chief of the Division of Publications, Department of Agriculture, and are the following:

Circular No. 94, "The Cause of American Foul Brood." By G. F. White, Ph. D. 1907. 4 pp.

This publication contains a brief account of the investigations which demonstrated for the first time the cause of one of the brood diseases of bees, American foul brood.

Bulletin No. 70, "Report of the Meeting of Inspectors of Apiaries, San Antonio, Tex., November 12, 1906." 1907. 79 pp., 1 pl.

Contains an account of the history of bee-disease investigations, the relationship of bacteria to bee diseases, and a discussion of treatment by various inspectors of apiaries and other practical beekeepers who are familiar with diseases of bees.

Bulletin No. 75, Part II, "Wax Moths and American Foul Brood." By E. F. Phillips, Ph. D. 1907. Pp. 19–22, 3 pls.

An account of the behavior of the two species of wax moths on combs containing American foul brood, showing that moths do not clean up the disease-carrying scales.

Bulletin No. 75, Part III, "Bee Diseases in Massachusetts." By Burton N. Gates. 1908. Pp. 23–32, map.

An account of the distribution of the brood diseases of bees in the State, with brief directions for controlling them.

Bulletin No. 75, Part IV, "The Relation of the Etiology (Cause) of Bee Diseases to the Treatment." By G. F. White, Ph. D. 1908. Pp. 33–42.

The necessity for a knowledge of the causes of bee diseases before rational treatment is possible is pointed out. The present state of knowledge of the causes of disease is summarized.

Technical Series, No. 14, "The Bacteria of the Apiary, with Special Reference to Bee Diseases." By G. F. White, Ph. D. 1906. 50 pp.

A study of the bacteria present in both the healthy and the diseased colony, with special reference to the diseases of bees.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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Issued April 21, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 444.

REMEDIES AND PREVENTIVES AGAINST MOSQUITOES.

BY

L. O. HOWARD, PH. D.,
Entomologist and Chief, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., March 1, 1911.

SIR: I have the honor to transmit herewith a manuscript on "Remedies and Preventives against Mosquitoes," which is largely a condensation of the most important of the matter contained in Bulletin No. 88 of the Bureau of Entomology. The bulletin in question contains a very extended consideration of the subject, including long quotations and a discussion of the value of remedies of secondary or even less importance, upon which, nevertheless, an expression of the judgment of the Bureau was thought desirable. I recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

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

Hon. JAMES WILSON,
Secretary of Agriculture.

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REMEDIES AND PREVENTIVES AGAINST MOSQUITOES.

INTRODUCTION.

Since the discovery that mosquitoes are not only nuisances, but are also conveyers of malaria, yellow fever, filariasis, and dengue fever, a great deal of remedial work has been done by individuals and communities. Many remedies and plans of action have been tested on a large scale, and what follows is a summary of the results.

PROTECTION FROM BITES.

PROTECTIVE LIQUIDS.

Spirits of camphor rubbed upon the face and hands or a few drops on the pillow at night will keep mosquitoes away for a time, and this is also a well-known property of oil of pennyroyal. Neither of these substances is durable; that is to say, a single application will not last through the night. Oil of peppermint, lemon juice, and vinegar have all been recommended, while oil of tar has been used in regions where mosquitoes are especially abundant. Oil of citronella is one of the best substances to be used in this way. The odor is objectionable to some people, but not to many, and it is efficient in keeping away mosquitoes for several hours. The best mixture tried by the writer was sent to him by Mr. C. A. Nash, of New York, and is as follows:

Oil of citronella	1 ounce
Spirits of camphor	1 ounce
Oil of cedar	½ ounce

Ordinarily a few drops on a bath towel hung over the head of the bed will keep the common house mosquitoes away. Where they are very abundant and persistent a few drops rubbed on the face and hands will suffice. Even this mixture, however, loses its efficacy toward the close of a long night. It is the habit of the yellow-fever mosquito, *Aëdes* (*Stegomyia*) *calopus* Meig., to begin to bite at daylight. By that time the average person is sleeping very soundly, and the effects of the mixture will usually have largely passed away. It follows that in the Southern States where this mosquito occurs these protective mixtures are not supposed to be as effective as they are in the North. As a matter of fact, however, this last mixture, could it be applied shortly before dawn, would be as effective as under other circumstances.

A mixture recommended by Mr. E. H. Gane, of New York, is as follows:

Castor oil	1 ounce
Alcohol	1 ounce
Oil of lavender	1 ounce

This mixture was prepared for the purpose of avoiding the odor of the oil of citronella.

Oscar Samostz, of Austin, Tex., recommends the following formula:

Oil of citronella	1 ounce
Liquid vaseline	4 ounces

This mixture greatly retards the evaporation of the oil of citronella. Mr. B. A. Reynolds has used successfully in New Orleans 20 minims of oil of citronella to the ounce of vaseline or lanolin.

A 5 per cent solution of sulphate of potash has been recommended, as also the oil of cassia. Pure kerosene has also been used extensively in the Philippines.

SCREENS AND CANOPIES.

Such obvious measures as the screening of houses, the use of netting for beds, and the wearing of veils and gloves after nightfall in badly infested regions need no detailed consideration. Screening of houses can not be too carefully done, and adjustable, folding, or sliding window and door screens seem never to be tight; even with well-fitted screens there are often opportunities for mosquitoes to enter; constant care and vigilance alone will prevent this. In certain seasons in mosquito regions mosquitoes will attempt to make their way through screens and are often able to do so. When they are very numerous wire screens should be painted lightly with kerosene or oil of citronella.

With bed canopies there should be ample material to admit of a perfect folding of the canopy under the mattress, and the greatest care should be taken to keep the fabric well mended. It often happens in mosquito regions that little care is taken of the bed nettings in the poorer hotels, and it is necessary for perfect protection that a traveler in the Southern States should carry with him a pocket "housewife" and should carefully examine his bed netting every night, prepared to mend all tears and expanded meshes. Veils and nettings for camping in the Tropics or other regions where mosquitoes abound are absolutely necessary. Light frames are made to fit helmetlike over the head and are covered with mosquito netting. Similar frames, readily folded into a compact form, are made to form a bed covering at night, and every camping outfit for work in tropical or malarial regions should possess such framework and plenty of mosquito netting as an essential part of the outfit.

The size of the mesh in mosquito bars and window screens is important. Twenty meshes to the inch can be relied upon to keep mosquitoes out, but 15 to the inch admits some of them.

SCREENING BREEDING PLACES.

Where the rain-water supply is conserved in large tanks, as in cities in the Gulf States, screening is necessary and is now rather generally enforced. Rain-water barrels everywhere should be screened in the same way, except where fish are used to kill the early stages of mosquitoes. A cheap cover for a water barrel can be made by covering a large iron hoop with a piece of stout calico or sacking, free from holes, in such a manner that a good deal of sag is left in the material.

SMUDGES AND FUMIGANTS.

Anything that will make a dense smoke will drive away mosquitoes, and various smudges are used by campers. For household use a number of different substances have been tried.

PYRETHRUM POWDERS.

Pyrethrum powders, known to the trade as Dalmatian insect powder, Persian insect powder, buhach, and otherwise, are very effective when fresh and pure. Pure powders are the finely ground flower-heads of two species of composite plants of the genus *Pyrethrum*. The essential principle seems to be a volatile oil that disappears with age and exposure. Many powders for sale in the drug stores are apparently diluted by the grinding of stems as well as flower-heads and in other ways. These powders are not so effective as pure powders. Pyrethrum powders are usually used dry, and are puffed or blown into crevices frequented by insects, or puffed or blown into the air of a room in which there are mosquitoes. The burning of the powder in a room at night is common practice. The powder is heaped up in a little pyramid which is lighted at the top and burns slowly, giving out a dense and pungent smoke. Often the powder is moistened and molded roughly into small cones, and after drying it burns readily and perhaps with less waste than does the dry powder. Mosquitoes are stupefied by the smoke and fall to the floor, where they may be swept up and burned. With open windows and constant currents of fresh air this fumigation is not especially effective, and it is necessary, for protection, to sit in a cloud of smoke.

The powder may be placed upon a metal screen above the chimney of a kerosene lamp, with the result that the vapor of the volatile oil will be dissipated. This is said to be very effective. It is economical in powder, and the odor is slight. Another method of burning the powder is to puff it from an insufflator into a burning gas jet. In New Orleans it has been found that in order to thoroughly clear houses of mosquitoes pyrethrum must be burned at the rate of nearly 1 pound of powder to every 1,000 cubic feet of space.

MIMMS CULICIDE.

This mixture is made of equal parts by weight of carbolic acid crystals and gum camphor. The acid crystals are melted over a gentle heat and poured slowly over the gum, resulting in the absorption of the camphor and a final clear, somewhat volatile liquid with an agreeable odor. This liquid is permanent, and may be kept for some time in tight jars. Volatilize 3 ounces of this mixture over a lamp of some kind for every 1,000 cubic feet of space. A simple apparatus for doing this may be made from a section of stovepipe cut so as to have three legs and an outlet for draft, an alcohol lamp beneath and a flat-bottom basin on top. The substance is inflammable, but the vapor is not explosive. The vapor is not dangerous to human life except when very dense, but it produces a headache if too freely breathed. Rooms to be fumigated should be made as nearly air-tight as possible.

SULPHUR DIOXID.

Burning of sulphur, or lump sulphur, in a small pot, at the rate of 2 pounds of sulphur for each 1,000 cubic feet of space, is efficient against mosquitoes where fumigation in the case of possible disease-bearing mosquitoes is desired.

OTHER FUMIGANTS.

According to Dr. John B. Smith, powdered jimson weed (*Datura stramonium*) can be burned to advantage in houses. He recommends 8 ounces to fumigate 1,000 cubic feet of space. He states that it should be made up by the druggist into an amount with niter or saltpeter 1 part to 3 of Datura, so as to burn more freely. He states that the fumes are not poisonous to human beings, are not injurious to fabrics or to metals, and can be used with entire safety. He suggests that it be burned in a tin pan or on a shovel.

The burning of dried orange peel has been recommended as a deterrent against mosquitoes by a Japanese physician.

APPARATUS FOR CATCHING ADULT MOSQUITOES.

An interesting homemade apparatus in common use in many parts of the United States is very convenient and effective. It consists of a tin cup or a tin-can cover nailed to the end of a long stick in such a way that a spoonful or so of kerosene can be placed in the cup, which may then, by means of the stick, be pressed up to the ceiling so as to inclose one mosquito after another. When covered over in this way the captured mosquito will attempt to fly and be caught in the kerosene. By this method perhaps the majority of the mosquitoes in a given bedroom—certainly all of those resting on the ceiling—can be caught before one goes to bed.

Mr. H. Maxwell-Lefroy, of India, makes a trap consisting of a wooden box lined with dark-green baize and having a hinged door. The trap is 12 inches long, 12 inches broad, and 9 inches deep. A small hole, covered by a revolving piece of wood or metal, was prepared in the top of the box. Owing to the habit of mosquitoes to seek a cool, shady place in which to rest, such as a dark corner of the room or a book shelf, or something of that sort, they will enter the trap, which is put in the part of the room most frequented by mosquitoes, all other dark places being rendered uninhabitable so far as possible. They are driven out of book shelves with a duster or with tobacco smoke, and go into the desirable sleeping place for the day. The door is then closed and fastened, and into the small hole at the top of the box a teaspoonful or less of benzine is introduced. This kills all of the mosquitoes inside, and the box is then thoroughly aired and replaced. In this way Mr. Lefroy is very successful in catching mosquitoes. At one time he averaged 83 a day.

REMEDIES FOR MOSQUITO BITES.

The most satisfactory remedy known to the writer, from his personal experience, has been moist soap. Wet the end of a piece of ordinary toilet soap and rub it gently on the puncture, and the irritation will soon pass away. Others have enthusiastically recommended household ammonia, or alcohol, or glycerin. One correspondent marks the puncture with a lump of indigo; another with one of the naphthaline moth balls; another, iodin. Rev. R. W. Anderson, of Wando, S. C., states that he has found that by holding his hand to a hot lamp chimney the irritation of mosquito punctures will be relieved instantly.

ABOLITION OF BREEDING PLACES.

It has been found that, taking the group of mosquitoes as a whole, their breeding places are of the most diverse character. Some species, however, are restricted in the character of their breeding places.

Certain forms, for example, breed only in tree holes; others in accumulations of water in epiphytic plants; another species breeds only in the crabholes on sea beaches. Others are of more general breeding habits and will live in almost any chance accumulation of water. Certain species breed only in the salt marshes and may lay their eggs on mud, and most others lay their eggs upon the surface of water. Certain of the species, especially those occurring inland, in the more northern States, seem to breed only in the pools formed by melting snow, and as these occur at only one time of the year there is but one generation, and the eggs are laid in midsummer or later in such hollows in the earth as will be filled by the melting snow the ensuing spring. Another species, which is frequently very annoying in certain of the northern States, breeds only in the stems of certain aquatic plants. Still another breeds in the pitchers of pitcher plants (Sarracenia).

Culex pipiens L. in the North and *Culex quinquefasciatus* Say and *Aëdes* (*Stegomyia*) *calopus* Meig. in the South, however, breed in every chance receptacle of water about residences, and their destruction means the abolition or treatment of all such receptacles.

Where the rain-water barrel and rain-water tank are necessary they should be screened. About a given house the waste places in the immediate vicinity should be carefully searched for tin cans, bottles, and wooden or tin boxes in which water can accumulate and all such receptacles should be destroyed or carried away. The roof gutters of every building should be carefully examined to make sure that they are not clogged so as to allow the water to accumulate. Where the branches of tall trees overhang roofs this is especially likely to occur by the agency of falling leaves or twigs. The chicken pans in the poultry yard, the water in the troughs for domestic animals, the water cup of the grindstone are all places in which these mosquitoes will breed and water should not be allowed to stand in them for more than a day or so at a time.

In the South the water accumulating under water tanks should be treated or drained away. The urns in the cemeteries in New Orleans have been found to breed mosquitoes abundantly. The holy-water fonts in churches, especially in the South, have been found to breed mosquitoes abundantly. In slightly marshy ground a favorite breeding place is the footprints of cattle and horses. In one country village, which contained many small vegetable gardens in clay soil, during a rainy season mosquitoes were found breeding abundantly in the water accumulating in the furrows in the gardens.

Even in the house these mosquitoes breed in many places where they may be overlooked. Where the water in flower vases is not frequently changed mosquitoes will breed. They will breed in water pitchers in unused guest rooms. They will breed in the tanks in the water-closets when these are not frequently in use. They will breed in pipes and under stationary washstands where these are not frequently in use, and they will issue from the sewer traps in back yards of city houses during dry spells in the summer time when the sewers have not recently been flushed by heavy rains. In warehouses and on docks they breed abundantly in the fire buckets and in water barrels. Of course such places as these can not be abolished, but should be treated in accordance with measures indicated in another section of this bulletin.

In country houses in the South, where ants are troublesome, and where it is the custom to insulate the legs of tables with small cups of water, mosquitoes will breed in these cups unless a small quantity of kerosene is poured in. Where broken bottles are placed upon a stone wall, water accumulates in the bottle fragments after rains, and mosquitoes will breed there.

Old, disused wells in gardens are frequent sources of mosquito supply, even where apparently carefully covered, and here the nuisance is easily abated by the occasional application of kerosene. The same thing may be said of cesspools. Cesspools are frequently covered with stone and cement, but the slightest break in the cement, the slightest crack, will allow the entrance of these minute insects, and unlimited breeding often goes on in these pools without a suspicion of the cause of the abundance of mosquitoes in the neighborhood.

Fountains and ornamental ponds are frequent breeding places, and here the introduction of fish, as indicated in another place, is usually all-sufficient. It frequently happens, however, that the grass is allowed to grow down into the edges of ornamental ponds and mosquito larvæ find refuge among the vegetation and so escape the fish. Broad-leaved water plants are also often grown in such ponds, and where these broad leaves lie flat on the surface of the water, as they frequently do, one portion of a given leaf may be submerged so that mosquito larvæ may breed freely in the water above the submerged portion of the leaf, protected from the fish by the leaf itself, the fish rising from below. It is necessary, therefore, to keep the edges of such ornamental ponds free from vegetation, and to choose aquatic plants whose growth will not permit of mosquito-larvæ protection.

In these latter localities not only the house mosquitoes, previously mentioned, or the rain-water barrel mosquitoes will be found, but also some of the other forms, and particularly the malaria-breeding mosquitoes of the genus Anopheles. Some of these breed in all sorts of water accumulations.

In many small country towns, even where there is a water supply, tanks are to be found under the roofs to supply bathrooms. Such tanks should be screened, since mosquitoes gain entrance to the tank room, either through dormer windows or by flying up through the house from below, in search of places to lay their eggs.

About a large old house or a public building there are so many of these chance breeding places that only the most careful and long-continued search will find them all. As an example, in a State hospital, after a search which lasted for many days, and after a treatment of all possible breeding places found, mosquitoes still continued to annoy the patients. Finally in the darkest part of a disused cellar was found a half-barrel with standing water in it, which was giving out mosquitoes at the rate of hundreds per day. Frequent change of water or the use of kerosene will render all such breeding places harmless.

In community work in cities all of the points mentioned must be borne in mind, and in the portions of the community where the residences are for the most part villas, in the absence of swampy suburbs the householders are in the main responsible for their own mosquitoes. There are, however, breeding places for which the municipality may be said to be responsible, and these entirely aside from public fountains, reservoirs, or marshes. Roadside open gutters or ditches may breed a generation of any one of several species of mosquitoes, including malarial mosquitoes. On a pasture or common, where sod has been removed, water accumulating in the excavation thus formed may breed a generation of malarial mosquitoes. All such accidental breeding places should be abolished by filling in.

It seems unlikely that in any general sewage system mosquitoes may breed in the sewers proper. That they do breed in the catch basins is well known. The purpose of the catch basin is to catch and retain by sedimentation sand and refuse which would otherwise enter the sewer and deposit in it. It is intended to be water tight and to hold a considerable body of water, which stands in it up to the level of the outlet pipe. Such catch basins are very commonly used in back yards and at the crossings of streets. The water is removed only by rain or when the street or yard surfaces are washed. In dry seasons the period of stagnation may last several weeks, certainly long enough for mosquito breeding. As a matter of fact mosquitoes in midsummer do breed in such traps or catch basins by millions. These basins may be treated with petroleum, or the municipal authorities may flush them once a week, carrying away such larvæ as may have hatched. Kerosene treatment, however, is best.

Public dumps are great breeding places, because here accumulate old bottles, cans, boxes, bits of tin or iron vessels, and other objects in which water may accumulate for a time. Even a very small amount of water will make a breeding place for very many mosquitoes. It is quite possible for a half of a beer bottle to contain enough water to give out literally thousands of mosquitoes. The writer knows of one instance where a veritable plague of mosquitoes was traced to a case of empty beer bottles allowed to remain in a back yard for some weeks in midsummer.

There is a possibility that under certain circumstances mosquitoes may breed in water accumulating in the troughs of underground-conduit electric railways. There is abundant opportunity for water to accumulate in these troughs, but no exact observations upon mosquito breeding in such situations have been made.

Search carefully for all such places, and either abolish the standing water by carting away chance receptacles, by turning over vessels, by filling in excavations, or by treating other receptacles with a film of kerosene, or by introducing fish into fountains and artificial pools.

DRAINAGE MEASURES.

Drainage measures really form a part of the consideration of the treatment of breeding places. The drainage of swamp areas for agricultural or industrial reasons needs no argument. The value of reclaimed swamp land for various purposes is well known. The drainage of swamp areas primarily in order to improve sanitary conditions and to reduce the scourge of mosquitoes which in itself often prevents the proper development of nearby regions is in operation and needs no argument. Drainage on a small scale for the purpose of doing away with mosquitoes has been practiced for a long time, and in many parts of the country large-scale drainage with mosquito abolition in view is going on, notably in New Jersey and in California. Methods of draining can not be entered into in this bulletin, but it should be pointed out that in case of salt-marsh land the operation is inexpensive, and results of great value have been reached both in California and in New Jersey.

DESTRUCTION OF LARVÆ BY TREATMENT OF BREEDING PLACES.

While it is obviously best to abolish breeding places in the ways mentioned, it often happens that it is not possible to drain, and at least as a temporary expedient it becomes desirable to treat the water so as to kill the mosquito larvæ. Many substances have been tried, and, aside from certain proprietary mixtures, nothing has given such good results as the use of oils. Efforts to find oils that can be used to better advantage than petroleum have failed. Common kerosene of low grade, or of the grade known as fuel oil, is the most satisfactory as regards efficiency and price.

In choosing the grade of oil two factors are to be considered: First, it should spread rapidly; second, it should not evaporate too quickly. The heavier grades of oil will not spread readily over the surface of the water, but will cling together in spots and the coating will be unnecessarily thick. The rapidity of spread of the film is also important. As to quantity, under still conditions, an ounce of kerosene to 15 square feet of surface space is about the right proportion, and in the absence of wind such a film will remain persistent for 10 days or slightly longer. Even after the iridescent scum apparently disappears there is still an odor of kerosene about the water. In a wind the film of kerosene is frequently blown to one side, but with a change will go back again, so that larvæ are destroyed. Not only are larvæ and pupæ destroyed by the kerosene film, but many adult mosquitoes alighting on the surface of the water to drink or to lay their eggs are killed by it. In California, Mr. H. J. Quayle has used a combination of heavy oil of 18° gravity and a light oil of 34° gravity, in the proportion of 4 to 1, respectively. This mixture made an oil that was just thin enough to spray well from an ordinary spray nozzle and yet was thick enough to withstand very rapid evaporation. It was applied by a barrel pump where this could be used, and by an ordinary knapsack pump in other regions. A single application was found by Mr. Quayle to be effective sometimes up to four weeks. The army of occupation in Cuba used oil every two weeks.

The use of a spray pump has been mentioned. Small ponds can be sprinkled out of an ordinary watering pot with a rose nozzle, or for that matter pouring it out of a dipper or cup will be satisfactory. In larger ponds pumps with a straight nozzle may be used. A straight stream will sink and then rise and spread until the whole surface of the pond can be covered without waste. The English workers in Africa advise mopping the kerosene upon the surface of the water by means of cloths tied to the end of a long stick and saturated with kerosene.

In Panama a larvicide is being used which is made as follows: 150 gallons of carbolic acid is heated in a tank to a temperature of 212° F., then 150 pounds of powdered or finely broken resin is poured in. The mixture is kept at a temperature of 212° F. Thirty pounds of caustic soda is then added and the solution is kept at the same temperature until a perfectly dark emulsion without sediment is formed. The mixture is thoroughly stirred from the time the resin is used until the end. One part of this emulsion to 10,000 parts of water is said to kill Anopheles larvæ in less than half an hour, while 1 part to 5,000 parts of water will kill them in from 5 to 10 minutes. At a larvicide plant at Ancon 4,600 gallons of this mixture were made at a cost of $0.1416 per gallon. Although this mixture has been used to a large extent in Panama, crude oil was also used for streams having a fair velocity.

THE PRACTICAL USE OF NATURAL ENEMIES OF MOSQUITOES.

The common goldfish and silverfish destroy mosquito larvæ and should be put in artificial ponds. Top-minnows of several species have been introduced successfully in several localities and are great feeders upon mosquito larvæ. Certain species introduced from Texas into Hawaii have been successful; and a small top-minnow of the genus Girardinus, known in the Barbados as "millions," has been carried with success to others of the British West India Islands. In Rio de Janeiro another top-minnow has been used by the public health service for placing in tanks and boxes where it was impossible to use petroleum.

There are many predatory aquatic insects that feed upon mosquito larvæ; others that catch the adults. Certain birds prey upon the adults, and they are also eaten by bats. An experiment is being carried on near San Antonio, Tex., in which a bat roost has been constructed with the dual purpose of gathering the bats to kill mosquitoes of that region and of collecting the bat guano.

DETERRENT TREES AND PLANTS.

A great deal has been published concerning the properties of certain growing plants which are said to keep away mosquitoes. Among these may be mentioned several species of Eucalyptus, the castor-oil plant, the Chinaberry tree, and others. Although the evidence in regard to these plants is contradictory, all observations made by scientific men in different parts of the world negative their value; claims that they are valuable are confined to people who have not made thoroughly scientific tests.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 447.

BEES.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 4, 1911.

Sir: I have the honor to transmit herewith a manuscript entitled "Bees," by E. F. Phillips, Ph. D., in charge of bee culture in this bureau.

This paper will supersede Farmers' Bulletins 59 and 397. A few new illustrations which add greatly to the value of the paper and some minor alterations in the text are the only changes in this from Farmers' Bulletin 397; but since it is not now the policy of the department to issue revised editions, it is recommended that this bulletin be issued under a new serial number.

In the preparation of this paper the aim has been to give briefly such information as is needed by persons engaged in the keeping of bees, and to answer inquiries such as are frequently received from correspondents of the department. No attempt has been made to include discussions of bee anatomy, honey plants, or the more special manipulations sometimes practiced, such as queen rearing. The discussion of apparatus is necessarily brief.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

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BEES.

INTRODUCTION.

Beekeeping for pleasure and profit is carried on by many thousands of people in all parts of the United States. As a rule, it is not the sole occupation. There are, however, many places where an experienced bee keeper can make a good living by devoting his entire time and attention to this line of work. It is usually unwise to undertake extensive beekeeping without considerable previous experience on a small scale, since there are so many minor details which go to make up success in the work. It is a good plan to begin on a small scale, make the bees pay for themselves and for all additional apparatus, as well as some profit, and gradually to increase as far as the local conditions or the desires of the individual permit.

Bee culture is the means of obtaining for human use a natural product which is abundant in almost all parts of the country, and which would be lost to us were it not for the honey bee. The annual production of honey and wax in the United States makes apiculture a profitable minor industry of the country. From its very nature it can never become one of the leading agricultural pursuits, but that there is abundant opportunity for its growth can not be doubted. Not only is the honey bee valuable as a producer, but it is also one of the most beneficial of insects in cross-pollinating the flowers of various economic plants.

Beekeeping is also extremely fascinating to the majority of people as a pastime, furnishing outdoor exercise as well as intimacy with an insect whose activity has been a subject of absorbing study from the earliest times. It has the advantage of being a recreation which pays its own way and often produces no mean profit.

It is a mistake, however, to paint only the bright side of the picture and leave it to the new bee keeper to discover that there is often another side. Where any financial profit is derived, beekeeping requires hard work and work at just the proper time, otherwise the surplus of honey may be diminished or lost. Few lines of work require more study to insure success. In years when the available nectar is limited, surplus honey is secured only by judicious manipulations, and it is only through considerable experience and often by expensive reverses that the bee keeper is able to manipulate properly to save his crop. Anyone can produce honey in seasons of plenty, but these do not come every year in most locations, and it takes a good bee keeper to make the most of poor years. When, even with the best of manipulations, the crop is a failure through lack of nectar, the bees must be fed to keep them from starvation.

The average annual honey yield per colony for the entire country, under good management, will probably be 25 to 30 pounds of comb honey or 40 to 50 pounds of extracted honey. The money return to be obtained from the crop depends entirely on the market and the method of selling the honey. If sold direct to the consumer, extracted honey brings from 10 to 20 cents per pound, and comb honey from 15 to 25 cents per section. If sold to dealers, the price varies from 6 to 10 cents for extracted honey and from 10 to 15 cents for comb honey. All of these estimates depend largely on the quality and neatness of the product. From the gross return must be deducted from 50 cents to $1 per colony for expenses other than labor, including foundation, sections, occasional new frames and hives, and other incidentals. This estimate of expense does not include the cost of new hives and other apparatus needed in providing for increase in the size of the apiary.

Above all it should be emphasized that the only way to make beekeeping a profitable business is to produce only a first-class article. We can not control what the bees bring to the hive to any great extent, but by proper manipulations we can get them to produce fancy comb honey, or if extracted honey is produced it can be carefully cared for and neatly packed to appeal to the fancy trade. Too many bee keepers, in fact, the majority, pay too little attention to making their goods attractive. They should recognize the fact that of two jars of honey, one in an ordinary fruit jar or tin can with a poorly printed label, and the other in a neat glass jar of artistic design with a pleasing, attractive label, the latter will bring double or more the extra cost of the better package. It is perhaps unfortunate, but nevertheless a fact, that honey sells largely on appearance, and a progressive bee keeper will appeal as strongly as possible to the eye of his customer.

LOCATION OF THE APIARY.

In choosing a section in which to keep bees on an extensive scale it is essential that the resources of the country be known. Beekeeping is more or less profitable in almost all parts of the United States, but it is not profitable to practice extensive beekeeping in localities where the plants do not yield nectar in large quantities. A man who desires to make honey production his business may find that it does not pay to increase the apiaries in his present location. It may be better to move to another part of the country where nectar is more abundant.

The location of the hives is a matter of considerable importance. As a rule it is better for hives to face away from the prevailing wind and to be protected from high winds. In the North, a south slope is desirable. It is advisable for hives to be so placed that the sun will strike them early in the morning, so that the bees become active early in the day, and thus gain an advantage by getting the first supply of nectar. It is also advantageous to have the hives shaded during the hottest part of the day, so that the bees will not hang out in front of the hive instead of working. They should be so placed that

FIG. 1.—A well-arranged apiary.

the bees will not prove a nuisance to passers-by or disturb live stock. This latter precaution may save the bee keeper considerable trouble, for bees sometimes prove dangerous, especially to horses. Bees are also sometimes annoying in the early spring, for on their first flights they sometimes spot clothes hung out to dry. This may be remedied by having the apiary some distance from the clothes-drying yard, or by removing the bees from the cellars on days when no clothes are to be hung out.

The plot on which the hives are placed should be kept free from weeds, especially in front of the entrances. The grass may be cut with a lawn mower, but it will often be found more convenient and as efficient to pasture one or more head of sheep in the apiary inclosure.

The hives should be far enough apart to permit of free manipulation. If hives are too close together there is danger of bees entering the wrong hive on returning, especially in the spring.

These conditions, which may be considered as ideal, need not all be followed. When necessary, bees may be kept on housetops, in the back part of city lots, in the woods, or in many other places where the ideal conditions are not found. As a matter of fact, few apiaries are perfectly located; nevertheless, the location should be carefully planned, especially when a large number of colonies are kept primarily for profit.

As a rule, it is not considered best to keep more than 100 colonies in one apiary, and apiaries should be at least 2 miles apart. There are so many factors to be considered, however, that no general rule can be laid down. The only way to learn how many colonies any given locality will sustain is to study the honey flora and the record of that place until the bee keeper can decide for himself the best number to be kept and where they shall be placed.

The experience of a relatively small number of good bee keepers in keeping unusually large apiaries indicates that the capabilities of the average locality are usually underestimated. The determination of the size of extensive apiaries is worthy of considerable study, for it is obviously desirable to keep bees in as few places as possible, to save time in going to them and also expense in duplicated apparatus. To the majority of bee keepers this problem is not important, for most persons keep but a small number of colonies. This is perhaps a misfortune to the industry as a whole, for with fewer apiaries of larger size under the management of careful, trained bee keepers the honey production of the country would be marvelously increased. For this reason, professional bee keepers are not favorably inclined to the making of thousands of amateurs, who often spoil the location for the honey producer and more often spoil his market by the injudicious selling of honey for less than it is worth or by putting an inferior article on the market.

Out apiaries, or those located away from the main apiary, should be so located that transportation will be as easy as possible. The primary consideration, however, must be the available nectar supply and the number of colonies of bees already near enough to draw on the resources. The out apiary should also be near to some friendly person, so that it may be protected against depredation and so that the owner may be notified if anything goes wrong. It is especially desirable to have it in the partial care of some person who can hive swarms or do other similar things that may arise in an emergency. The terms under which the apiary is placed on land belonging to some one else is a matter for mutual agreement. There is no general usage in this regard.

EQUIPMENT IN APPARATUS.

It can not be insisted too strongly that the only profitable way to keep bees is in hives with movable frames. The bees build their combs in these frames, which can then be manipulated by the bee keeper as necessary. The keeping of bees in boxes, hollow logs, or straw "skeps" is not profitable, is often a menace to progressive bee keepers, and should be strongly condemned. Bees in box hives (plain boxes with no frames and with combs built at the will of the bees) are too often seen in all parts of the country. The owners may obtain from them a few pounds of inferior honey a year and carelessly continue in the antiquated practice. In some cases this type of beekeeping does little harm to others, but where diseases of the brood are present the box hive is a serious nuisance and should be abolished.

WORKSHOP.

It is desirable to have a workshop in the apiary where the crop may be cared for and supplies may be prepared. If the ground on which the hives are located is not level, it is usually better to have the shop on the lower side so that the heavier loads will be carried down grade. The windows and doors should be screened to prevent the entrance of bees. The wire cloth should be placed on the outside of the window frames and should be extended about 6 inches above the opening. This upper border should be held away from the frame with narrow wooden strips one-fourth inch in thickness so as to provide exits for bees which accidentally get into the house. Bees do not enter at such openings, and any bees which are carried into the house fly at once to the windows and then crawl upward, soon clearing the house of all bees. The windows should be so arranged that the glass may be slid entirely away from the openings to prevent bees from being imprisoned. The equipment of benches and racks for tools and supplies can be arranged as is best suited to the house. It is a good plan to provide racks for surplus combs, the combs being hung from strips separated the distance of the inside length of the hive.

HIVES.

It is not the purpose of this bulletin to advocate the use of any particular make of hive or other apparatus. Some general statements may be made, however, which may help the beginner in his choice.

The type of hive most generally used in this country (fig. 2) was invented by Langstroth in 1851. It consists of a plain wooden box holding frames hung from a rabbet at the top and not touching the sides, top, or bottom. Hives of this type are made to hold eight, ten, or more frames. The size of frame in general use, known as the

Langstroth (or L) frame ($9\frac{1}{8}$ by $17\frac{5}{8}$ inches), is more widely used than all others combined. One of the best features in hive manufacture developed by Langstroth is the making of the spaces between frames, side walls, and supers accurately, so that there is just room for the easy passage of bees. In a space of this size (called a "bee space") bees rarely build comb or deposit propolis. The number of frames used depends on the kind of honey produced (whether comb or extracted) and on the length of honey flow and other local factors. There are other hives used which have points of superiority. These will be found discussed in the various books on beekeeping and in the catalogues of dealers in bee keepers' supplies.

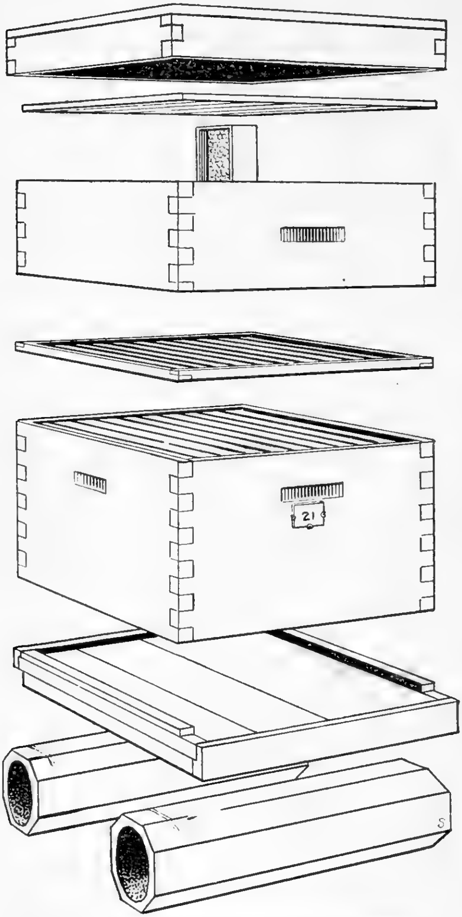

FIG. 2.—A 10-frame hive with comb-honey super and perforated zinc queen excluder.

Whatever hive is chosen, there are certain important points which should be insisted on. The material should be of the best; the parts must be accurately made, so that all frames or hives in the apiary are interchangeable. All hives should be of the same style and size; they should be as simple as it is possible to make them, to facilitate operation. Simple frames diminish the amount of propolis, which will interfere with manipulation. As a rule, it is better to buy hives and frames from a manufacturer of such goods rather than to try to make them, unless one is an expert woodworker.

The choice of a hive, while important, is usually given undue prominence in books on bees. In actual practice experienced bee keepers with different sizes and makes of hives under similar conditions do not find as much difference in their honey crop as one would be led to believe from the various published accounts.

Hives should be painted to protect them from the weather. It is usually desirable to use white paint to prevent excessive heat in the colony during hot weather. Other light colors are satisfactory, but it is best to avoid red or black.

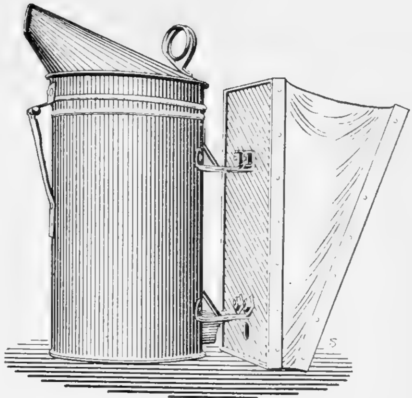
FIG. 3.—Smoker.

HIVE STANDS.

Generally it is best to have each hive on a separate stand. The entrance should be lower than any other part of the hive. Stands of wood, bricks, tile (fig. 2), concrete blocks, or any other convenient material will answer the purpose. The hive should be raised above the ground, so that the bottom will not rot. It is usually not necessary to raise the hive more than a few inches. Where ants are a nuisance special hive stands are sometimes necessary.

OTHER APPARATUS.

In addition to the hives in which the bees are kept some other apparatus is necessary. A good smoker to quiet the bees (fig. 3), consisting of a tin or copper receptacle to hold burning rotten wood or other material, with a bellows attached, is indispensable. A veil of black material, preferably with a black silk-tulle front (fig. 4), should be used. Black wire-cloth veils are also excellent. Even if a veil is not always used, it is desirable to have one at hand in case the bees become cross. Cloth or leather gloves are sometimes used to protect the hands, but they hinder most manipulations. Some sort of tool (fig. 5) to pry hive covers loose and frames apart is desirable. A screwdriver will answer, but any of the tools made especially for that purpose is perhaps better. Division boards


FIG. 4.—Bee veil with silk-tulle front.

drone traps (fig. 6), bee escapes (figs. 7 and 8), feeders (figs. 17, 18, 19, 20), foundation fasteners, wax extractors, bee brushes (fig. 9), queen-rearing outfits, and apparatus for producing comb or extracted honey (figs. 2, 21, 22) will be found described in catalogues of supplies; a full discussion of these implements would require too much space in this bulletin. A few of these things are illustrated, and their use will be evident to the bee keeper. It is best to have the frames filled with foundation to insure straight combs composed of worker cells only. Foundation is made from thin sheets of pure beeswax on which are impressed the bases of the cells of the comb. On this as a guide the worker bees construct the combs. When sheets of foundation are inserted they should be supported by wires stretched across the frames. Frames purchased from supply dealers are usually pierced for wiring. It should be remembered that manipulation based on a knowledge of bee behavior is of far greater importance than any particular style of apparatus. In a short discussion like the present it is best to omit descriptions of appliances, since supply dealers will be glad to furnish whatever information is desired concerning apparatus.

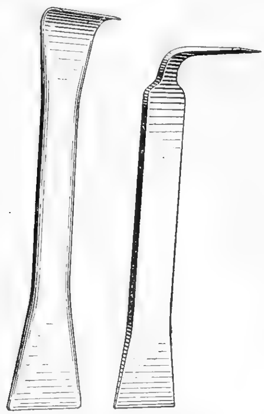

FIG. 5.—Hive tools.

EQUIPMENT IN BEES.

As stated previously, it is desirable to begin beekeeping with a small number of colonies. In purchasing these it is usually best to obtain them near at home rather than to send to a distance, for there is considerable liability of loss in shipment. Whenever possible it is better to get bees already domiciled in the particular hive chosen by the bee keeper, but if this is not practicable then bees in any hives or in box hives may be purchased and transferred. It is a matter of small importance what race of bees is purchased, for queens of any race may be obtained and introduced in place of the original queen, and in a short time the workers will all be of the same

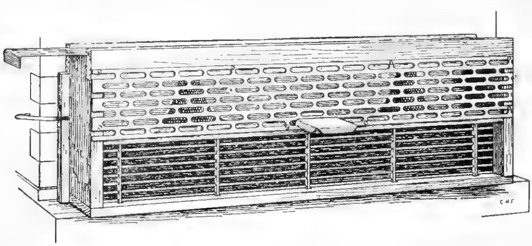

FIG. 6.—Drone and queen trap on hive entrance.

race as the introduced queen. This is due to the fact that during the honey season worker bees die rapidly, and after requeening they are replaced by the offspring of the new queen.

A most important consideration in purchasing colonies of bees is to see to it that they are free from disease. In many States and counties there are inspectors of apiaries who can be consulted on this point, but if this is not possible even a novice can tell whether or not there is anything wrong with the brood, and it is always safest to refuse hives containing dead brood.

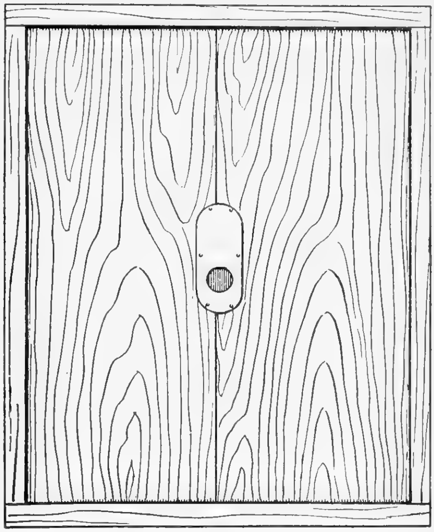

FIG. 7.—Bee escape for removing bees from supers.

The best time of the year to begin beekeeping is in the spring, for during the first few months of ownership the bee keeper can study the subject and learn what to do, so that he is not so likely to make a mistake which will end in loss of bees. It is usually best to buy good strong colonies with plenty of brood for that season of the year, but if this is not practicable, then smaller colonies, or nuclei, may be purchased and built up during the summer season. Of course, no surplus honey can be expected if all the honey gathered goes into the making of additional bees. It is desirable to get as little drone comb as possible and a good supply of honey in the colonies purchased.

The question as to what race and strain of bees is to be kept is important. If poor stock has been purchased locally, the bee keeper should send to some reliable queen breeder for good queens as a foundation for his apiary. Queens may be purchased for $1 each for "untested" to several dollars each for "selected" breeding queens. Usually it will not pay beginners to buy "selected" breeding queens, for they are not yet prepared to make the best use of such stock. "Untested" or "tested" queens are usually as good a quality as are profitable for a year or so, and there is also less danger in mailing "untested" (young) queens.

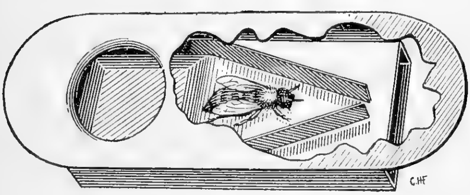

FIG. 8.—Spring bee escape.

Various races of bees have been imported into the United States and among experienced bee keepers there are ardent advocates of almost all of them. The black or German race was the first imported, very early in the history of the country, and is found everywhere, but usually not entirely pure. As a rule this race is not desirable. No attention has been paid to breeding it for improvement in this country, and it is usually found in the hands of careless bee keepers. As a result it is inferior, although it often produces beautiful comb honey.

The Italian bees, the next introduced, are the most popular race among the best bee keepers in this country, and with good reason. They are vigorous workers and good honey gatherers, defend their hives well, and above all have been more carefully selected by American breeders than any other race. Especially for the last reason it is usually desirable to keep this race. That almost any other race of bees known could be bred to as high a point as the Italians, and perhaps higher, can not be doubted, but the bee keeper now gets the benefit of what has been done for this race. It should not be understood from this that the efforts at breeding have been highly successful. On the contrary, bee breeding will compare very unfavorably with the improvement of other animals or plants which have been the subject of breeding investigations.

FIG. 9.—Bee brush.

Italian bees have been carefully selected for color by some breeders to increase the area of yellow on the abdomen, until we now have what are known as "five-banded" bees. These are very beautiful, but it can scarcely be claimed that they are improved as honey producers or in regard to gentleness. They are kept mostly by amateurs.

Some breeders have claimed to select Italians for greater length of tongue, with the object of getting a bee which could obtain the abundance of nectar from red clover. If any gain is ever made in this respect, it is soon lost. The terms "red-clover bees" or "long-tongued bees" are somewhat misleading, but are ordinarily used as indicating good honey producers.

Caucasian bees, formerly distributed throughout the country by this department, are the most gentle race of bees known. They are not stingless, however, as is often stated in newspapers and other periodicals. Many report them as good honey gatherers. They are more prolific than Italians and may possibly become popular. Their worst characteristic is that they gather great quantities of propolis and build burr and brace combs very freely. They are most desirable bees for the amateur or for experimental purposes.

Carniolan and Banat bees have some advocates, and are desirable in that they are gentle. Little is known of Banats in this country. Carniolans swarm excessively unless in large hives. Cyprians were formerly used somewhat, but are now rarely found pure, and are undesirable either pure or in crosses because of the fact that they sting with the least provocation and are not manageable with smoke. They are good honey gatherers, but their undesirable qualities have caused them to be discarded by American bee keepers. "Holy-land," Egyptian, and Punic (Tunisian) bees have also been tried and have been universally abandoned.

The Department of Agriculture does not now distribute or sell queen bees or colonies of bees of any race.

BEE BEHAVIOR.

The successful manipulation of bees depends entirely on a knowledge of their habits. This is not generally recognized, and most of the literature on practical beekeeping consists of sets of rules to guide manipulations. This is too true of the present paper, but is due to a desire to make the bulletin short and concise. While this method usually answers, it is nevertheless faulty, in that, without a knowledge of fundamental principles of behavior, the bee keeper is unable to recognize the seemingly abnormal phases of activity, and does not know what to do under such circumstances. Rules must, of course, be based on the usual behavior. By years of association the bee keeper almost unconsciously acquires a wide knowledge of bee behavior, and consequently is better able to solve the problems which constantly arise. However, it would save an infinite number of mistakes and would add greatly to the interest of the work if more time were expended on a study of behavior; then the knowledge gained could be applied to practical manipulation.

A colony of bees consists normally of one queen bee (fig. 10, *b*), the mother of the colony, and thousands of sexually undeveloped females called workers (fig. 10, *a*), which normally lay no eggs, but build the comb, gather the stores, keep the hive clean, feed the young, and do the other work of the hive. During part of the year there are also present some hundreds of males (fig. 10, *c*) or drones (often removed or restricted in numbers by the bee keeper), whose only service is to mate with young queens. These three types are easily recognized, even by a novice. In nature the colony lives in a hollow tree or other cavity, but under manipulation thrives in the artificial hives provided. The combs which form their abode are composed of wax secreted by the workers. The hexagonal cells of the two vertical layers constituting each comb have interplaced ends on a common septum. In the cells of these combs are reared the developing bees, and honey and pollen for food are also stored here.

The cells built naturally are not all of the same size, those used in rearing worker bees being about one-fifth of an inch across, and those used in rearing drones and in storing honey about one-fourth of an inch across (fig. 11). The upper cells in natural combs are more irregular, and generally curve upward at the outer end. They are used chiefly for the storage of honey. Under manipulation the size of the cells is controlled by the bee keeper by the use of comb foundation—sheets of pure beeswax on which are impressed the bases of cells and on which the bees build the side walls.

In the North, when the activity of the spring begins, the normal colony consists of the queen and some thousands of workers. As the outside temperature raises, the queen begins to lay eggs (fig. 12, *a*) in the worker cells. These in time develop into white larvæ (fig. 12,

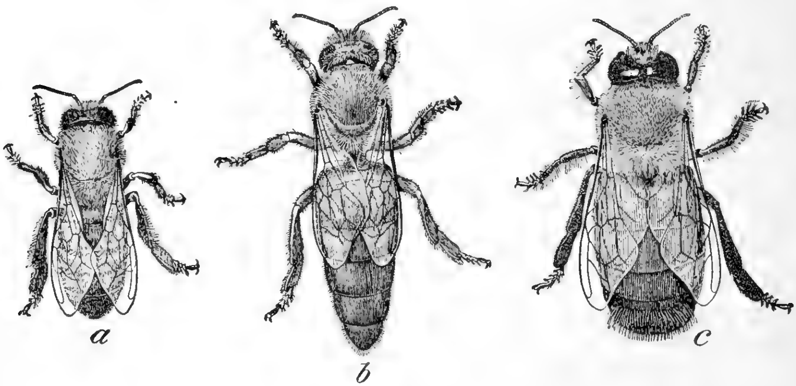

FIG. 10.—The honey bee: *a*, Worker; *b*, queen; *c*, drone. Twice natural size.

b, *c*), which grow to fill the cells. They are then capped over and transform first into pupæ (fig. 12, *d*) and then into adult worker bees. As the weather grows warmer, and the colony increases in size by the emergence of the young bees, the quantity of brood is increased. The workers continue to bring in pollen, nectar to be made into honey, and water for brood rearing. When the hive is nearly filled with bees and stores, or when a heavy honey flow is on, the queen begins to lay eggs in the larger cells, and these develop into drones or males.

Continued increase of the colony would result in the formation of enormous colonies, and unless some division takes place no increase in the number of colonies will result. Finally, however, the workers begin to build queen cells (fig. 13). These are larger than any other cells in the hive and hang on the comb vertically. In size and shape they may be likened to a peanut, and are also rough on the outside.

In preparing for swarming the queen sometimes lays eggs in partly constructed queen cells, but when a colony becomes queenless the cells are built around female larvæ. The larvæ in these cells receive special food, and when they have grown to full size they, too, are sealed up, and the colony is then ready for swarming.

The issuing of the first swarm from a colony consists of the departure of the original queen with part of the workers. They leave behind

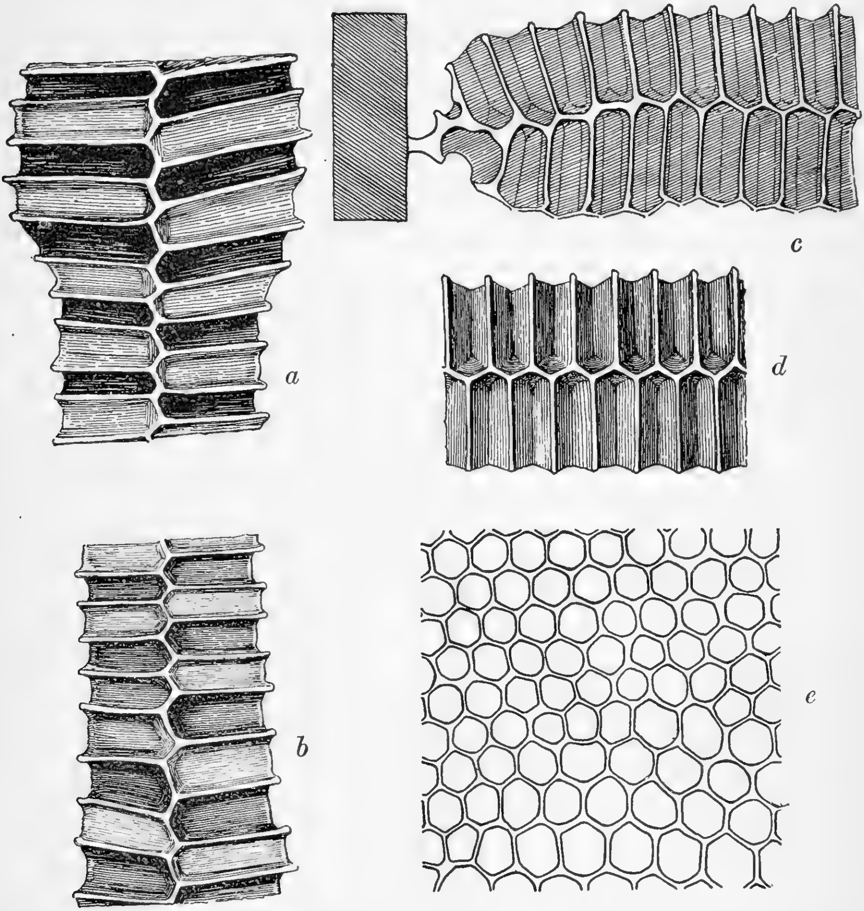

FIG. 11.—Comb architecture: *a*, Vertical section at top of comb; *b*, vertical section showing transition from worker to drone cells; *c*, horizontal section at side of comb showing end bar of frame; *d*, horizontal section of worker brood cells; *e*, diagram showing transition cells. Natural size.

the honey stores, except such as they can carry in their honey stomachs, the brood, some workers, drones, several queen cells, from which will later emerge young queens, but no adult queen. By this interesting process the original colony is divided into two.

The swarm finds a new location in some place, such as a hollow tree, or, if cared for by the bee keeper, in a hive. The workers build new combs, the queen begins laying, and in a short time the swarm becomes a normal colony.

The colony on the old stand (parent colony) is increased by the bees emerging from the brood. After a time (usually about seven or eight days) the queens in their cells are ready to emerge. If the colony is only moderately strong the first queen to emerge is allowed by the workers to tear down the other queen cells and kill the queens not yet emerged, but if a "second swarm" is to be given off the queen cells are protected.

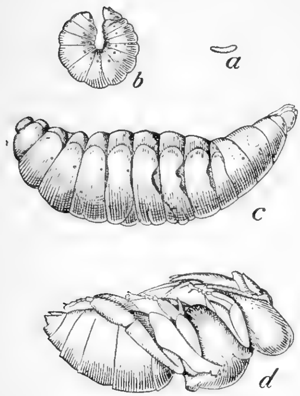

FIG. 12.—The honey bee: *a*, Egg; *b*, young larva; *c*, old larva; *d*, pupa. Three times natural size.

If the weather permits, when from 5 to 8 days old, the young queen flies from the hive to mate with a drone. Mating usually occurs but once during the life of the queen and always takes place on the wing. In mating she receives enough spermatozoa (male sex cells) to last throughout her life. She returns to the hive after mating, and in about two days begins egg laying. The queen never leaves the hive except at mating time or with a swarm, and her sole duty in the colony is to lay eggs to keep up the population.

When the flowers which furnish most nectar are in bloom, the bees usually gather more honey than they need for their own use, and this the bee keeper can safely remove. They continue the collection of honey and other activities until cold weather comes on in the fall, when brood rearing ceases; they then become relatively quiet, remaining in the hive all winter, except for short flights on warm days. When the main honey flow is over, the drones are usually driven from the hive. By that time the virgin queens have been mated and drones are of no further use. They are not usually stung to death, but are merely carried or driven from the hive by the workers and starve. A colony of bees which for any reason is without a queen does not expel the drones.

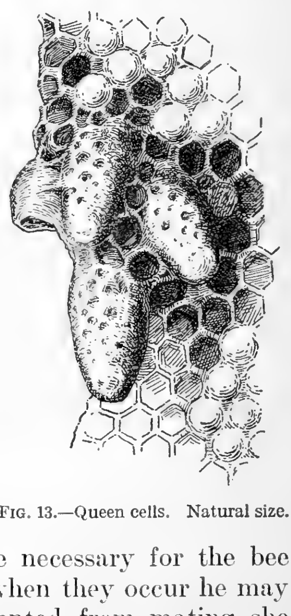
FIG. 13.—Queen cells. Natural size.

Many abnormal conditions may arise in the activity of a colony, and it is therefore necessary for the bee keeper to understand most of these, so that when they occur he may overcome them. If a virgin queen is prevented from mating she generally dies, but occasionally begins to lay eggs after about four weeks. In this event, however, all of the eggs which develop become males. Such a queen is commonly called a "drone layer."

If the virgin queen is lost while on her flight, or the colony at any other time is left queenless without means of rearing additional queens, it sometimes happens that some of the workers begin to lay eggs. These eggs also develop only into drones.

It also happens at times that when a queen becomes old her supply of spermatozoa is exhausted, at which time her eggs also develop only into drones. These facts are the basis of the theory that the drone of the bee is developed from an unfertilized egg or is parthenogenetic. A full discussion of this point is impossible in this place.

The work of the hive is very nicely apportioned among the inmates, so that there is little lost effort. As has been stated, the rearing of young is accomplished by having one individual to lay eggs and numerous others (immature females or workers) to care for the larvæ. In like manner all work of the colony is apportioned. In general, it may be stated that all inside work—wax building, care of brood, and cleaning—is done by the younger workers, those less than 17 days old, while the outside work of collecting pollen and nectar to be made into honey is done by the older workers. This plan may be changed by special conditions. For example, if the colony has been queenless for a time and a queen is then given, old workers may begin the inside work of feeding larvæ, and these may also secrete wax. Or, if the old workers are all removed, the younger bees may begin outside work. As a rule, however, the general plan of division of labor according to age is probably followed rather closely.

DIRECTIONS FOR GENERAL MANIPULATIONS.

Bees should be handled so that they will be little disturbed in their work. As much as possible, stings should be avoided during manipulation. This is true, not so much because they are painful to the operator, but because the odor of poison which gets into the air irritates the other bees and makes them more difficult to manage. For this reason it is most advisable to wear a black veil (fig. 4) over a wide-brimmed hat and to have a good smoker (fig. 3). Gloves, however, are usually more an inconvenience than otherwise. Gauntlets or rubber bands around the cuffs keep the bees from crawling up the sleeve. It is best to avoid black clothing, since that color seems to excite bees; a black felt hat is especially to be avoided.

Superfluous quick movements tend to irritate the bees. The hive should not be jarred or disturbed any more than necessary. Rapid movements are objectionable, because with their peculiar eye structure bees probably perceive motion more readily than they do objects. Persons not accustomed to bees, on approaching a hive, often strike at bees which fly toward them or make some quick movement of the head or hand to avoid the sting which they fear is to follow. This should not be done, for the rapid movement, even if not toward the bee, is far more likely to be followed by a sting than remaining quiet.

The best time to handle bees is during the middle of warm days, particularly during a honey flow. Never handle bees at night or on cold, wet days unless absolutely necessary. The work of a beginner may be made much easier and more pleasant by keeping gentle bees. Caucasians, Carniolans, Banats, and some strains of Italians ordinarily do not sting much unless unusually provoked or except in bad weather. Common black bees or crosses of blacks with other races are more irritable. It may be well worth while for the beginner to procure gentle bees while gaining experience in manipulation. Later on, this is less important, for the bee keeper learns to handle bees with little inconvenience to himself or to the bees. Various remedies for bee stings have been advocated, but they are all useless. The puncture made by the sting is so small that it closes when the sting is removed and liquids can not be expected to enter. The best thing to do when stung is to remove the sting as soon as possible without squeezing the poison sac, which is usually attached. This can be done by scraping it out with a knife or finger nail. After this is done the injured spot should be let alone and not rubbed with any liniment. The intense itching will soon disappear; any irritation only serves to increase the afterswelling.

Before opening a hive the smoker should be lighted and the veil put on. A few puffs of smoke directed into the entrance will cause the bees to fill themselves with honey and will drive back the guards. The hive cover should be raised gently, if necessary being pried loose with a screwdriver or special hive tool. When slightly raised, a little more smoke should be blown in vigorously on the tops of the frames, or if a mat covering for the frames is used, the cover should be entirely removed and one corner of the mat lifted to admit smoke. It is not desirable to use any more smoke than just enough to subdue the bees and keep them down on the frames. If at any time during manipulation they become excited, more smoke may be necessary. Do not stand in front of the entrance, but at one side or the back.

After the frames are exposed they may be loosened by prying gently with the hive tool and crowded together a little so as to give room for the removal of one frame. In cool weather the propolis (bee glue) may be brittle. Care should be exercised not to loosen this propolis with a jar. The first frame removed can be leaned against the hive, so that there will be more room inside for handling the others. During all manipulations bees must not be mashed or crowded, for it irritates the colony greatly and may make it necessary to discontinue operations. Undue crowding may also crush the queen. If bees crawl on the hands, they may be gently brushed off or thrown off.

In examining a frame hold it over the hive if possible, so that any bees or queen which fall may drop into it. Freshly gathered honey also often drops from the frame, and if it falls in the hive the bees can quickly clean it up, whereas if it drops outside it is untidy and may cause robbing. If a frame is temporarily leaned against the hive, it should be placed in a nearly upright position to prevent breakage and leaking of honey. The frame on which the queen is located should not be placed on the ground, for fear she may crawl away and be lost. It is best to lean the frame on the side of the hive away from the operator, so that bees will not crawl up his legs.

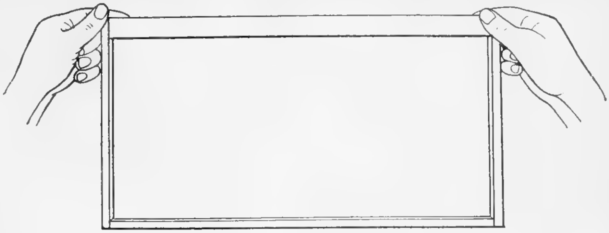

FIG. 14.—Handling the frame: First position.

In handling frames the comb should always be held in a vertical position, especially if it contains much honey. When a frame is lifted from the hive by the top bar, the comb is vertical with one side toward the operator (fig. 14). To examine the reverse side, raise one end of the top bar until it is perpendicular (fig. 15), turn the frame on the top bar as an axis until the reverse side is in view, and then lower to a horizontal position with the top bar below (fig. 16). In this way there is no extra strain on the comb and the bees are not irritated. This care is not so necessary with wired combs, but it is a good habit to form in handling frames.

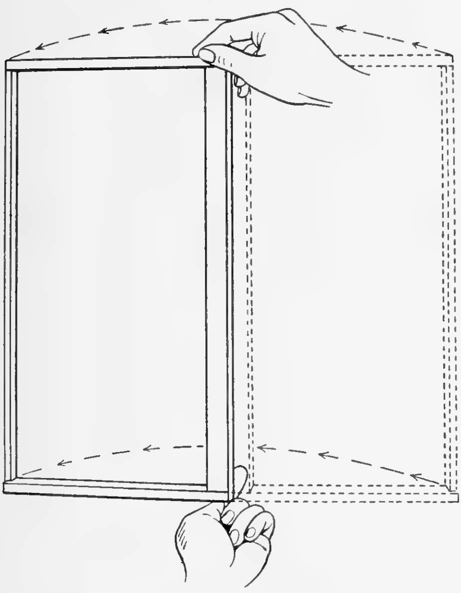

FIG. 15.—Handling the frame: Second position.

It is desirable to have combs composed entirely of worker cells in order to reduce the amount of drone brood. The use of full sheets of foundation will bring this about and is also of value in making the combs straight, so that bees are not mashed in removing the frame. It is extremely difficult to remove combs built crosswise in the hive, and this should never be allowed to occur. Such a hive is even worse than a plain box hive. Superfluous inside fixtures should be avoided, as they tend only to impede manipulation. The hive should also be placed so that the entrance is perfectly horizontal and a little lower than the back of the hive. The frames will then hang in a vertical position, and the outer ones will not be fastened by the bees to the hive body if properly spaced at the top.

In placing frames in the hive great care should be exercised that they are properly spaced. Some frames are self-spacing, having projections on the side, so that when placed as close as possible they are the correct distance apart. These are good for beginners or persons who do not judge distances well and are preferred by many professional bee keepers. If unspaced frames are used, the brood frames should be $1\frac{3}{8}$ inches from center to center. A little practice will usually enable anyone to space quickly and accurately. Careful spacing is necessary to prevent the building of combs of irregular thickness and to retard the building of pieces of comb from one frame to another.

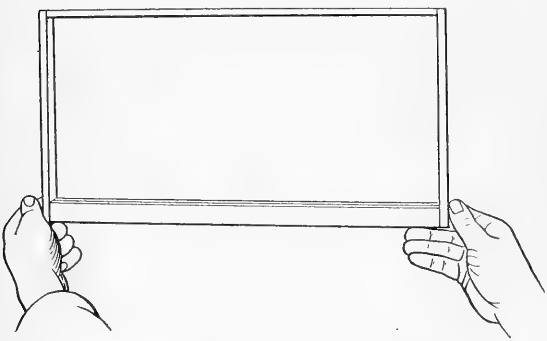

FIG. 16.—Handling the frame: Third position.

A beginner in beekeeping should by all means, if possible, visit some experienced bee keeper to get suggestions in handling bees. More can be learned in a short visit than in a considerably longer time in reading directions, and numerous short cuts which are acquired by experience will well repay the trouble or expense of such a visit. Not all professional bee keepers manipulate in the very best way, but later personal experience will correct any erroneous information. Above all, personal experimentation and a study of bee activity are absolute necessities in the practical handling of bees.

TRANSFERRING.

In increasing the apiary it is sometimes best to buy colonies in box hives on account of their smaller cost and to transfer them to hives with movable frames. This should be done as soon as possible, for box-hive colonies are of small value as producers. The best time to transfer is in the spring (during fruit bloom in the North) when the amount of honey and the population of the colony are at a minimum.

Transferring should not be delayed until spring merely because that season is best for the work. It may be done at any time during the active season, but, whenever possible, during a honey flow, to prevent robbing. If necessary, it may be done in a tent such as is often used in manipulating colonies. By choosing a time of the day when the largest number of bees are in the field the work will be lessened.

Plan 1.—The box hive should be moved a few feet from its stand and in its place should be put a hive with movable frames containing full sheets of foundation. The box hive should be turned upside down and a small, empty box inverted over it. By drumming continuously on the box hive with sticks for a considerable time the bees will be made to desert their combs and go to the upper box, and when most of them are clustered above, the bees may be dumped in front of the entrance of the hive which is to house them. The queen will usually be seen as the bees enter the hive, but, in case she has not left the old combs, more drumming will induce her to do so. It is necessary that the queen be in the hive before this manipulation is finished. The old box hive containing brood may now be placed right side up in a new location and in 21 days all of the worker brood will have emerged and probably some new queens will have been reared. These bees may then be drummed out and united with their former hive mates by vigorously smoking the colony and the drummed bees and allowing the latter to enter the hive through a perforated zinc to keep out the young queens. The comb in the box hive may then be melted up and any honey which it may contain used as the bee keeper sees fit. By this method good straight combs are obtained. If little honey is being gathered, the colony in the hive must be provided with food.

Plan 2.—If, on the other hand, the operator desires to save the combs of the box hive, the bees may be drummed into a box and the brood combs and other fairly good combs cut to fit frames and tied in place or held with rubber bands, strings, or strips of wood until the bees can repair the damage and fill up the breaks. These frames can then be hung in a hive on the old stand and the bees allowed to go in. The cutting of combs containing brood with more or less bees on them is a disagreeable job, and, since the combs so obtained are usually of little value in an apiary, the first method is recommended.

Plan 3.—Another good plan is to wait until the colony swarms and then move the box hive to one side. A movable frame hive is now placed in the former location of the box hive and the swarm is hived in it. In this way all returning field bees are forced to join the swarm. In 21 days all of the worker brood in the box hive will have emerged. These young bees may then be united with the bees in the frame hive and the box hive destroyed.

Colonies often take up their abode in walls of houses and it is often necessary to remove them to prevent damage from melting combs. If the cavity in which the combs are built can be reached, the method of procedure is like that of transferring, except that drumming is impractical and the bees must simply be subdued with smoke and the combs cut out with the bees on them.

Another method which is often better is to place a bee escape over the entrance to the cavity, so that the bees can come out, but can not return. A cone of wire cloth about 8 inches high with a hole at the apex just large enough for one bee to pass will serve as a bee escape, or regular bee escapes (fig. 8) such as are sold by dealers may be used. A hive which they can enter is then placed beside the entrance. The queen is not obtained in this way and, of course, goes right on laying eggs, but as the colony is rapidly reduced in size the amount of brood decreases. As brood emerges, the younger bees leave the cavity and join the bees in the hive, until finally the queen is left practically alone. A new queen should be given to the bees in the hive as soon as possible, and in a short time they are fully established in their new quarters. After about four weeks, when all or nearly all of the brood in the cavity has emerged, the bee escape should be removed and as large a hole made at the entrance of the cavity as possible. The bees will then go in and rob out the honey and carry it to the hive, leaving only empty combs. The empty combs will probably do no damage, as moths usually soon destroy them and they may be left in the cavity and the old entrance carefully closed to prevent another swarm from taking up quarters there.

In transferring bees from a hollow tree the method will depend on the accessibility of the cavity. Usually it is difficult to drum out the bees and the combs can be cut out after subduing the colony with smoke.

UNITING.

Frequently colonies become queenless when it is not practicable to give them a new queen, and the best practice under such conditions is to unite the queenless bees to a normal colony. If any colonies are weak in the fall, even if they have a queen, safe wintering is better insured if two or more weak colonies are united, keeping the best queen. Under various other conditions which may arise the bee keeper may find it desirable to unite bees from different colonies. Some fundamental facts in bee behavior must be thoroughly understood to make this a success.

Every colony of bees has a distinctive colony odor and by this means bees recognize the entering of their hive by bees from other colonies and usually resent it. If, however, a bee comes heavily laden from the field and flies directly into the wrong hive without hesitation it is rarely molested. In uniting colonies, the separate colony odors must be hidden, and this is done by smoking each colony vigorously. It may at times be desirable to use tobacco smoke, which not only covers the colony odor but stupefies the bees somewhat. Care should be taken not to use too much tobacco, as it will completely overcome the bees. The queen to be saved should be caged for a day or two to prevent the strange bees from killing her in the first excitement.

Another fact which must be considered is that the bees of a colony carefully mark the location of their own hive and remember that location for some time after they are removed. If, therefore, two colonies in the apiary which are not close together are to be united, they should be moved gradually nearer, not more than a foot at a time, until they are side by side, so that the bees will not return to their original locations and be lost. As the hives are moved gradually the slight changes are noted and no such loss occurs. As a further precaution, a board should be placed in front of the entrance in a slanting position, or brush and weeds may be thrown down so that when the bees fly out they recognize the fact that there has been a change and accustom themselves to the new place. If uniting can be done during a honey flow, there is less danger of loss of bees by fighting, or if done in cool weather, when the bees are not actively rearing brood, the colony odors are diminished and the danger is reduced.

It is an easy matter to unite two or more weak swarms to make one strong one, for during swarming the bees have lost their memory of the old location, are full of honey, and are easily placed wherever the bee keeper wishes. They may simply be thrown together in front of a hive. Swarms may also be given to a newly established colony with little difficulty.

PREVENTING ROBBING IN THE APIARY.

When there is no honey flow bees are inclined to rob other colonies, and every precaution must be taken to prevent this. Feeding often attracts other bees, and, if there are indications of robbing, the sirup or honey should be given late in the day. As soon as robbing begins, manipulation of colonies should be discontinued, the hives closed, and, if necessary, the entrances contracted as far as the weather will permit. If brush is thrown in front of the entrance, robbers are less likely to attempt entering. At all times honey which has been removed from the hives should be kept where no bees can get at it, so as not to incite robbing.

FEEDING.

During spring manipulations, in preparing bees for winter, and at other times it may be necessary to feed bees for stimulation or to provide stores. *Honey from an unknown source should never be used,* for fear of introducing disease, and sirup made of granulated sugar is cheapest and best for this purpose. The cheaper grades of sugar or molasses should never be used for winter stores. The proportion of sugar to water depends on the season and the purpose of the feeding. For stimulation a proportion of one-fourth to one-third sugar by volume is enough, and for fall feeding, especially if rather late, a solution containing as much sugar as it will hold when cold is best. There seems to be little advantage in boiling the sirup. Tartaric acid in small quantity may be added for the purpose of changing part of the cane sugar to invert sugar, thus retarding granulation. The medication of sirup as a preventive or cure of brood disease is often practiced, but it has not been shown that such a procedure is of any value. If honey is fed, it should be diluted somewhat, the amount of dilution depending on the season. If robbing is likely to occur, feeding should be done in the evening.

Numerous feeders are on the market, adapted for different purposes and methods of manipulation (figs. 17, 18, 19). A simple feeder can be made of a tin pan filled with excelsior or shavings (fig. 20). This is filled with sirup and placed on top of the frames in a super or hive body. It is advisable to lean pieces of wood on the pan as runways for the bees, and to attract them first to the sirup, either by mixing in a little honey or by spilling a little sirup over the frames and sticks.

It may be stated positively that it does not pay financially, or in any other way, to feed sugar sirup to be stored in sections and sold as comb honey. Of course, such things have been tried, but the consumption of sugar during the storing makes the cost greater than the value of pure floral honey.

SPRING MANAGEMENT.

The condition of a colony of bees in the early spring depends largely upon the care given the bees the preceding autumn and in the method of wintering. If the colony has wintered well and has a good prolific queen, preferably young, the chances are that it will become strong in time to store a good surplus when the honey flow comes.

The bees which come through the winter, reared the previous autumn, are old and incapable of much work. As the season opens they go out to collect the early nectar and pollen, and also care for the brood. The amount of brood is at first small, and as the new workers emerge they assist in the brood rearing so that the extent of the brood can be gradually increased until it reaches its maximum about the beginning of the summer. The old bees die off rapidly.

If brood rearing does not continue late in the fall, so that the colony goes into winter with a large percentage of young bees, the old bees may die off in the spring faster than they are replaced by emerging brood. This is known as "spring dwindling." A preventive remedy for this may be applied by feeding, if necessary, the autumn before, or keeping up brood rearing as late as possible by some other means.

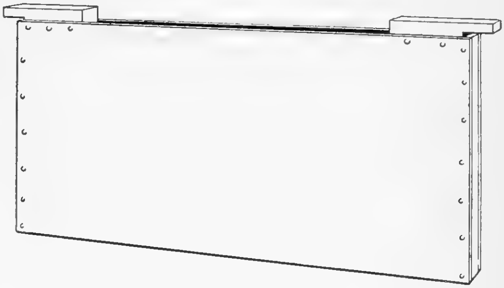

FIG. 17.—Division-board feeder to be hung in hive in place of frame.

If spring dwindling begins, however, it can be diminished somewhat by keeping the colony warm and by stimulative feeding, so that all the energy of the old bees may be put to the best advantage in rearing brood to replace those dying off. The size of the brood chamber can also be reduced to conserve heat.

It sometimes happens that when a hive is examined in the spring the hive body and combs are spotted with brownish yellow excrement. This is an evidence of what is commonly called "dysentery." The cause of this trouble is long-continued confinement with a poor quality of honey for food. Honey-dew honey and some of the inferior floral honeys contain a relatively large percentage of material which bees can not digest, and, if they are not able to fly for some time, the intestines become clogged with fæcal matter and a diseased condition results. Worker bees never normally deposit their fæces in the hive. The obvious preventive for this is to provide the colony with good honey or sugar sirup the previous fall. "Dysentery" frequently entirely destroys colonies, but if the bees can pull through until warm days permit a cleansing flight they recover promptly.

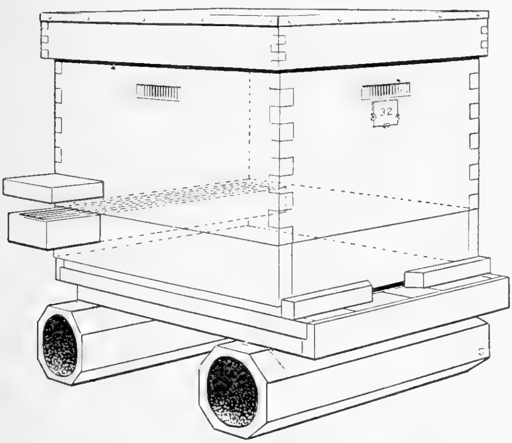

FIG. 18.—Feeder set in collar under hive body.

Bees should not be handled in the early spring any more than necessary, for to open a hive in cool weather wastes heat and may even kill the brood by chilling. The hive should be kept as warm as possible in early spring as an aid to brood rearing. It is a good practice to wrap hives in *black* tar paper in the spring, not only that it may aid in conserving the heat of the colony, but in holding the sun's heat rays as a help to the warmth of the hive. This wrapping should be put on as soon as an early examination has shown the colony to be in good condition, and there need be no hurry in taking it off. A black wrapping during the winter is not desirable, as it might induce brood rearing too early and waste the strength of the bees.

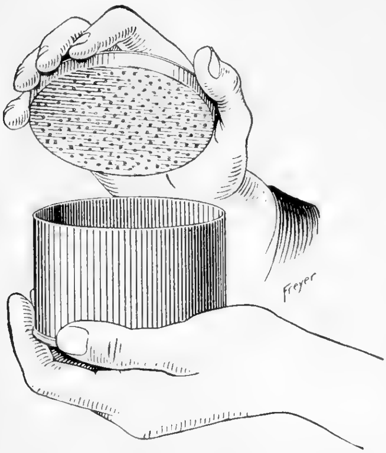

FIG. 19.—"Pepper-box" feeder for use on top of frames.

As a further stimulus to brood rearing, stimulative feeding of sugar sirup in early spring may be practiced. This produces much the same effect as a light honey flow does and the results are often good. Others prefer to give the bees such a large supply of stores in the fall that when spring comes they will have an abundance for brood rearing, and it will not be necessary to disturb them in cool weather. Both ideas are good, but judicious stimulative feeding usually more than pays for the labor. Colonies should be fed late in the day, so that the bees will not fly as a result of it, and so that robbing will not be started. When the weather is warmer and more settled the brood cluster may be artificially enlarged by spreading the frames so as to insert an empty comb in the middle. The bees will attempt to cover all the brood that they already had, and the queen will at once begin laying in the newly inserted comb, thus making a great increase in the brood. This practice is desirable when carefully done, but may lead to serious

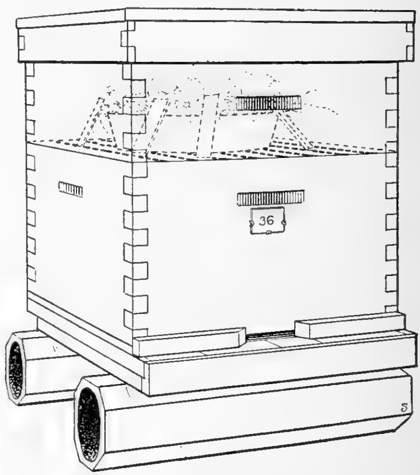

FIG. 20.—Pan in super arranged for feeding.

results if too much new brood is produced. A beginner had better leave the quantity of brood to the bees.

It is desirable early in the season, before any preparations are made for swarming, to go through the apiary and clip one wing of each queen (see p. 30). This should be done before the hive becomes too populous. It is perhaps best to clip queens as they are introduced, but some colonies may rear new ones without the knowledge of the owner, and a spring examination will insure no escaping swarms. The beginner should perhaps be warned not to clip the wings of a virgin queen.

Queens sometimes die during the winter and early spring, and since there is no brood from which the bees can replace them, the queenless colonies are "hopelessly queenless." Such colonies are usually restless and are not active in pollen gathering. If, on opening a colony, it is found to be without a queen and reduced in numbers, it should be united with another colony by smoking both vigorously and caging the queen in the queen-right colony for a day or two to prevent her being killed. A frame or two of brood may be added to a queenless colony, not only to increase its strength, but to provide young brood from which they can rear a queen. Bee keepers in the North can frequently buy queens from southern breeders early in the spring and naturally this is better than leaving the colony without a queen until the bees can rear one, as it is important that there be no stoppage in brood rearing at this season.

SWARM MANAGEMENT AND INCREASE.

The excessive rearing of brood at the wrong season or increase in the number of colonies greatly reduces the surplus honey crop by consumption. The ideal to which all progressive bee keepers work, when operating simply for honey, is to stimulate brood rearing to prepare bees for gathering, to retard breeding when it is less desirable, and to prevent swarming. Formerly the measure of success in beekeeping was the amount of increase by swarming, but this is now recognized as being quite the contrary of success.

The stimulation of brood rearing in the spring, however, makes it more likely that swarming will occur; so that the operator must counteract the tendency to swarm. This is especially true in comb-honey production. Very few succeed in entirely preventing swarming, but by various methods the situation can be largely controlled.

When a swarm issues, it usually first settles on a limb of a tree or bush near the apiary. It was formerly common to make a noise by beating pans or ringing bells in the belief that this causes the swarm to settle. There is no foundation for such action on the part of the bee keeper. If the bees alight on a small limb that can be spared it may simply be sawed off and the bees carried to the hive and thrown on a sheet or hive cover in front of the entrance. If the limb can not be cut, the swarm can be shaken off into a box or basket on a pole and hived. If the bees light on the trunk of a tree or in some inaccessible place they can first be attracted away by a comb, preferably containing unsealed brood. In these manipulations it is not necessary to get all the bees, but if the queen is not with those which are put into the hive the bees will go into the air again and join the cluster.

If a queen is clipped as recommended under "Spring management" (p. 29) the swarm will issue just the same, but the queen, not being able to fly, will simply wander about on the ground in front of the hive, where she can be caught and caged. The parent colony can then be removed to a new stand and a new hive put in its place. The bees will soon return and the queen can be freed among them as they enter. The field bees on returning will enter the new hive with the swarm, thus decreasing still more the parent colony and making a second swarm less probable. To make sure of this, however, all queen cells except one good one can be removed soon after the swarm issues. Another method of preventing second swarms is to set the old hive beside the swarm and in a week move the old hive to another place. The field bees of the parent colony then join the swarm and the parent colony is so much reduced that a second swarm does not issue.

To hold a swarm it is desirable to put one frame containing healthy unsealed brood in the new hive. The other frames may contain full sheets or starters of foundation. Usually comb-honey supers or surplus bodies for extracting frames will have been put on before swarming occurs. These are given to the swarm on the old stand and separated from the brood chamber by queen-excluding perforated zinc. In three or four days the perforated zinc may be removed if desired.

When clipping the queen's wing is not practiced, swarms may be prevented from leaving by the use of queen traps of perforated zinc (fig. 6). These allow the workers to pass out, but not drones or queens, which, on leaving the entrance, pass up to an upper compartment from which they can not return. These are also used for keeping undesirable drones from escaping, and the drones die of starvation. When a swarm issues from a hive provided with a queen trap the queen goes to the upper compartment and remains there until released by the bee keeper. The workers soon return to the hive. When the operator discovers the queen outside, the colony may be artificially swarmed to prevent another attempt at natural swarming. A queen trap should not be kept on the hive all the time for fear the old queen may be superseded and the young queen prevented from flying out to mate.

ARTIFICIAL SWARMING

If increase is desired, it is better to practice some method of artificial swarming and to forestall natural swarming rather than be compelled to await the whims of the colonies. The situation should be under the control of the bee keeper as much as possible. The bees, combs, and brood may be divided into two nearly equal parts and a queen provided for the queenless portion; or small colonies, called nuclei, may be made from the parent colony, so reducing its strength that swarming is not attempted. These plans are not as satisfactory as shaken swarms, since divided colonies lack the vigor of swarms.

A good method of artificially swarming a colony is to shake most of the bees from the combs into another hive on the old stand with starters (narrow strips) of foundation. The hive containing the brood with some bees still adhering is then moved to a new location. If receptacles for surplus honey have been put on previously, as they generally should be, they should now be put over the artificial swarm separated from the brood compartment by perforated zinc.

This method of artificially swarming (usually called by bee keepers "shook" swarming) should not be practiced too early, since natural swarming may take place later. The colony should first have begun its preparations for swarming. The method is particularly useful in comb-honey production. The bees may be prevented from leaving the hive by the use of a drone trap (fig. 6) or by putting in one frame containing unsealed brood. Some bee keepers prefer using full sheets of foundation or even drawn combs for the artificial swarm, but narrow strips of foundation have some advantages. By using narrow strips the queen has no cells in which to lay eggs for a time, thus reducing brood rearing, but, since by the time artificial swarming is practiced the profitable brood rearing is usually over, this is no loss but rather a gain. There are also in the brood compartment no cells in which the gathering workers can deposit fresh honey, and they consequently put it in the supers. Gradually the combs below are built out and brood rearing is increased. Later the colony is allowed to put honey in the brood combs for its winter supply. If no increase is desired, the bees which emerge from the removed brood combs may later be united with the artificial swarm and by that time there will usually be little danger of natural swarming.

Artificial swarming can readily be combined with the shaking treatment for bee diseases, thus accomplishing two objects with one manipulation. If disease is present in the parent colony, only strips of foundation should be used and the colony should be confined to the hive with a queen and drone trap and not with a frame of brood.

PREVENTION OF SWARMING.

Unless increase is particularly desired, both natural and artificial swarming should be done away with as far as possible, so that the energy of the bees shall go into the gathering of honey. Since crowded and overheated hives are particularly conducive to swarming, this tendency may be largely overcome by giving plenty of ventilation and additional room in the hive. Shade is also a good preventive of swarming. Extra space in the hive may be furnished by adding more hive bodies and frames or by frequent extracting, so that there may be plenty of room for brood rearing and storage at all times. These manipulations are, of course, particularly applicable to extracted-honey production.

To curb the swarming impulse frequent examinations of the colonies (about every week or 10 days during the swarming season) for the purpose of cutting out queen cells is a help, but this requires considerable work, and since some cells may be overlooked, and particularly since it frequently fails in spite of the greatest care, it is not usually practiced. Requeening with young queens early in the season, when possible, generally prevents swarming.

Swarming is largely due to crowded brood chambers, and since eggs laid immediately before and during the honey flow do not produce gatherers, several methods have been tried of reducing the brood. The queen may either be entirely removed or be caged in the hive to prevent her from laying. In either event the bees will usually build queen cells to replace her, and these must be kept cut out. These plans would answer the purpose very well were it not for the fact that queenless colonies often do not work vigorously. Under most circumstances these methods can not be recommended. A better method is to remove brood about swarming time and thus reduce the amount. There are generally colonies in the apiary to which frames of brood can be given to advantage.

In addition to these methods various nonswarming devices have been invented, and later a nonswarming hive so constructed that there is no opportunity for the bees to form a dense cluster. The breeding of bees by selecting colonies with less tendency to swarm has been suggested.

On the whole, the best methods are the giving of plenty of room, shade, and ventilation to colonies run for extracted honey; and ventilation, shade, and artificial swarming of colonies run for comb honey. Frequent requeening (about once in two years) is desirable for other reasons, and requeening before swarming time helps in the solution of that difficulty.

PREPARATION FOR THE HARVEST.

An essential in honey production is to have the hive overflowing with bees at the beginning of the honey flow, so that the field force will be large enough to gather more honey than the bees need for their own use. To accomplish this, the bee keeper must see to it that brood rearing is heavy some time before the harvest, and he must know accurately when the honey flows come, so that he may time his manipulations properly. Brood rearing during the honey flow usually produces bees which consume stores, while brood reared before the flow furnishes the surplus gatherers. The best methods of procedure may be illustrated by giving as an example the conditions in the white-clover region.

In the spring the bees gather pollen and nectar from various early flowers, and often a considerable quantity from fruit bloom and dandelions. During this time brood rearing is stimulated by the new honey, but afterwards there is usually a period of drought when brood rearing is normally diminished or not still more increased as it should be. This condition continues until the white-clover flow comes on, usually with a rush, when brood rearing is again augmented. If such a condition exists, the bee keeper should keep brood rearing at a maximum by stimulative feeding during the drought. When white clover comes in bloom he may even find it desirable to prevent brood rearing to turn the attention of his bees to gathering.

A worker bee emerges from its cell 21 days after the egg is laid, and it usually begins field work in from 14 to 17 days later. It is evident, therefore, that an egg must be laid five weeks before the honey flow to produce a gatherer. Since the flow continues for some time and since bees often go to the field earlier than 14 days, egg laying should be pushed up to within two or three weeks of the opening of the honey flow. In addition to stimulative feeding, the care of the colony described under the heading of "Spring management" (p. 26) will increase brood production.

THE PRODUCTION OF HONEY.

The obtaining of honey from bees is generally the primary object of their culture. Bees gather nectar to make into honey for their own use as food, but generally store more than they need, and this surplus the bee keeper takes away. By managing colonies early in the spring as previously described the surplus may be considerably increased. The secret of maximum crops is to "Keep all colonies strong."

Honey is gathered in the form of nectar secreted by various flowers, is transformed by the bees, and stored in the comb. Bees also often gather a sweet liquid called "honeydew," produced by various scale insects and plant-lice, but the honeydew honey made from it is quite unlike floral honey in flavor and composition and should not be sold for honey. It is usually unpalatable and should never be used as winter food for bees, since it usually causes dysentery (p. 40). When nectar or honeydew has been thickened by evaporation and otherwise changed, the honey is sealed in the cells with cappings of beeswax.

It is not profitable to cultivate any plant solely for the nectar which it will produce, but various plants, such as clovers, alfalfa, and buckwheat, are valuable for other purposes and are at the same time excellent honey plants; their cultivation is therefore a benefit to the bee keeper. It is often profitable to sow some plant on waste land; sweet clovers are often used in this way. The majority of honey-producing plants are wild, and the bee keeper must largely accept the locality as he finds it and manage his apiary so as to get the largest possible amount of the available nectar. Since bees often fly as far as 2 or 3 miles to obtain nectar, it is obvious that the bee keeper can rarely influence the nectar supply appreciably. Before deciding what kind of honey to produce the bee keeper should have a clear knowledge of the honey resources of his locality and of the demands of the market in which he will sell his crop. If the bulk of the honey is dark, or if the main honey flows are slow and protracted, it will not pay to produce comb honey, since the production of fancy comb honey depends on a rapid flow. The best localities for comb-honey production are in the northern part of the United States east of the Mississippi River, where white clover is a rapid and abundant yielder. Other parts of the United States where similar conditions of rapidity of flow exist are also good. Unless these favorable conditions are present it is better to produce extracted honey.

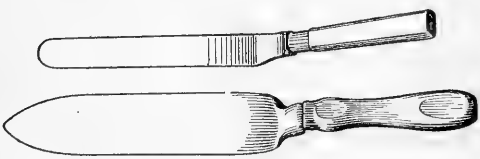

FIG. 21.—Knives for uncapping honey.

EXTRACTED HONEY.[1]

Extracted honey is honey which has been removed by means of centrifugal force from the combs in which the bees stored it. While it is possible to adulterate extracted honey by the addition of cheap sirups, this is rarely done, perhaps largely on account of the possibility of detection. It may be said to the credit of bee keepers as a class that they have always opposed adulteration of honey.

[1] For further discussion of the production and care of extracted honey, see Bulletin 75, Part I, Bureau of Entomology.

In providing combs for the storage of honey to be extracted the usual practice is to add to the top of the brood chamber one or more hive bodies just like the one in which brood is reared, and fill these with frames. If preferred, shallower frames with bodies of proper size may be used, but most honey extractors are made for full-size frames. The surplus bodies should be put on in plenty of time to prevent the crowding of the brood chamber, and also to act as a preventive of swarming.

Honey for extracting should not be removed until it is well ripened and a large percentage of it capped. It is best, however, to remove the crop from each honey flow before another heavy producing plant comes into bloom, so that the different grades of honey may be kept separate. It is better to extract while honey is still coming in, so that the bees will not be apt to rob. The extracting should be done in a building, preferably one provided with wire cloth at the windows (p. 9).

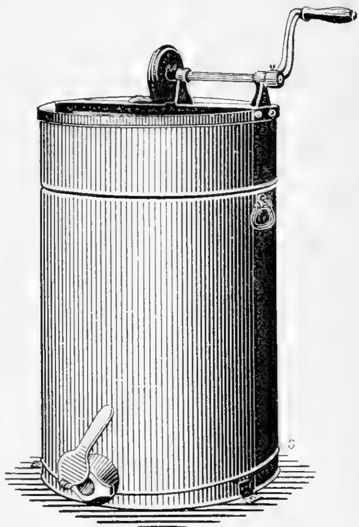

Fig. 22.—Honey extractor.

The frames containing honey to be extracted are removed from the hive, the cappings cut off with a sharp, warm knife (fig. 21) made specially for this purpose, and the frames are then put into the baskets of the honey extractor (fig. 22). By revolving these rapidly the honey is thrown out of one side. The basket is then reversed and the honey from the other side is removed. The combs can then be returned to the bees to be refilled, or if the honey flow is over, they can be returned to the bees to be cleaned and then removed and stored until needed again. This method is much to be preferred to mashing the comb and straining out the honey, as was formerly done.

In large apiaries special boxes to receive cappings, capping melters to render the cappings directly into wax, and power-driven extractors are often used. These will be found listed in supply catalogues.

The extracted honey is then strained and run into vessels. It is advisable not to put it in bottles at once, but to let it settle in open vessels for a time, so that it can be skimmed. Most honeys will granulate and become quite hard if exposed to changes of temperature, and to liquefy granulated extracted honey it should be heated in a water bath. Never heat honey directly over a stove or flame, as the flavor is thereby injured. The honey should never be heated higher than 160° F. unless it is necessary to sterilize it because of contamination by disease.

Extracted honey is put up in bottles or small tin cans for the retail trade, and in 5-gallon square tin cans or barrels for the wholesale market. Great care must be exercised if barrels are used, as honey will absorb moisture from the wood, if any is present, and cause leakage. The tin package is much to be preferred in most cases. In bottling honey for retail trade, it will well repay the bee keeper or bottler to go to considerable expense and trouble to make an attractive package, as the increased price received will more than compensate for the increased labor and expense. Honey should be heated to 160° F. and kept there for a time before bottling, and the bottle should be filled as full as possible and sealed hermetically.

Granulated honey.—Some honeys, such as alfalfa, granulate quickly after being extracted. Such honeys are sometimes allowed to granulate in large cans and the semisolid mass is then cut into 1-pound bricks like a butter print and wrapped in paraffin paper. It may be put into paraffined receptacles before granulation, if desired. There is always a ready market for granulated honey, since many people prefer it to the liquid honey.

COMB HONEY.

Comb honey is honey as stored in the comb by the bees, the size and shape being determined by the small wooden sections provided by the bee keeper. Instead of having comb in large frames in which to store surplus honey, the bees are compelled to build comb in the sections and to store honey there (fig. 2). A full section weighs about 1 pound; larger ones are rarely used. By the use of modern sections and foundation the comb honey now produced is a truly beautiful, very uniform product, so uniform in fact that it is often charged that it must be artificially manufactured. The purchaser of a section of comb honey may be absolutely certain, however, that he is obtaining a product of the bees, for never has anyone been able to imitate the bees' work successfully. To show their confidence in the purity of comb honey, the National Bee Keepers' Association offers $1,000 for a single pound of artificial comb filled with an artificially prepared sirup, which is at all difficult of detection.

There are several different styles of sections now in use, the usual sizes being 4¼ inches square and 4 by 5 inches. There are also two methods of spacing, so that there will be room for the passage of bees from the brood chamber into the sections and from one super of sections to another. This is done either by cutting "bee ways" in the sections and using plain flat separators or by using "no bee-way" or plain sections and using "fences"—separators with cleats fastened on each side, to provide the bee space. To describe all the different "supers" or bodies for holding sections would be impossible in a bulletin of this size, and the reader must be referred to catalogues of dealers in beekeeping supplies. Instead of using regular comb-honey supers, some bee keepers use wide frames to hold two tiers of sections. It is better, however, to have the supers smaller, so that the bees may be crowded more to produce full sections. To overcome this difficulty, shallow wide frames holding one tier of sections may be used. The majority of bee keepers find it advisable to use special comb-honey supers.

In producing comb honey it is even more necessary to know the plants which produce surplus honey, and just when they come in bloom, than it is in extracted honey production. The colony should be so manipulated that the maximum field force is ready for the beginning of the flow. This requires care in spring management, and, above all, the prevention of swarming. Supers should be put on just before the heavy flow begins. A good indication of the need of supers is the whitening of the brood combs at the top. If the bees are in two hive-bodies they should generally be reduced to one, and the frames should be filled with brood and honey so that as the new crop comes in the bees will carry it immediately to the sections above. If large hives are used for the brood chamber it is often advisable to remove some of the frames and use a division board to crowd the bees above. To prevent the queen from going into the sections to lay, a sheet of perforated zinc (fig. 23) may be put between the brood chamber and the super (fig. 2).

It is often difficult to get bees to begin work in the small sections, but this should be brought about as soon as possible to prevent loss of honey. If there are at hand some sections which have been partly drawn the previous year, these may be put in the super with the new sections as "bait." Another good plan is to put a shallow extracting frame on either side of the sections. If a few colonies in the apiary that are strong enough to go above refuse to do so, lift supers from some colonies that have started to work above and give them to the slow colonies. The super should generally be shaded somewhat to keep it from getting too hot. Artificial swarming will quickly force bees into the supers.

To produce the finest quality of comb honey full sheets of foundation should be used in the sections. Some bee keepers use nearly a full sheet hung from the top of the section and a narrow bottom starter. The use of foundation of worker-cell size is much preferred.

When one super becomes half full or more and there are indications that there will be honey enough to fill others, the first one should be raised and an empty one put on the hive under it. This tiering up can be continued as long as necessary, but it is advisable to remove filled sections as soon as possible after they are nicely capped, for they soon become discolored and less attractive. Honey removed immediately after capping finds a better market, but if left on the hive even until the end of the summer the quality of the honey is improved. A careful watch must be kept on the honey flow, so as to give the bees only enough sections to store the crop. If this is not done a lot of unfinished sections will be left at the end of the flow.

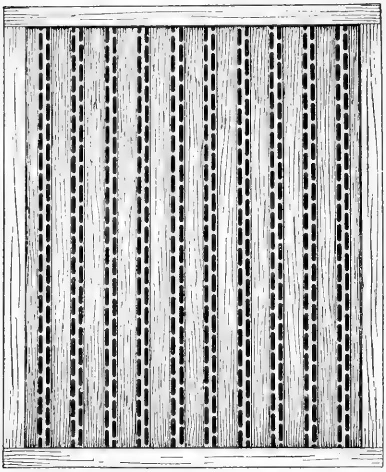

FIG. 23.—Perforated zinc queen excluder.

Honeys from different sources should not be mixed in the sections, as it usually gives the comb a bad appearance

To remove bees from sections, the super may be put over a bee escape so that the bees can pass down but can not return, or the supers may be removed and covered with a wire-cloth-cone bee escape.

After sections are removed the wood should be scraped free of propolis (bee glue) and then packed in shipping cases (fig. 24) for the market. Shipping cases to hold 12, 24, or 48 sections, in which the various styles of sections fit exactly, are manufactured by dealers in supplies. In shipping these cases, several of them should be put in a box or crate packed in straw and paper and handles provided to reduce the chances of breakage. When loaded in a freight car the combs should be parallel with the length of the car.

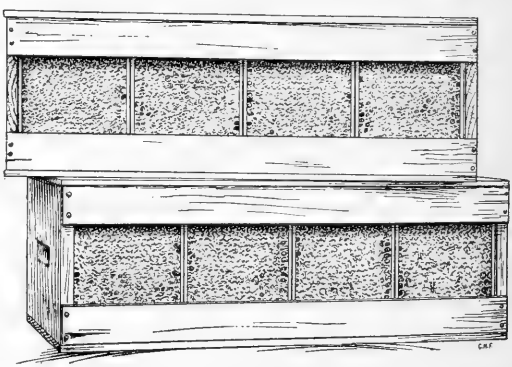

FIG. 24.—Shipping cases for comb honey.

In preparing comb honey for market it should be carefully graded so that the sections in each shipping case are as uniform as possible. Nothing will more likely cause wholesale purchasers to cut the price than to find the first row of sections in a case fancy and those behind of inferior grade. Grading rules have been adopted by various bee keepers' associations or drawn up by honey dealers. The following sets of rules are in general use:

Eastern Grading Rules for Comb Honey.

Fancy.—All sections well filled; combs straight; firmly attached to all four sides; the combs unsoiled by travel, stain, or otherwise; all the cells sealed except an occasional one; the outside surface of the wood well scraped of propolis.

A No. 1.—All sections well filled except the row of cells next to the wood; combs straight; one-eighth part of comb surface soiled, or the entire surface slightly soiled; the outside surface of the wood well scraped of propolis.

No. 1.—All sections well filled except the row of cells next to the wood; combs comparatively even; one-eighth part of comb surface soiled, or the entire surface slightly soiled.

No. 2.—Three-fourths of the total surface must be filled and sealed.

No. 3.—Must weigh at least half as much as a full-weight section.

In addition to this the honey is to be classified according to color, using the terms white, amber, and dark; that is, there will be "Fancy White," "No. 1 Dark," etc.

THE PRODUCTION OF WAX.

New Comb-Honey Grading Rules Adopted by the Colorado State Bee Keepers' Association.

No. 1 White.—Sections to be well filled and evenly capped, except the outside row, next to the wood; honey white or slightly amber, comb and cappings white, and not projecting beyond the wood; wood to be well cleaned; cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections.

No. 1 Light Amber.—Sections to be well filled and evenly capped, except the outside row next to the wood; honey white or light amber; comb and cappings from white to off color, but not dark; comb not projecting beyond the wood; wood to be well cleaned. Cases of separatored honey to average 21 pounds net per case of 24 sections; no section in this grade to weigh less than 13½ ounces. Cases of half-separatored honey to average not less than 22 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 23 pounds net per case of 24 sections.

No. 2.—This includes all white honey, and amber honey not included in the above grades; sections to be fairly well filled and capped, no more than 25 uncapped cells, exclusive of outside row, permitted in this grade; wood to be well cleaned; no section in this grade to weigh less than 12 ounces. Cases of separatored honey to average not less than 19 pounds net. Cases of half-separatored honey to average not less than 20 pounds net per case of 24 sections. Cases of unseparatored honey to average not less than 21 pounds net per case of 24 sections.

Beeswax, which is secreted by the bees and used by them for building their combs, is an important commercial product. There are times in almost every apiary when there are combs to be melted up, and it pays to take care of even scraps of comb and the cappings taken off in extracting. A common method of taking out the wax is to melt the combs in a solar wax extractor. This is perhaps the most feasible method where little wax is produced, but considerable wax still remains in old brood combs after such heating. Various wax presses are on the market, or one can be made at home. If much wax is produced, the bee keeper should make a careful study of the methods of wax extraction, as there is usually much wax wasted even after pressing.

PREPARATIONS FOR WINTERING.

After the main honey flow is over the management must depend on what may be expected later in the season from minor honey flows. If no crop is to be expected, the colony may well be kept only moderately strong, so that there will not be so many consumers in the hive.

In localities where winters are severe and breeding is suspended for several months great care should be taken that brood rearing is rather active during the late summer, so that the colony may go into winter with plenty of young bees. In case any queens show lack of vitality they should be replaced early, so that the bees will not become queenless during the winter.

The important considerations in wintering are plenty of young bees, a good queen, plenty of stores of good quality, sound hives, and proper protection from cold and dampness.

If, as cold weather approaches, the bees do not have stores enough, they must be fed. Every colony should have from 25 to 40 pounds, depending on the length of winter and the methods of wintering. It is better to have too much honey than not enough, for what is left is good next season. If feeding is practiced, honey may be used, but sirup made of granulated sugar is just as good and is perfectly safe. If honey is purchased for feeding, great care should be taken that it comes from a healthy apiary, otherwise the apiary may be ruined by disease. *Never feed honey bought on the open market.* The bees should be provided with stores early enough so that it will not be necessary to feed or to open the colonies after cold weather comes on. Honeydew honey should not be left in the hives, as it produces "dysentery." Some honeys are also not ideal for winter stores. Those which show a high percentage of gums (most tree honeys) are not so desirable, but will usually cause no trouble.

In wintering out of doors the amount of protection depends on the severity of the winter. In the South no packing is necessary, and even in very cold climates good colonies with plenty of stores can often pass the winter with little protection, but packing and protection make it necessary for the bees to generate less heat, and consequently they consume less stores and their vitality is not reduced. Dampness is probably harder for bees to withstand than cold, and when it is considered that bees give off considerable moisture, precautions should be taken that as it condenses it does not get on the cluster. An opening at the top would allow the moisture to pass out, but it would also waste heat, so it is better to put a mat of burlap or other absorbent material on top of the frames. The hive may also be packed in chaff, leaves, or other similar dry material to diminish the loss of heat. Some hives are made with double walls, the space being filled with chaff; these are good for outdoor wintering. The hive entrance should be lower than any other part of the hive, so that any condensed moisture may run out. The hives should be sound and the covers tight and waterproof.

Entrances should be contracted in cold weather not only to keep out cold wind, but to prevent mice from entering. There should always be enough room, however, for bees to pass in and out if warmer weather permits a flight.

In the hands of experienced bee keepers cellar wintering is very successful, but this method requires careful study. The cellar must be dry and so protected that the temperature never varies more than from 40 to 45° F.; 43° F. seems to be the optimum temperature. The ventilation must be good or the bees become fretful. Light should not be admitted to the cellar, and consequently some means of indirect ventilation is necessary.

Cellar wintering requires the consumption of less honey to maintain the proper temperature in the cluster and is therefore economical. Bees so wintered do not have an opportunity for a cleansing flight, often for several months, but the low consumption makes this less necessary. Some bee keepers advocate carrying the colonies out a few times on warm days, but it is not fully established whether this is entirely beneficial and it is usually not practiced.

The time for putting colonies in the cellar is a point of dispute, and practice in this regard varies considerably. They should certainly be put in before the weather becomes severe and as soon as they have ceased brood rearing. The time chosen may be at night when they are all in the hive, or on some chilly day.

The hives may be piled one on top of the other, the lower tier raised a little from the floor. The entrances should not be contracted unless the colony is comparatively weak. It is usually not considered good policy to close the entrances with ordinary wire cloth, as the dead bees which accumulate more or less on the bottom boards may cut off ventilation, and the entrance should be free so that these may be cleaned out.

It is, however, good policy to cover the entrance with wire cloth having three meshes to the inch to keep out mice.

The time of removing bees from the cellar is less easily determined than that of putting them in. The colonies may be removed early and wrapped in *black* tar paper or left until the weather is settled. If the weather is very warm and the bees become fretful, the cellar must either be cooled or the bees removed. Some bee keepers prefer to remove bees at night, so that they can recover from the excitement and fly from the hive normally in the morning. One of the chief difficulties is to prevent the bees from getting into the wrong hives after their first flights. They often "drift" badly with the wind, and sometimes an outside row will become abnormally strong, leaving other colonies weak.

The night before the bees are removed from the cellar it is good practice to leave the cellar doors and windows wide open.

DISEASES AND ENEMIES.

There are two infectious diseases of the brood of bees which cause great losses to the beekeeping industry of the United States. These are known as American foul brood and European foul brood. Both of these diseases destroy colonies by killing the brood, so that there are not enough young bees emerging to take the place of the old adult bees as these die from natural causes. The adult bees are not attacked by either disease. In the hands of careful bee keepers both diseases may be controlled, and this requires careful study and constant watching. In view of the fact that these diseases are now widely distributed throughout the United States, every bee keeper should read the available literature on the subject, so that if disease enters his apiary he may be able to recognize it before it gets a start. The symptoms and the treatment recommended by this department are given in another publication which will be sent free on request.[1]

It is difficult for a bee keeper to keep his apiary free from disease if others about him have diseased colonies which are not properly treated. The only way to keep disease under control is for the bee keepers in the neighborhood to cooperate in doing everything possible to stamp out disease as soon as it appears in a single colony. The progressive bee keeper who learns of disease in his neighborhood should see to it that the other bee keepers around him are supplied with literature describing symptoms and treatment, and should also try to induce them to unite in eradicating the malady. Since it is so often impossible to get all of the bee keepers in a community to treat infected colonies properly and promptly, it is desirable that the States pass laws providing for the inspection of apiaries and granting to the inspector the power to compel negligent bee keepers to treat diseased colonies so that the property of others may not be endangered and destroyed. This has been done in a number of States, but there are still some where the need is great and in which no such provision has been made. When no inspection is provided, bee keepers should unite in asking for such protection, so that the danger to the industry may be lessened.

In case there is an inspector for the State or county, he should be notified as soon as disease is suspected in the neighborhood. Some bee keepers hesitate to report disease through fear that the

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[1] Farmers' Bulletin No. 442, "The Treatment of Bee Diseases."

inspector will destroy their bees or because they feel that it is a disgrace to have disease in the apiary. There is no disgrace in having colonies become diseased; the discredit is in not treating them promptly. The inspectors are usually, if not universally, good practical bee keepers who from a wide experience are able to tell what should be done in individual cases to give the best results with the least cost in material and labor. They do not destroy colonies needlessly, and, in fact, they all advocate and teach treatment.

The brood diseases are frequently introduced into a locality by the shipping in of diseased colonies; or, more often, the bees get honey from infected colonies which is fed to them, or which they rob, from discarded honey cans. It is decidedly dangerous to purchase honey on the market, with no knowledge of its source, to be used in feeding bees. Many outbreaks of disease can be traced to this practice (see "Feeding," p. 26). It is difficult to prevent bees from getting contaminated honey accidentally. If colonies are purchased, great care should be taken that there is no disease present. Whenever possible, colonies should be purchased near at home, unless disease is already present in the neighborhood.

There are other diseased conditions of the brood, known to bee keepers as "pickle brood," but these can usually be distinguished from the two diseases previously mentioned. The so-called "pickle brood" is not contagious and no treatment is necessary. Bees also suffer from "dysentery," which is discussed in the earlier part of this bulletin, and from the so-called "paralysis," a disease of adult bees. No treatment for the latter disease can as yet be recommended as reliable. The sprinkling of powdered sulphur on the top bars of frames or at the entrance is sometimes claimed to be effective, but under what circumstances it is beneficial is unknown.

A number of insects, birds, and mammals must be classed as enemies of bees, but of these the two wax moths, and ants, are the only ones of importance. There are two species of moth, the larger wax moth (*Galleria mellonella* L.), and the lesser wax moth (*Achroia grisella* Fab.), the larvæ of which destroy combs by burrowing through them.[1] Reports are frequently received in the department that the larvæ of these moths (usually the larger species) are destroying colonies of bees. It may be stated positively that moths do not destroy strong, healthy colonies in good hives, and if it is supposed that they are causing damage the bee keeper should carefully study his colonies to see what other trouble has weakened them enough for the moths to enter. Queenlessness, lack of stores, or some such trouble may be the condition favorable to the entrance of the pest, but a careful examination should be made of the brood to see whether there is any

[1] Bee keepers refer to these insects as "moths," "wax moths," "bee moths," "millers," "wax worms," "honey moths," "moth worms," "moth millers," and "grubs." The last six terms are not correct.

evidence of disease. This is the most frequent cause of the cases of moth depredation reported to this department. Black bees are less capable of driving moth larvæ out, but, even with these bees, strong colonies rarely allow them to remain. The observance of the golden rule of bee keeping, "Keep all colonies strong," will solve the moth question unless disease appears.

Moth larvæ often destroy combs stored outside the hive. To prevent this the combs may be fumigated with sulphur fumes or bisulphid of carbon in tiers of hives or in tight rooms. If bisulphid of carbon is used, great care should be taken not to bring it near a flame, as it is highly inflammable. Combs should be stored in a dry, well-ventilated, light room.

In the warmer parts of the country ants are often a serious pest. They may enter the hive for protection against changes of temperature, or to prey on the honey stores or the brood. The usual method of keeping them out is to put the hive on a stand, the legs of which rest in vessels containing water or creosote. Another method is to wrap a tape soaked in corrosive sublimate around the bottom board.

GENERAL INFORMATION.

For the purpose of answering numerous questions which are asked of this department the following brief topics are included.

BREEDERS OF QUEENS.

There are a large number of bee keepers who make a business of rearing queens of good stock for sale. The queens are usually sent by mail. If poor stock is all that can be obtained locally, it is recommended that such colonies be purchased and the queens removed and replaced with those obtained from a good breeder. This department can supply names of breeders, nearest the applicant, of any race raised in this country.

INTRODUCING QUEENS.

When queens are shipped by mail they usually come in cages (fig. 25) which can be used for introducing. If the colony to receive the new queen has one, she must be removed and the cage inserted between the frames. The small hole leading into the candy compartment is uncovered, and the bees gradually eat through and release the queen. If queens are reared at home, a similar cage may be used for introducing. In view of the fact that disease may be transmitted in mailing cages, it is always a wise precaution to remove the new queen and destroy the accompanying workers and the cage and its contents. The queen may then be put into a clean cage without worker bees, with candy known to be free from contamination (made from honey from healthy hives), and introduced in the regular way.

Queens sold by breeders are always mated unless otherwise specified, and consequently the colony in which they are introduced has no effect on her offspring. During the active season the bees in the colony are all the offspring of the new queen in about nine weeks. Three weeks is required for the previous brood to emerge (if the colony has not been queenless), and in six weeks after all the old brood emerges most of the workers from it will have died. Queens are usually sold according to the following classification:

"*Untested queen*"—one that has mated, but the race of the drone is not known.

"*Tested queen*"—one that has mated and has been kept only long enough to show, from the markings of her progeny, that she mated with a drone of her own race.

"*Breeding queen*"—a tested queen which has shown points of superiority, making her desirable for breeding purposes.

DEALERS IN BEE KEEPERS' SUPPLIES.

There are several manufacturers of supplies in this country who can furnish almost anything desired by the bee keeper. Some of them have agents in various parts of the country from whom supplies may be purchased, thus saving considerable in freight.

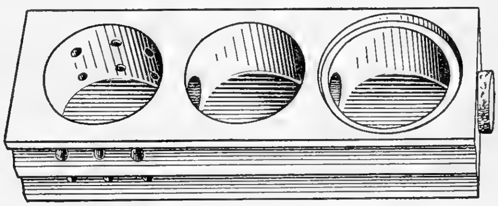

FIG. 25.—Queen mailing cage.

BEE KEEPERS' ASSOCIATIONS.

There are a large number of associations of bee keepers in all parts of the country, formed for the betterment of the industry, and a few associations which are organized to aid the members in purchasing supplies and in selling the crops. Of these the National Bee Keepers' Association is the largest. It helps its members in obtaining their legal rights, and aids in securing legislation for the furtherance of the industry. The annual conventions are held in different parts of the country, and copies of the proceedings are sent to the members. There are also numerous State, county, and town associations, some of which publish proceedings. The names of officers of the nearest associations or of the National Bee Keepers' Association will be sent from this department on request.

LAWS AFFECTING BEEKEEPING.

Disease inspection.—Various States have passed laws providing for the State or county inspection of apiaries for bee-disease control, and every bee keeper should get in touch with an inspector when disease is suspected, if one is provided. The inspectors are practical bee keepers who fully understand how to control the diseases, and are of great help in giving directions in this matter. The name of the inspector of any locality can usually be furnished, and this department is glad to aid bee keepers in reaching the proper officers.

Laws against spraying fruit trees while in bloom.—The spraying of fruit trees while in bloom is not now advised by economic entomologists, and to prevent the practice some States have passed laws making it a misdemeanor. Such spraying not only kills off honey bees, causing a loss to the bee keeper, but interferes with the proper pollination of the blossoms and is thus a detriment to the fruit grower. Bee keepers should do everything in their power to prevent the practice.

Laws against the adulteration of honey.—The national food and drugs act of 1906, and various State pure food laws, are a great aid to the bee keeper in preventing the sale of adulterated extracted honey as pure honey. Bee keepers can often aid in this work by reporting to the proper officials infringements of these laws which come to their notice.

When bees are a nuisance.—Some cities have passed ordinances prohibiting the keeping of bees in certain areas, but so far none has been able to enforce them. If bees are a nuisance in individual cases, the owner may be compelled to remove them. The National Bee Keepers' Association will help any of its members in such cases, if they are in the right, as well as in cases where bees sting horses. Bee keepers should be careful not to locate bees where they can cause any trouble of this kind.

SUPPOSED INJURY OF CROPS BY BEES.

Bee keepers are often compelled to combat the idea that bees cause damage to fruit or other crops by sucking the nectar from the flower. This is not only untrue, but in many cases the bees are a great aid in the pollination of the flowers, making a good crop possible. A more frequent complaint is that bees puncture fruit and suck the juices. Bees never puncture sound fruit, but if the skin is broken by some other means bees will often suck the fruit dry. In doing it, however, they are sucking fruit which is already damaged. These and similar charges against the honey bee are prompted by a lack of information concerning their activities. Bees may, of course, become a nuisance to others through their stinging propensities, but bee keepers should not be criticized for things which their bees do not do.

JOURNALS AND BOOKS ON BEEKEEPING.

The progressive bee keeper will find it to his profit to subscribe for at least one journal devoted to beekeeping. Several of these are published in the United States. The names and addresses of such journals may usually be obtained from a subscription agent for periodicals, or from a supply dealer.

It will also be advantageous to read and study books on beekeeping, of which several are published in this country. These are advertised in journals devoted to beekeeping, or may usually be obtained through the local book dealer or through dealers in bee keepers' supplies.

PUBLICATIONS OF THE DEPARTMENT OF AGRICULTURE ON BEE KEEPING.[1]

There are several publications of this department which are of interest to bee keepers, and new ones are added from time to time in regard to the different lines of investigation.

The following publications relating to bee culture, prepared in the Bureau of Entomology, are for free distribution and may be obtained by addressing the Secretary of Agriculture:[2]

Farmers' Bulletin No. 447, "Bees." By E. F. Phillips, Ph. D. 1911. 48 pp., 25 figs.

A general account of the management of bees.

Farmers' Bulletin No. 442, "The Treatment of Bee Diseases." By E. F. Phillips, Ph. D. 1911. 22 pp., 7 figs.

This publication gives briefly the symptoms of the various bee diseases, with directions for treatment.

Circular No. 94, "The Cause of American Foul Brood." By G. F. White, Ph. D. 1907. 4 pp.

This publication contains a brief account of the investigations which demonstrated for the first time the cause of one of the brood diseases of bees, American foul brood.

Circular No. 138. "The Occurrence of Bee Diseases in the United States. (Preliminary Report.)" By E. F. Phillips, Ph. D. 1911. 25 pp.

A record of the localities from which samples of diseased brood were received prior to March 1, 1911.

Bulletin No. 55, "The Rearing of Queen Bees." By E. F. Phillips, Ph. D. 1905. 32 pp., 17 figs.

A general account of the methods used in queen rearing. Several methods are given, so that the bee keeper may choose those best suited to his individual needs.

Bulletin No. 70, "Report of the Meeting of Inspectors of Apiaries, San Antonio, Tex., November 12, 1906." 1907. 79 pp., 1 plate.

Contains a brief history of bee-disease investigations, an account of the relationship of bacteria to bee diseases, and a discussion of treatment by various inspectors of apiaries and other practical bee keepers who are familiar with diseases of bees.

Bulletin No. 75, Part I, "Production and Care of Extracted Honey." By E. F. Phillips, Ph. D. "Methods of Honey Testing for Bee Keepers." By C. A. Browne, Ph. D. 1907. 18 pp.

The methods of producing extracted honey, with special reference to the care of honey after it is taken from the bees, so that its value may not be decreased by improper handling. The second portion of the publication gives some simple tests for adulteration.

Bulletin No. 75, Part II, "Wax Moths and American Foul Brood." By E. F. Phillips, Ph. D. 1907. Pp. 19–22, 3 plates.

An account of the behavior of the two species of wax moths on combs containing American foul brood, showing that moths do not destroy the disease-carrying scales.

Bulletin No. 75, Part III, "Bee Diseases in Massachusetts." By Burton N. Gates. 1908. Pp. 23–32, map.

An account of the distribution of the brood diseases of bees in the State, with brief directions for controlling them.

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[1] List revised to April 1, 1911. (VII.)

[2] Farmers' Bulletin No. 59, "Bee Keeping," and Farmers' Bulletin No. 397, "Bees," have been superseded by Farmers' Bulletin No. 447.

Circular No. 79, "The Brood Diseases of Bees," has been superseded by Farmers' Bulletin No. 442.

Bulletin No. 1, "The Honey Bee," has been discontinued.

Bulletin No. 75, Part IV, "The Relation of the Etiology (Cause) of Bee Diseases to the Treatment." By G. F. White, Ph. D. 1908. Pp. 33-42.

The necessity for a knowledge of the cause of bee diseases before rational treatment is possible is pointed out. The present state of knowledge of the causes of disease is summarized.

Bulletin No. 75, Part V, "A Brief Survey of Hawaiian Bee Keeping." By E. F. Phillips, Ph. D. 1909. Pp. 43-58, 6 plates.

An account of the beekeeping methods used in a tropical country and a comparison with mainland conditions. Some new manipulations are recommended.

Bulletin No. 75, Part VI, "The Status of Apiculture in the United States." By E. F. Phillips, Ph. D. 1909. Pp. 59-80.

A survey of present-day beekeeping in the United States, with suggestions as to the work yet to be done before apiculture will have reached its fullest development.

Bulletin No. 75, Part VII, "Bee Keeping in Massachusetts." By Burton N. Gates. 1909. Pp. 81-109, 2 figs.

An account of a detailed study of the apicultural conditions in Massachusetts. The object of this paper is to point out the actual conditions and needs of beekeeping in New England.

Bulletin No. 75, Contents and Index. 1911. Pp. VIII+111-123.

Bulletin No. 75, Parts I-VII, complete with Contents and Index. 1911. Pp. VIII+123.

Bulletin No. 98. "Historical Notes on the Causes of Bee Diseases." By E. F. Phillips, Ph. D., and G. F. White, Ph. D., M. D. (In press.)

A summary of the various investigations concerning the etiology (cause) of bee diseases.

Technical Series, No. 14, "The Bacteria of the Apiary, with Special Reference to Bee Diseases." By G. F. White, Ph. D. 1906. 50 pp.

A study of the bacteria present in both the healthy and the diseased colony, with special reference to the diseases of bees.

Technical Series No. 18, "The Anatomy of the Honey Bee." By R. E. Snodgrass. 1910. 162 pp., 57 figs.

An account of the structure of the bee, with technical terms omitted so far as possible. Practically all of the illustrations are new, and the various parts are interpreted according to the best usage in comparative anatomy of insects. A brief discussion of the physiology of the various organs is included.

BUREAU OF CHEMISTRY.

Bulletin No. 110, "Chemical Analysis and Composition of American Honeys." By C. A. Browne. Including "A Microscopical Study of Honey Pollen." By W. J. Young. 1908. 93 pp., 1 fig., 6 plates.

A comprehensive study of the chemical composition of American honeys. This publication is technical in nature and will perhaps be little used by practical bee keepers, but it is an important contribution to apicultural literature. By means of this work the detection of honey adulteration is much aided.]

HAWAII AGRICULTURAL EXPERIMENTAL STATION, HONOLULU, HAWAII.

Bulletin No. 17, "Hawaiian Honeys." By D. L. Van Dine and Alice R. Thompson. 1908. 21 pp., 1 plate.

A study of the source and composition of the honeys of Hawaii. The peculiar conditions found on these islands are dealt with.

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FARMERS' BULLETIN 450.

SOME FACTS ABOUT MALARIA.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 24, 1911.

Sir: I have the honor to transmit herewith a manuscript, entitled "Some Facts About Malaria," which has been drafted to meet a strong demand for such information from persons connected with agricultural pursuits in various parts of the country, and more especially in the South. I recommend its publication as a Farmers' Bulletin.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

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SOME FACTS ABOUT MALARIA.

INTRODUCTION.

It is a noticeable fact that in most parts of the world where anti-mosquito measures have been undertaken on a large scale the work has been done with the direct end of doing away with mosquito-borne diseases. In the United States, however, such antimosquito work as has been undertaken has almost invariably been done with the direct incentive of simply ridding communities or localities from a great nuisance. Almost the only exception has been the work done on Staten Island by Dr. Doty, the health officer of New York.

There are, however, many localities in the United States where malaria is prevalent, and some in which the existence of the disease in an aggravated form is a serious barrier to agricultural or industrial development. It has been shown, for example, that, agriculturally speaking, the lands of the Delta region of Mississippi and adjoining States are the richest in the whole world, with the possible exception of the delta of the Nile, and yet, on account of the extraordinary prevalence of malaria in this region, it is sparsely settled and land prices are low. The advance of the cotton-boll weevil into this section has had its customary effect of driving a considerable proportion of the negro labor into other regions not yet invaded, and unless the country is to become impoverished it will be necessary to import white labor. Negroes are more or less resistant to malaria, but this will not be true of the white labor coming into this region, which will undoubtedly become rapidly infected with the disease.

Malaria is not a difficult disease to fight. This has been shown in many parts of the world—in Italy, in Cuba, in Panama, in West Africa, in India, in Egypt, and elsewhere. People, generally, should know the exact truth about the disease and what is to be done. The efforts of individuals, after they have acquired the proper knowledge, will have an effect upon the malaria rate, while with a general knowledge of these facts community work must come sooner or later.

In the pages which follow, the statements regarding the disease itself are partly drawn, with the permission of the American publishers, from an admirable summary prepared by Dr. Ronald Ross,[1]

[1] See Ronald Ross, The Prevention of Malaria. London and New York.

of the Liverpool School of Tropical Medicine, who was the first discoverer of the relation between malaria and mosquitoes, something over 12 years ago, in India. His results were soon confirmed by workers in many parts of the world, and the statements here made are accepted by the best physicians of all countries.

THE DISEASE AND ITS CAUSE.

The disease known as malaria, or fever and ague, or chills and fever, or marsh fever, and the varieties called intermittent fever, remittent fever, and pernicious fever, are caused by parasites in the blood which feed upon the red blood cells.

Malaria occurs more or less in all warm climates, especially in the summer after rains and near marshy ground. It is said to cause one-fourth or more of all the sickness in the Tropics.

The parasites in the blood are microscopic one-celled animals called plasmodia.

These minute parasites are introduced into the blood through the proboscis of certain mosquitoes of the genus Anopheles.

On being introduced in this way, each parasite enters one of the red blood cells, in which it lives and grows.

When full grown, each parasite divides and thus produces a number of spores, which escape from the blood cell and enter fresh cells. This method of propagation may continue for years.

Although only a few of the parasites may have been introduced originally through the beak of the mosquito, they rapidly increase until millions upon millions of them may exist in the blood.

At first, when the number of parasites is still small, an infected person may remain apparently well. When, however, the number is large enough, he begins to suffer from fever.

The parasites tend to produce their spores all at the same time, and it is at the moment when these spores escape from the blood cells, almost simultaneously, that the fever begins.

The fever is probably caused by a little poison which escapes from each parasite with the spores.

After from 6 to 40 hours or more this poison is eliminated from the patient's system and his fever tends to leave him.

In the meantime, however, a new generation of parasites from the spores is approaching maturity; and when this is reached they in their turn break up and cause another attack of the fever like the first, and so on indefinitely for months and months. In this way the attacks of the fever follow each other at regular intervals.

But it often happens, as the result of repeated infections, that a new attack has commenced before the former one has ceased, so that they overlap and the fever continues.

After a time, even without treatment, the number of parasites may decrease until not enough of them are left to produce fever, in which case the patient improves temporarily.

It generally happens, however, sooner or later, that the number of parasites increases again, and the patient again suffers from a series of attacks.

Such relapses are frequently encouraged by fatigue, heat, chill, wetting, dissipation, or illness, and they may occur at intervals for a long time after the patient was first infected by the mosquito, and even after he has moved to localities where there is no malaria.

Besides fever, these malarial parasites often produce anemia and enlargement of the spleen, especially with patients who have suffered many relapses.

Death is often caused in malarial patients by other diseases, such as pneumonia or dysentery, the system being already weakened by the malarial parasites.

If the patient survives, the parasites tend to die out of themselves, without treatment, after a long period of illness, leaving him more or less immune.

The parasites are of at least three kinds, which can be easily distinguished in the blood if placed under the microscope. These are (1) a parasite which produces its spores every three days and causes what is called quartan fever; (2) a parasite which produces its spores every other day and causes tertian fever; (3) parasites which cause the so-called malignant fever or pernicious malaria, which is of an irregular type and in which dangerous complications most frequently occur.

Quinine kills the parasites when administered at the proper time; but generally it will not destroy all the parasites in the body unless it is given in sufficient doses and continued for several months. As long as a single parasite remains alive in the blood, the patient may be subject to relapses. Ross advises that at least 5 grains of sulphate of quinine should be taken by an adult patient every day without fail for four months, but he should consult a physician regarding the details of the treatment.

METHOD OF INFECTION.

The malaria parasite has several different stages. Aside from those forms which produce spores in the body, there are other stages—male and female. When one of these anopheline mosquitoes, which carries malaria, happens to feed on a patient whose blood contains parasites, these are sucked, with the blood, into the mosquito's stomach.

If the sexual forms of the parasites are present, those of opposite sexes at once unite. The parasite now undergoes certain changes in the mosquito's stomach. It passes through the stomach wall and finally affixes itself to its outer surface.

Here it grows very considerably and, after a week under favorable conditions, produces a large number of spores.

These spores, thus entering the general body cavity of the mosquito, find their way into the salivary glands. These glands secrete the irritating fluid injected under the human skin when the mosquito begins to feed.

Thus, when one of these mosquitoes, which has fed upon a malarial patient containing the sexual forms of the parasites, bites, after a week, another person, it injects these spores together with its saliva under his skin and generally into his blood.

These spores now cause or may cause infection or reinfection in this second person.

Thus the parasites of malaria pass from men to certain mosquitoes and back from these mosquitoes to men.

Malarial fever is then an infectious disease, which is carried from the sick to the healthy by anopheline mosquitoes, and only in this way can it be contracted.

It has always been known that malaria is most prevalent in the vicinity of marshes, and it was formerly supposed that the air or exhalations from these marshes produced the disease. Parasites of malaria have not been found in the water or air of marshes, nor in decaying vegetation, nor in the soil, although they have been diligently searched for. Attempts to produce infection by these agencies have always failed. The mosquitoes which carry these parasites, however, breed in marshes or in marshy pools and streams.

Issuing from these breeding places, they enter nearby houses and feed upon the inmates, mostly at night, biting first one person and then others, and living for weeks or months.

If an infected person happens to be present in any of these houses, the anopheline mosquitoes biting him will also become infected, and the disease is likely, ultimately, to be carried by these mosquitoes to others and to neighboring houses.

Thus a whole neighborhood soon becomes infected and the locality is called malarious. In such localities it is easy to find the parasites of malaria in the proper mosquitoes. Sometimes 25 per cent or more of them are found to be infected.

In malarious localities the anopheline mosquitoes bite the healthy new-born children and infect many of them.

Such children if not thoroughly treated may remain infected for years. They may become anemic and possess enlarged spleens, and of course may spread the infection to others.

In malarious localities almost every child has been found to contain the parasites of malaria or to possess an enlarged spleen.

In such a locality, therefore, the infection is constantly passed on by means of the mosquitoes from the older children or from adults to the newly born infants, so that the locality may remain malarious for very many years, in fact indefinitely.

In the same way a newcomer arriving in such a locality will very probably become infected, especially if he sleeps in an infected house, even for one night, at a time when mosquitoes are flying and biting. A locality is malarious only when it contains persons infected with the parasites, and also sufficient numbers of the proper species of mosquitoes to carry the infection to the healthy persons.

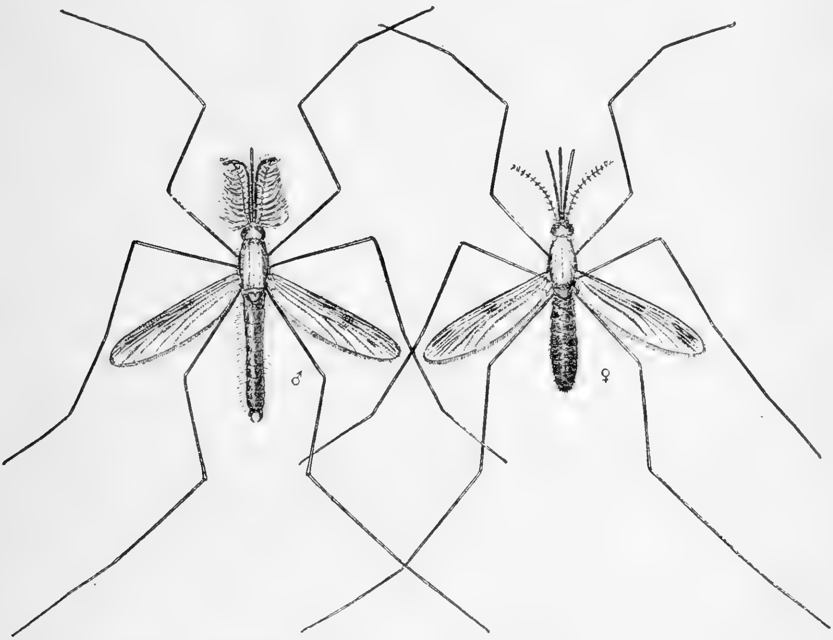

FIG. 1.—*Anopheles quadrimaculatus:* Male and female mosquitoes. Greatly enlarged. (Original.)

THE MALARIAL MOSQUITOES.

There are in the United States only three species of mosquitoes which commonly carry malaria, namely, *Anopheles quadrimaculatus* Say, *Anopheles crucians* Wied., and *Anopheles punctipennis* Say. Several other species of Anopheles are occasionally found, but are not important malarial factors.

Anopheles quadrimaculatus (figs. 1, 4, 5, 6) is commonly found in the more Northern States, and *A. crucians* (fig. 2) more abundantly in the Southern States, particularly in the coastal region.

A. punctipennis (fig. 3) occurs in both Northern and Southern States. It has been found to carry quartan and tertian malaria in the South, but not in the North. A number of experiments have been made with this species in the North, and especially at Baltimore and New York, to see if it will carry malarial parasites, but without success.

The anopheline mosquitoes are distinguished from most other mosquitoes of the United States by the fact that their wings are more or less spotted, and that in resting on the wall their bodies incline away from the wall at an angle, while with most others the body is parallel

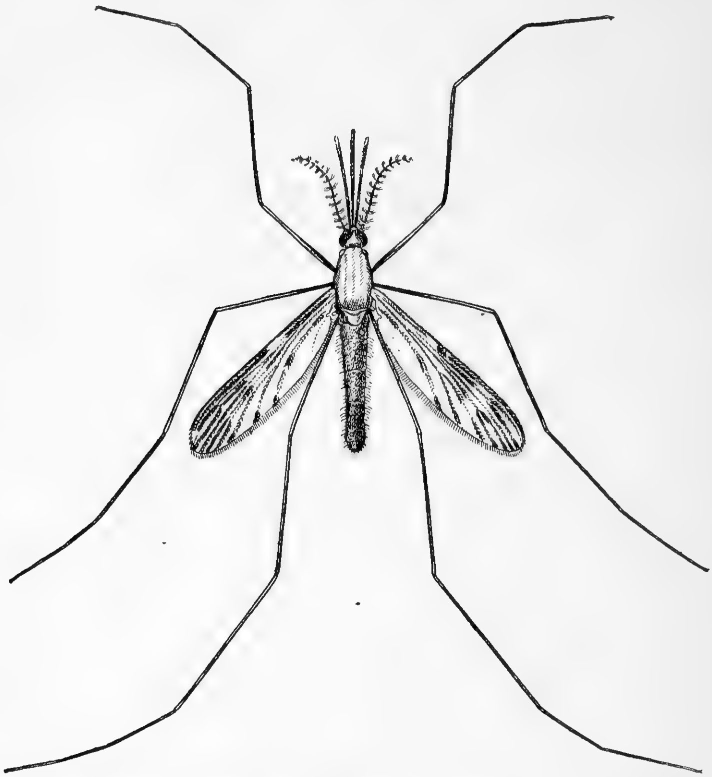

FIG. 2.—*Anopheles crucians:* Female mosquito. Greatly enlarged. (Original.)

to the wall. The females also have palpi which are nearly as long as the proboscis, or beak.

The Anopheles mosquitoes above mentioned pass the winter as adults. In the autumn they enter houses, stables, barns, or other outhouses, or seek other sheltered hiding places, and remain there until spring. They are often found in the winter in numbers in the cellars of houses, where they may be killed by fumigation.

These mosquitoes, as a rule, bite only after sundown. *Anopheles crucians* has on rare occasions been known to bite during the day, as has *A. punctipennis.* This has not been recorded of *A. quadrimaculatus.*

They do not fly far. It is doubtful whether any of these species ever flies for more than half a mile.

These Anopheles mosquitoes breed in all sorts of accumulations of standing water, in pools, springs, watering troughs, in the footprints of cattle in marshy land, and in marshes where fish are not abundant, in drains and gutters choked with grass or weeds, in old boats along the waterfronts, in hollows in rocks, in the backwaters of even rapid

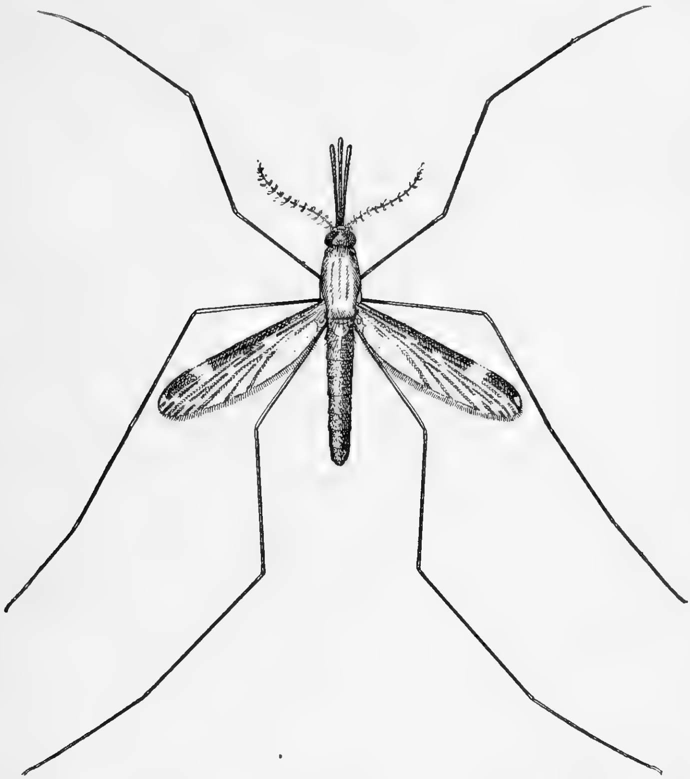

FIG. 3.—*Anopheles punctipennis:* Female mosquito. Greatly enlarged. (Original.)

streams, in earthenware vessels, in water barrels and tubs, in cesspools, and all places carrying water accumulations, whether pure or foul. *Anopheles crucians* and *A. quadrimaculatus* have even been found breeding in brackish water along the seacoast.

The minute, blackish eggs (fig. 4) are laid on the surface of the water and are found floating on their sides singly or in groups.

Their larvæ do not hang from the surface of the water by the tail, as do other mosquito larvæ or " wrigglers " when at rest, but lie flat at the surface, with their heads turned upside down, feeding upon minute floating particles at or near the surface (fig. 5).

Their growth is rather rapid, and they may in midsummer reach full size in two weeks after hatching.

When full grown these larvæ transform to pupæ (fig. 6) and remain in this stage at the surface of the water for three or more days, when the adult mosquitoes issue.

FIG. 4.—*Anopheles quadrimaculatus:* Eggs. Highly magnified. (Original.)

PREVENTION AND CURE.

There are now three recognized means of warfare against malaria: (1) The mechanical protection of individuals from the bites of malarial mosquitoes; (2) the destruction of the Anopheles mosquitoes in any or all of their different stages of growth; (3) the systematic treatment of the population of a malarious locality with quinine until the malaria has been stamped out and there are none of the parasites which cause this disease for the Anopheles mosquitoes to carry.

The first of these methods is largely a matter of personal prevention, and consists in thoroughly screening all habitations of human beings and, in the summer time, of wearing veils and gloves when out of doors after sundown. This method was systematically enforced at the stations on the Italian railroads some years since and resulted in a very great reduction in the malaria rate.

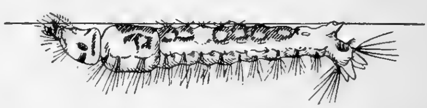

FIG. 5.—*Anopheles quadrimaculatus:* Larva in resting position. Greatly enlarged. (Original.)

The second measure, that of destroying the Anopheles, has been practiced with admirable success in Cuba, in Panama, in West Africa, in Egypt, and in certain localities in India. The measures of mosquito destruction used in these localities and elsewhere are described in a companion Farmers' Bulletin (No. 444).

The quininization method, or cinchonization method as it is called by the Germans and the Italians, has been used by the Germans in East Africa and by the Italians and, to some extent, by the English in India. In Italy, by the means of mechanical protection, the malaria rate was reduced from 65 or 70 per cent down to 14 per cent, but here it held. The quininization method was then introduced, and the general malaria rate for Italy has by its means been reduced to less than 4 per cent.

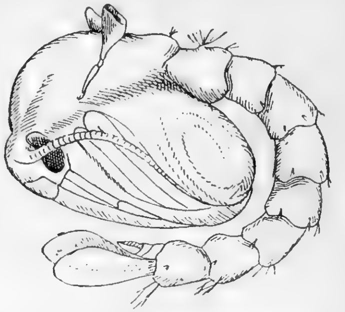

FIG. 6.—*Anopheles quadrimaculatus.* Pupa. Greatly enlarged. (Original.)

This method consists in the distribution of free quinine to all laborers and to the poor living in malarious localities. The quinine is prepared in its most agreeable form, as confectionery and principally as chocolates, the latter containing tannate of quinine, which is not so bitter. It is more easy to induce children and those adults who can not tolerate the ordinary quinine salts to take the quinine in this form.

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FARMERS' BULLETIN No. 453.

DANGER OF GENERAL SPREAD OF THE GIPSY AND BROWN-TAIL MOTHS THROUGH IMPORTED NURSERY STOCK.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., March 27, 1911.

Sir: I have the honor to transmit, for publication, a paper dealing with the danger of the general establishment throughout the United States of the gipsy moth and the brown-tail moth, which have been during the preceding two years, and are again the present year, imported from European countries on nursery stock and widely distributed in the United States. While every effort has been made to examine and disinfect such imported stock, it is by no means certain that all of the infested shipments have been reported and examined by inspectors, especially as, in the absence of any law, all reports and work of this kind are more or less voluntary. There is, therefore, considerable danger that the brown-tail moth, or perhaps the gipsy moth, has already become established in one or more interior points.

This paper gives a record of the infested importations during the last two years and descriptions of nursery conditions in Europe, showing the nature of the infestation there, and concludes with a brief description, with illustrations, of the two moth pests which are now being thus imported. The publication is, therefore, a warning to users of such imported stock and gives descriptions and figures enabling the prompt recognition of either of these pests wherever they may become established.

The nonexistence of a general law providing for the reporting of all imported stock and for uniform and thorough inspection and disinfection of such stock makes it highly desirable that the information here given should be made promptly available and widely distributed.

I recommend its publication as a Farmer's Bulletin.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

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DANGER OF GENERAL SPREAD OF THE GIPSY AND BROWN-TAIL MOTHS THROUGH IMPORTED NURSERY STOCK.

INTRODUCTION.

Winter nests of the brown-tail moth, each filled with hundreds of young larvæ, and occasional egg masses of the gipsy moth have been brought into the United States, the former in enormous numbers, during 1909–10 on imported nursery stock, and the importations for the season of 1911 are again bringing in these brown-tail moth nests. This infested stock, coming largely from nurseries in northern France, has been scattered widely over the United States east of the Rocky Mountains, and while every effort has been made to trace these importations and inspect and disinfect them the probability of many unreported shipments or inefficient inspection is very great.

A general warning is therefore given to all users of such imported plant stock, namely, to nurserymen, fruit raisers, and purchasers of ornamentals for city or park planting, to keep all such imported stock under strict watch to see that these pests do not develop.

As an aid in this direction this bulletin has been prepared. It gives a record of the infested importations of the past two years, a review of the nursery conditions in Europe showing the nature of contamination there, and a brief description, with illustrations, of the two moth pests which are now being imported and widely distributed.

IMPORTATIONS OF INFESTED NURSERY STOCK OF 1909–1911.

Space will not be taken to give the details of the shipment and distribution of infested nursery stock during these years. Some idea of the situation can be gained, however, from the following brief summary of importations, drawn largely from the annual reports of the Bureau of Entomology by Dr. Howard for the two years in question.

BROWN-TAIL MOTH NESTS IMPORTED IN 1909.

Early in 1909 it was discovered that nests of the brown-tail moth, filled with hundreds of small hibernating larvæ, were being introduced into this country on imported European nursery stock—chiefly from northern France—and distributed into many States. These brown-tail moth nests were first reported in connection with a consignment of seedlings shipped from Angers, France, to New York. The nests were discovered by the New York State inspector, and the information was communicated to the Bureau of Entomology by the commissioner of agriculture of that State.

A little later information came from Ohio that the winter nests of the brown-tail moth had been found on seedlings imported into that State from the same locality in France.

Warning letters were promptly sent out by Dr. L. O. Howard, chief of the Bureau of Entomology, to the different entomologists, and special arrangements were made with the customs office, through the kindness of the Secretary of the Treasury, and by agreement with the railroads, so that this bureau was to be informed of all cases of plants received at customs or subsequently handled by the principal railroad companies. By this means the receipt and ultimate destination was ascertained of much of the imported stock of that year. This information was transmitted to the State inspectors and other competent persons near the points of ultimate destination of such packages and an effort was made to have all such imported material inspected.

Information was secured concerning nearly 800 shipments, divided among 35 different States. In shipments to 15 of these States, namely, Alabama, Georgia, Illinois, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Missouri, Nebraska, New Jersey, New York, North Carolina, Ohio, and Pennsylvania, nests of the brown-tail moth were found, ranging in number from one nest to many nests in each shipment. These brown-tail nests—little webbed packets of leaves containing the very small hibernating larvæ to the number of 300 or 400 in each nest—were found on the seedling and other nursery stock in enormous numbers, some 7,000 nests (approximately 2,800,000 larvæ) being found in shipments to New York State alone.

In one locality in Ohio an egg mass of the gipsy moth was found and Prof. P. J. Parrott, of the New York Experiment Station, at Geneva, N. Y., found another important European fruit pest (*Hyponomeuta padella*), which had probably been introduced on these same French seedlings.

BROWN-TAIL MOTH NESTS IMPORTED IN 1910.

In view of the dangerous conditions of the shipments of 1909, a strong effort was made on the part of Dr. Howard to have the French authorities provide for the competent inspection and disinfection of material preliminary to the shipping season of 1910. In spite of promises of the authorities that such inspection would be made, the shipments of nursery stock from France in 1910 again brought to this country enormous quantities of nests of the brown-tail moth, filled with the one-fourth grown larvæ. Moreover, one shipment of nursery stock from Belgium to Louisiana contained an egg mass of the gipsy moth.

All of this imported European stock was again followed up as far as possible in accordance with the arrangement of the previous year with the customs officers and by agreement with the railroads, and all reported shipments were inspected at their destination.

Of the shipments of 1910 not less than 291 different lots were found to be infested with nests of the brown-tail moth. These went to the following States: Colorado, Connecticut, Georgia, Illinois, Indiana, Kansas, Louisiana, Michigan, Montana, New Jersey, New York, Ohio, and Virginia.

BROWN-TAIL MOTH NESTS IMPORTED IN 1911.

As a result of a thorough investigation of European conditions, which will be described later, a much better effort during the last year has been made, notably in France and Belgium, to improve the conditions of export stock, and as a result the importations of the present season of 1911 so far have shown a very notable improvement in amount of infestation. Nevertheless, the imported stock still shows occasional infestation, and such infested stock is being widely distributed. The danger as the infestation becomes less general is perhaps just as great or even greater from the very natural lessening of care or greater haste which will be given to examinations, and one overlooked nest or egg mass is quite sufficient to establish these pests.

RECORDS OF DISTRIBUTION OF THE IMPORTED NURSERY STOCK INCOMPLETE.

Nursery stock imported by dealers and sent direct in bond to destination is probably all reported and subsequently examined. Much of the imported nursery stock is, however, handled by customs brokers or receiving agents in New York, and the different packing cases are so marked that these distributing agents know where to send them, and they are distributed widely over the country, often in bond, without being examined in New York, and often without any record being made of such shipment or final destination. As pointed out by Dr. Howard in his testimony before the House Committee on Agriculture, much of such nursery stock which enters at the port of New York and is thence distributed in original packages the Government has been able to trace through the courtesy of the railroads, in addition to the regular arrangement with the customs office to advise the Department of Agriculture on the receipt of such stock. Nevertheless, the information gained from the customs office is evidently incomplete, as very often the railroad companies report the handling of stock of which no advice has been gained by the customs office, and, on the other hand, material is reported by the customs office which is not reported by the railroad companies. For this reason there is no certainty that all of the imported stock is reported, and undoubtedly some of it is miscellaneously distributed and never is examined at all. This condition of affairs, from local experience in his State, was strongly brought out by Dr. J. B. Smith, entomologist of New Jersey, in his testimony before the House Committee on Agriculture.

Dr. Smith also called attention to two other features of the importation of nursery stock which have an important bearing on the entrance of such pests as the gipsy moth and the brown-tail moth. The first of these relates to the importation by large department stores of New York, Philadelphia, and Washington, and in large interior towns, of inferior stock of ornamental plants, roses, and even fruit trees, massed down under enormous pressure in large boxes, thousands of plants in a single case. This largely worthless and often infested stock is distributed by these agencies at a very low price, or is given to the customers, and goes in small parcels here and there where it can not be followed, and necessarily entails the greatest risk of the introduction of dangerous pests and plant diseases. It is almost impossible to make any proper examination of such material even when its importation and destination are reported. Some of these shipments contain hundreds of thousands of plants, so that the chances of overlooking infestation are exceedingly great.

The other condition referred to by Dr. Smith is the importation by private persons, owners of large estates, or head gardeners, of greater or less quantities of ornamental and floral stock, such miscellaneous importations being very difficult to get advice of, and undoubtedly many of them are never reported or inspected.

CONDITIONS IN THE DISTRICT OF COLUMBIA.

A recent and very undesirable development in the introduction of foreign nursery stock has come to light in Washington, D. C., and probably is occurring in other large cities. In the latter part of March it was learned that a large shipment of miscellaneous ornamental stock had been made by a Dutch nursery firm to a local auctioneer, to be sold under the hammer, and, on the authority of the auctioneer in question, without previous arrangement. This new development seems to have arisen from an experience of the previous year (1910), where a shipment of stock was refused by the consignee and was turned over to this same auctioneer for sale. The results were evidently sufficiently satisfactory to lead the Holland firm to make the shipment of stock this year direct to the auctioneer, on the chance of a profitable sale.

The situation in the District of Columbia is probably the worst in the United States, inasmuch as there is no law whatever which authorizes the examination or inspection of nursery stock imported into the District. Examination of stock imported by local department stores, by nurserymen, and that sent for auction, as noted above, can be made only by officials of the Department of Agriculture through the courtesy of these different receivers of such stock. Very often such courtesy is scant, or refusal is made to open up the stock or separate it so that it can be properly examined. Such stock, when reported, has, however, been as thoroughly inspected as conditions permitted. It is sold to a multitude of purchasers, many of whom reside in near-by points in Virginia and Maryland, and thus finds entry into these States without the knowledge of the State officials.

NATURE OF INSPECTION AND LIKELIHOOD OF LOCAL INFESTATION.

As already indicated, the principal function of the Bureau of Entomology has been to get as complete information of importations as possible and transmit this information to the State inspectors, where such existed, of the several States. In some instances, where no local means of inspection was available, the imported material was inspected directly by agents of this bureau. In most of the States receiving infested goods the inspection made was conscientious and thorough. In some instances, however, the inspection was undoubtedly indifferent or worthless. This is illustrated by the fact that material received by a large Missouri nurseryman, and on his own statement "carefully inspected," was reshipped by him to Maryland, still infested with the brown-tail moth.

The condition of the imported nursery stock is such as to make inspection difficult and also to render it practically impossible to be absolutely sure that the inspection has resulted in the detection and destruction of all larvæ. The nests themselves are sufficiently prominent to be easily seen if the masses of thousands of plants in a case are properly separated so that each can be given individual examination. This means, however, a lot of time and absolute conscientiousness on the part of the inspector.

Many of the nests, however, in the process of packing and unpacking become broken and the minute larvæ are scattered more or less through the seedling stock and also in the packing material. Under these conditions, the chance of larvæ being overlooked by the inspector is very great. It by no means follows, therefore, that even where material is located and inspected the brown-tail moth and perhaps other pests have not been introduced. Furthermore, the unpacking is done, in many nurseries, in the open, in close proximity to growing nursery or ornamental stock, and the packing straw and wrappings are piled about and touching growing or heeled-in trees, so that plenty of opportunity may exist for the moth larvæ, in such packing material or otherwise scattered, to find lodgment and opportunity for development.

There is also, in addition to the difficulties experienced in actual inspection, the very large risk, already indicated, that many shipments are not inspected at all.

The fact that the brown-tail moth or any other pest does not develop immediately in the regions where these infested shipments are opened is no indication that such pests have not been introduced and that they will not eventually become established. When in very scanty numbers, they are inconspicuous enough to be easily overlooked for a number of years, as was illustrated in the case of the gipsy moth near Boston, which remained slowly increasing for over 20 years before it came to public notice. The brown-tail moth, brought in on roses, probably from Holland, about 1890, also had become thoroughly established over quite a large area before it was recognized, in 1897, as a new pest. The latter case is all the more instructive because the brown-tail moth was developing in the very region which was then being thoroughly examined every year for the gipsy moth. It may well be possible, therefore, that either the brown-tail moth or the gipsy moth is now slowly gaining headway at different points in one or more States as a result of the shipments of infested material of 1909 and 1910.

SIGNIFICANCE OF IMPORTATIONS OF 1909–1911.

It is scarcely necessary to comment on the tremendous danger which the importations of nursery stock of the last three seasons have brought to this country. The enormous cost of the gipsy moth and the brown-tail moth in New England is now well known. Throughout the infested districts of New England orchards have been completely destroyed and forests largely obliterated, and even where woodlands and parks have been protected at an enormous expense their beauty and value have been vastly lessened.

Massachusetts has spent millions of dollars in an effort to control these pests, and with their spread to other States the work of control has been taken up in these also. The National Government has been asked to come to the rescue, and is now appropriating $300,000 a year in the mere attempt to check the distribution of these pests along the principal highways. Massachusetts and the other infested New England States are now spending more than a million dollars a year in control work. In spite of these efforts and this enormous expenditure the gipsy moth and the brown-tail moth are steadily spreading in New England and great damage is experienced from them yearly. Extermination is entirely out of the question, and all these expenditures must go on indefinitely at a probably increasing rate, unless some natural check by means of parasites can be brought about.

In addition to the great destructiveness of these pests to orchards and forests, their establishment in any suburban residential district means an enormous depreciation in property values, as is now illustrated about the city of Boston, and very notably lessens the attractiveness of coast or mountain summer resorts. The north shore towns of Massachusetts and lower Maine resorts have already felt this influence, and for such regions as the Catskills or Adirondacks the establishment of these pests would be most disastrous, inasmuch as control over such extended forested mountains is practically impossible.

When it is realized that these two pests have been widely distributed, on imported nursery stock, in 22 States during the years of 1909 and 1910, and are now coming in on imported stock from France and Belgium, the danger to the whole country is fully apparent, and this danger applies to every orchard and to every owner of private grounds and also to our entire forest domain. The tax from these pests, should they gain foothold throughout the country, as measured by the existing cost in New England, is almost beyond estimate.

EFFECT OF THE BROWN-TAIL MOTH ON HEALTH.

In addition to the great monetary loss, the brown-tail moth exercises a very deleterious effect on health. The hairs which cover the caterpillars of this moth are strongly nettling, and not only are they so from accidental contact with a caterpillar which may fall on clothes, face, neck, or hands from an infested tree, but also from the myriads of hairs which are shed by these caterpillars when they transform to the chrysalis state. The latter fall and find lodgment on clothing, or collect on the face, neck, or hands, and frequently cause very disagreeable and extensive nettling, the effects of which may last for months. Breathed into the lungs they may cause inflammation and become productive of tuberculosis. The brown-tail rash is well known throughout the regions infested in New England and thousands have suffered from it. All of the assistants who have been connected with the Government work with these pests in the New England States have been seriously poisoned. Two of them have had to give up their work and go to the Southwest to attempt to recover from pulmonary troubles superinduced by the irritating hairs of the brown-tail moth, and the death of one man employed on the work was due to severe internal poisoning contracted in field work against larvæ.

This insect is, therefore, a most undesirable neighbor, even if it were not responsible for great injury to orchards and ornamental trees.

CHARACTER AND VALUE OF IMPORTED NURSERY STOCK.

The actual value of the importations of nursery stock which is thus jeopardizing the entire fruit and forest interests of this country, as declared at customs during the years 1907 and 1908, of which we have tabulated records, is about $350,000 annually, but little more than the sum which the United States Government is spending every year in an endeavor to eliminate the spread of the gipsy moth and the brown-tail moth, and one-third the sum which the New England States are spending annually in an attempt to control these pests.

The major part of the imported stock consists of seedling apple, pear, plum, and cherry from north France. There is also considerable importation of ornamental and flowering plants, shrubs, and trees. The latter is purely commercial, and comes in very largely for the reason that it can be produced more cheaply abroad than in this country. Of the seedling stock, it is claimed by nurserymen that the imported plum, cherry, and quince stock particularly is much better material for grafting purposes than home-grown seedlings. In the case of the apple seedlings, however, the great mass of such stock is still produced in this country and can undoubtedly be just as well produced here, if not better, than in France or elsewhere in Europe.

The stock of the last two years which has been most infested has come from northern France, accumulated from various smaller or larger nurseries, including a French seedling agency, managed by an American corporation composed largely of New York nurserymen.

If, as is claimed, some of this seedling stock is better than any that can be produced in this country, it becomes all the more imperative that such stock, or all imported stock, should be subject to rigid inspection, and that every possible means should be taken to safeguard this country from the further establishment of these two very dangerous insect pests.

EUROPEAN NURSERY CONDITIONS.

During the summer of 1909, and also again in 1910, Dr. Howard, who was in Europe principally to supervise the introduction of parasites for the gipsy and brown-tail moths into Massachusetts, made a careful inspection of the nursery regions of Holland, Belgium, and northern France, and also England.

The writer was in Europe, on a personal trip, in the summer of 1909, and made an examination of similar conditions in Holland, Belgium, and parts of Germany.

Holland probably presents the cleanest bill of health in the matter of insect pests, and particularly of the gipsy moth and brown-tail moth. This country enjoys a good inspection service, and all Dutch nurseries are carefully inspected twice each year, so there is probably less danger now from shipments from Holland than from any other country.

Belgium, in 1909, was in very bad condition, and the writer found the brown-tail moth more abundant there than he had ever seen it, hedge rows often being plastered with the winter nests. One such row the writer noted was only a few miles from the border of Holland and within easy flight of the moths to large Dutch nurseries. Belgium has, however, since September, 1909, established an inspection service, applying only to nurseries exporting to America and limited to field examination, twice yearly, of growing stock. While a distinct improvement, the inspection as indicated is still inadequate, as shown by much infested stock still coming to this country under official certificate.

In France, in 1909, Dr. Howard found no governmental inspection system of nurseries. The certificates attached to shipments of nursery stock received in this country from France were signed, as a rule, by men connected with agricultural schools, and probably in the case of most of the certificates the stock had never been seen by the expert. The general infestation of the stock coming from France to this country during the last two years made it abundantly plain that these certificates were absolutely valueless.

Dr. Howard found that nursery stock for export was in many cases grown in the vicinity of hedges and trees infested with the brown-tail moth and gipsy moth and other injurious insects not yet introduced into the United States, and no special precautions were being taken by the nurserymen to prevent the infestation of export stock by injurious insects. The brown-tail moth nests are so characteristic and noticeable that it is only by absolute indifference on the part of French exporters that they are packed for shipment without removal.

As a result of the agitation of 1909, the French exporters promised to take all possible precautions, and the French ministry of agriculture promised to found a governmental inspection service. The Chamber of Deputies, however, failed to pass the inspection law proposed by the ministry of agriculture, and, as already noted, the condition of the "inspected material" of 1910 was no better than in the previous year.

The director of agriculture of France, however, continued to urge the need of a plant-inspection service for export nursery stock, and early in November of 1910 this department was advised, through the Department of State and the ambassador of France to the United

States, of the final establishment of such service. Later the details of the law were communicated to Dr. Howard by Dr. Paul Marchal, who is charged with its execution.

Dr. Marchal's high reputation gives a guarantee of thoroughness, and a great improvement has actually taken place in the condition of the nursery stock coming from France. The rank infestation of 1909–10 has given place to moderate infestation of 1911, but there is still decided room for betterment.

In England Dr. Howard found that, as in France, there was no governmental nursery inspection. The nursery conditions there are somewhat better than in France, but the brown-tail moth and other injurious insects which might easily be imported on nursery stock occur in England. The officials of the Government had the establishment of a governmental inspection service under consideration, and were willing to establish such a service, but stated that the demand for it must come from British nurserymen. An attempt was therefore made by Dr. Howard to get these interests to ask for such service, and, while no action has yet been taken, it seems probable that the English Government will move in this direction.

IMPORTATION OF REFUSE STOCK.

The fact that all the continental countries of Europe have enacted very strict inspection and quarantine laws relating to the entrance into their territories of nursery stock, or other living plant materials, operates very unfavorably for this country, where there is no bar to the entrance of any stock, however worthless, or insect-infested, or diseased. As a result, the United States receives, in addition to fairly good nursery stock brought in by reliable importers, a great mass of refuse stock, imported under the worst conditions, massed in vast quantities in large packing cases, at best in poor condition and often diseased or insect-infested. The United States thus becomes a sort of dumping ground for material which could not find sale in Europe. Much of this worst-quality stock is that referred to elsewhere as being imported by department stores of our larger cities, and also by unscrupulous nurserymen who are careless of their own reputations and the interests of their customers.

NECESSITY OF QUARANTINE LEGISLATION.

The necessity of National quarantine to prevent the general introduction of such dangerous insect pests as those discussed in this bulletin, and also of equally dangerous plant diseases, has long been recognized.

The need of legislation is much increased by the fact that the United States is the only great power without protection from the importation of insect-infested or diseased plant stock. Referring to European powers only, Austria-Hungary, France, Germany, Holland, Switzerland, and Turkey prohibit absolutely the entry from the United States of all nursery stock whatever. Furthermore, our fruits are admitted to these countries only when a most rigid examination shows freedom from insect infestation. Most of the other European countries have strict quarantine and inspection laws, and the same is true of important English and other colonial possessions.

A properly enforced quarantine inspection law in the past would have excluded many, if not most, of the foreign insect enemies which are now levying an enormous tax upon the products of the farms, orchards, and forests of this country. Fully 50 per cent of the insect pests in this country are of foreign origin, and new important foreign pests are becoming established practically every year.

It is of the greatest importance, therefore, that an adequate inspection and quarantine law be passed at the earliest moment.

BRIEF DESCRIPTION OF THE DIFFERENT STAGES OF THE GIPSY AND BROWN-TAIL MOTHS.

THE GIPSY MOTH.

The gipsy moth (*Porthetria dispar* L.) is an European pest which was accidentally introduced into Massachusetts nearly 40 years ago, and has since spread rather slowly, being still confined to the eastern part of Massachusetts and Rhode Island, the southern part of New Hampshire, and to more or less isolated localities in eastern Connecticut and southwestern Maine.

The presence of this insect was first discovered in Boston in 1889, and the State of Massachusetts for a number of years kept up a vigorous effort to exterminate the insect, making large appropriations therefor. This work was abandoned, however, in 1900, but the conditions soon became so bad that appropriations were again made in 1905, and have since been continued annually. In spite of the work of that State, the situation became so serious that the National Government, particularly on the ground of the great danger that these pests would soon spread to other States, was called upon to assist, and since 1907 Congress has been making annual appropriations to aid in the work of control. The amount of this appropriation is now $300,000 annually.

The destructive work of the gipsy moth has been referred to in the foregoing portions of this bulletin. A brief sketch is here given of the life history and habits of the insect with photographs to aid anyone in promptly recognizing it should it appear in new localities.

The gipsy moth has a wide distribution throughout middle and southern Europe, northern Africa, and Asia, including Japan. In a large portion of the Old World range of the gipsy moth it is occasionally abundant and injurious, but as a rule it is held in check by parasites and natural enemies, and in no instance have there been such continuous and disastrous depredations as those exhibited in Massachusetts and more recently in the adjacent New England States.[1]

European outbreaks usually terminate in two or three years. Nevertheless in recent years in Europe and Asia exceptional outbreaks have occurred in which thousands of acres of forests have been completely denuded, and where such denudation has been repeated for two or three years in succession enormous areas have been found covered with dead and dying trees.

The following description of the different stages and habits of the insect is reproduced from Farmers' Bulletin 275 (pp. 12 to 15):

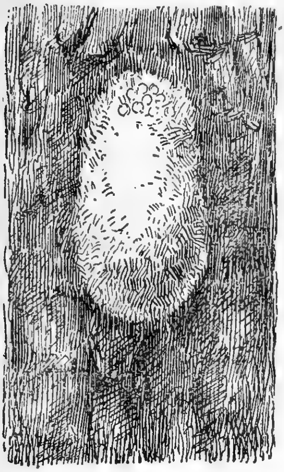

FIG. 1.—Egg mass of the gipsy moth (*Porthetria dispar*). (From Kirkland.)

Description of the different stages of the insect.

The eggs.—The eggs of the gipsy moth are laid in masses (fig. 1) of about 500. The individual egg is minute, about the size of a pinhead, and is salmon-colored when first laid, but turns dark in the course of a few weeks. Each egg mass is yellowish in appearance and seems covered with hair. It is somewhat oval, being one-half of an inch long and about three-fourths of an inch wide. During winter, from exposure to moisture in the atmosphere, it becomes dingy white in color. Egg masses have been found on bark of imported stock during the last two years, and inspectors should be on the lookout for them.

The larva, or caterpillar.—The young larvæ or young caterpillars are dark in color and well furnished with dark hairs. The full-grown larva (fig. 2) is between 2 and 3 inches long, dark brown or sooty in color, with two rows of red spots and two rows of blue spots along the back, and with a yellowish but rather dim stripe between them. The body generally is clothed with long hairs, and sometimes reaches the length of 3 inches.

The pupa.—The pupa (fig. 3) is not inclosed within a perfect cocoon, but the full-grown larva spins a few threads of silk as a sort of support and changes to the pupa, which is dark reddish or chocolate in color and very thinly sprinkled with light reddish hairs.

The adult, or moth.—The male moth (fig. 4) is brownish yellow in color, sometimes having a greenish-brown tinge; it has a slender body, well-feathered antennæ, and a wing expanse of about an inch and a half. The forewings are marked with wavy zigzag darker lines. It flies actively all day as well as by night.

The female moth (fig. 5) is nearly white, with slender black antennæ, each of the forewings marked with three or four zigzag, transverse, dark lines, and the outer border of both pairs of wings with a series of black dots. The body of the female is so heavy as to prevent flight.

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[1] For a more detailed account of the gipsy moth, see Farmers' Bulletin No. 275 (1907) and Bulletin 87 (1910), Bureau of Entomology, U. S. Department of Agriculture.

Seasonal History.

The moths emerge from the pupæ from the middle of July to the middle of August, the date varying considerably according to the season. After mating they live but a short time, and the female dies after depositing her eggs.

The eggs are laid therefore in July and August. They are deposited by the moths on the trunks of the trees upon which the caterpillars have lived, and in fact usually in the vicinity of the place where the female has transformed. The caterpillars before transforming frequently crawl for some distance from the trees upon which they have been feeding, and it therefore happens that the egg masses will be found on fences and in all sorts of protected situations in which the caterpillars hide during the day. The crevices in stone fences often contain very many of these egg masses, and knot holes in old trees will also contain many which would not at first be discovered. The egg masses are found also in hollow trees, in crevices under rough bark, on shrubbery, on buildings, in woodpiles, in barrels, in boxes, and among rubbish in dooryards. The moths seem to choose the inner or lower surface of an object upon which to lay their eggs, and therefore egg masses are placed out of sight perhaps as often as in sight.

The eggs hatch about May 1, and the young caterpillars begin immediately to feed, usually upon the lower surfaces of the leaves. As they grow they cast their skins several times, and as they become larger they feed only at night, hiding during the daytime, usually in clusters on the shady side of tree trunks, beneath large limbs, in holes in trees, under loose bark, and in fact under any near-by shelter. It is the habit of most of them to descend before daybreak upon the trunks of the trees and to seek for such shelters as those just indicated, returning after nightfall to resume their nocturnal feeding.

The larvæ usually become full grown about the 1st of July, and then transform to pupæ. The pupæ are found in the same situations as those we described for the egg clusters, but are found also in the foliage of trees and shrubs.

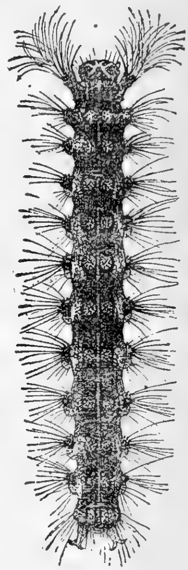

FIG. 2.—Full-grown caterpillar of the gipsy moth. Natural size. (From Insect Life.)

How the Insect Spreads.

As indicated above, the bodies of the females are so heavy as to prevent flight. Therefore the insect must be principally distributed while in the caterpillar or larval condition. The caterpillars are active crawlers, but as a rule do not migrate from the localities where they were born except when food is scarce. When young, and when there is hardly enough food, the larvæ spin down from trees by means of silken threads and often alight upon vehicles of one kind or another, and are thus carried often for great distances from the place of birth. Trolley cars, carriages, automobiles, and bicycles are thus means of transportation almost unlimited in their possibilities. The caterpillars often crawl upon vehicles which happen to stand for any length of time in an infested locality, and thus may be carried great distances. Sometimes even pedestrians aid unwittingly in this distribution, since the caterpillars may drop by their threads upon the garments of a person passing under an infested tree.

The species may be transported, too, in the egg stage on nursery or ornamental stock, as already noted, and it has been shown that the egg clusters are laid upon many different kinds of objects. Cord wood stacked and piled may be carried away in the autumn bearing many egg masses, and, if not burned before summer, larvæ may issue in a new locality. The same may be said for lumber piles near infested trees. Freight cars may have been sidetracked near an infested place long enough to permit laying of the eggs upon them.

It is by these methods that the comparatively rapid spread of the insect previously noticed, during the years 1900–1905, is to be explained.

Damage to Plants.

The larva of the gipsy moth feeds upon the foliage of practically all orchard trees, all shade and ornamental trees, all out-of-door shrubs, and all forest trees. Not only are the deciduous forest trees stripped, but the coniferous trees as well. In June and July patches of forests in the infested territory are stripped of every green leaf and the trees appear as bare as in winter. After several such consecutive strippings, deciduous forest and shade trees are killed, but with a coniferous tree, such as a pine, hemlock, or spruce, one complete stripping will cause death. It is this fact which makes the gipsy moth so much more serious a pest than the brown-tail moth, and the loss which will result from its spread into northern New England will be very great, owing to the enormous coniferous forest interests in that part of the country.

In cities and towns the insect does damage not only by destroying all vegetation, but by swarming in numbers upon and about houses, frequently entering them. It has been the experience in eastern Massachusetts that where a locality becomes thoroughly infested the value of real estate rapidly depreciates, and it becomes a matter of difficulty to rent or sell property.

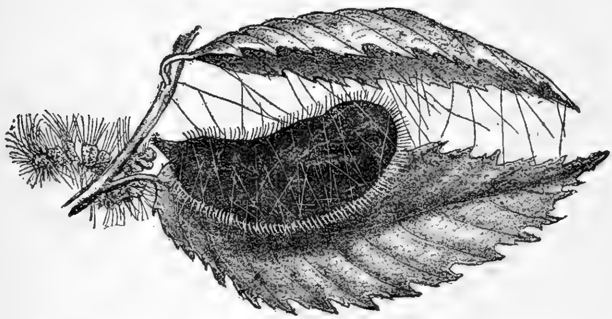

FIG. 3.—Pupa of the gipsy moth. Natural size. (From Insect Life.)

Among its food plants the gipsy moth caterpillar seems to prefer apple, white oak, red oak, willow, and elm, but those who have studied it most carefully in Massachusetts say that it will on occasion devour almost every useful grass, plant, flower, shrub, vine, bush, garden, or field crop that grows in the State.

THE BROWN-TAIL MOTH.

The brown-tail moth (*Euproctis chrysorrhœa* L.) was imported by a florist in Somerville, a suburb of Boston, about 20 years ago, probably on roses from Holland or France. Its presence was not discovered until 1897, when it had already gained such headway that extermination was out of the question. Since 1907 it has rapidly spread, and its range now includes much of the coastal area of New England, including eastern Rhode Island, the eastern half of Massachusetts, the eastern half of New Hampshire, and the southern half of Maine. Both sexes are strong fliers, and the prevailing winds during the flying season (July) have carried the insect northward and eastward, rather than southward and westward. Moths of this species have been taken as far away from Boston as St. Johns, New Brunswick.

This insect is a very serious enemy of orchard, forest, and shade trees and all ornamental shrubbery. In Europe it has a wide distribution, extending from England to the Himalayas, and as far north as Sweden and as far south as Algeria. It is a well-known orchard pest, and for many years laws have been operative in Europe requiring the property owners to clear their trees of the hibernating nests of this insect in winter.

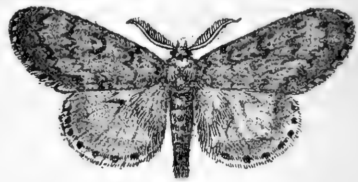

FIG. 4.—Male gipsy moth. Slightly enlarged. (From Insect Life).

The damage to trees and shrubs by this insect is often very severe. It has a special liking for pear and apple, but has a recorded list of over 80 different food plants. Thousands of fruit trees in the vicinity of Boston have been killed by this insect, and serious injury has been done to woodlands and forests, not, however, equaling the damage by the gipsy moth. It does not seem to attack coniferous trees.

One of the most serious results of the presence of the brown-tail is the poisoning of human beings by the hairs shed by the caterpillars, discussed in an earlier paragraph of this publication (p. 11).

The following description of the different stages of the insect and its seasonal history is taken from Farmers' Bulletin 264, which gives a general account of this pest, with general methods of controlling it.[1]

Description of the Different Stages of the Insect.

The eggs.—The eggs of the brown-tail moth are small and globular, and are laid in masses on the underside of leaves in the latter part of July. The egg masses are brown in color and are covered with hair, each mass containing about 300 eggs. They are much smaller than the egg masses of the gipsy moth, with which they are most likely to be confused, and average about two-thirds of an inch in length by about one-fourth of an inch in width. They are thus elongate in form, and are convex.

FIG. 5.—Female gipsy moth. Slightly enlarged. (From Insect Life.)

The larva, or caterpillar.—The full-grown larva (fig. 6 at right) is about 2 inches long, reddish brown in color, with a broken white stripe on each side and two red dots on the back near the hind end. It carries also patches of orange and is covered with tubercles bearing long barbed hairs. The tubercles along the back and sides are covered with short brown hairs in

[1] For a full account of the brown-tail moth see Farmers' Bulletin 264 (1906) and Bulletin 87 (1910), Bureau of Entomology, U. S. Department of Agriculture.

addition to the longer ones, which give the tubercles when magnified an appearance like velvet. The head of the larva is pale brown with darker mottlings.

The young larvæ are of a blackish color covered with reddish brown hairs. The head is jet black. Close examination will show projecting from the back of the fourth and fifth abdominal segments a large tuft of reddish brown hairs, and on the middle line of the ninth and tenth segments is an orange or reddish tubercle which may be withdrawn into the body. After the second spring molt the larva is about three-eighths of an inch long, the yellow markings on the body are more apparent, and the brown tufts on the back less prominent, while the band of white dashes along the sides, characteristic of the full-grown larva, is noticeable.

The pupa.—The full-grown larva spins a cocoon of grayish silk, which is very loose in its construction and is so far from being compact that the pupa may be readily seen through it. The pupa itself is about five-eighths of an inch long, dark brown in color, with a conical spine at the end of the abdomen bearing a cluster of minute hooks at the tip. Smooth, yellowish brown hairs are found scattered over the abdomen and the top of the thorax.

The cocoons are apparently spun by preference among the leaves at the tips of branches, and often a dozen or more larvæ will spin a common web within which each individual forms its own cocoon and transforms to pupa. The cocoons are also found under fences and beneath the edges of clapboards. Mr. Kirkland has seen a mass of cocoons nearly 2 feet across in the cornice of a house in Somerville.

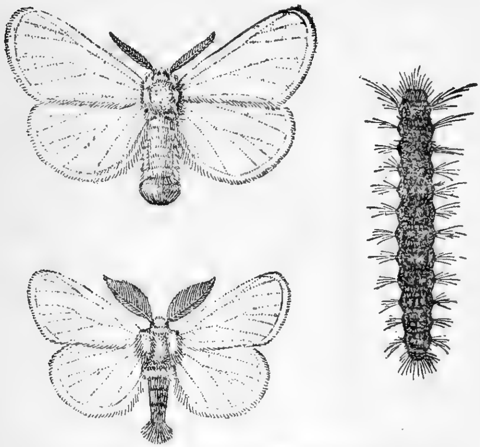

FIG. 6.—The brown-tail moth (*Euproctis chrysorrhœa*): Female moth above, male moth below, larva or caterpillar at right. Slightly enlarged. (From Howard.)

The adult, or moth.—The moths (fig. 6, at left) are pure white, the end of the abdomen being brownish, and both sexes bear at the tip of the abdomen, more conspicuously with the female, a tuft of brown hairs, almost globular in form, from which comes the name brown-tail moth. It is the only moth occurring in America to which this description applies, and is therefore unmistakable. The female expands about 1½ inches, and the male is smaller.

Seasonal History.

The moths fly in New England from the 1st to the 20th of July, the time varying with the condition of the season. In 1898 the height of the flying season is said by Fernald and Kirkland to have been July 16, in 1899 July 8, and in 1902 July 14. It is a night-flying insect, and only a few are ever seen on the wing in the daytime. Soon after sunset a few begin to fly, the number increasing as it grows dark, and from 10 o'clock to midnight they swarm to the greatest extent. They are strong flyers, and are attracted to light. So great have been their numbers in the infested region that the sides of red brick buildings near electric lights have appeared perfectly white. It is at this time that the great spread of the species occurs, and the reason that the direction of the spread has been greatest toward the northeast has been the fact that the prevalent night winds at that time of the year seem to have been from the southwest. Aside from actual flight, the species has spread by being carried in the moth condition on railway trains and on vessels. Captains of vessels have reported that the moths have alighted upon their ships in great numbers in the vicinity of Boston along toward midnight on several occasions, and the introduction of the species at more than one seaport in Maine has been by means of vessels coming from the infested district rather than by direct flight. Of course, the brown-tail moth is carried in the caterpillar stage, just as is the gipsy moth, upon vehicles of different kinds passing through the infested region and upon the persons of pedestrians as well. In late May, 1906, the writer, in company with three other persons, walked through the woods in a region not far from Boston, and although the most careful efforts were made by each of us to pick the caterpillars from the clothes of the others, an hour or two afterwards, and many miles away by automobile, still others were found under the upturned trousers and lapels of coats and in other hidden places about garments.

The eggs are laid by the moths soon after the flight begins, say in the latter part of July. They hatch during August and the young larvæ feed in clusters on the upper surface of leaves, skeletonizing them and causing the foliage to turn brown as if blighted. At first they feed upon the leaf which bears the egg mass, but soon wander to others, returning at night to the original leaf. When first hatched they are about one-twelfth of an inch long, and in five to six days shed their skin, increasing in length to one-fifth of an inch.

Later the second molt occurs, although this sometimes does not take place until autumn within the winter web. Along in September they begin to spin their winter webs by drawing together a number of leaves with silk, and in each of these nests a large number of caterpillars stow themselves away for the winter. These webs or nests, composed of leaves and silk, will average from 5 to 6 inches in length, and each will contain 200 or more caterpillars. The caterpillars feed until cold weather, and then all enter the web and close the exit holes. They are then about one-fourth grown.

FIG. 7.—Winter nest of the brown-tail moth, containing 300 or 400 young caterpillars. (Original.)

These winter webs (fig. 7) of the brown-tail moth are very characteristic, and there are practically no other insect structures common upon trees which may be mistaken for them. There are certain old webs of native species which might possibly, by the untrained eye, be considered to be those of the brown-tail moth, but these are empty in the winter time. Any web of this character and general size found during the winter which contains young caterpillars in any number is the web of the brown-tail moth.

The following spring, as soon as the buds begin to appear upon fruit trees, these young, one-fourth-grown caterpillars issue from the overwintering nests and attack first the buds and blossoms and later the foliage. Apparently half starved by their long hibernation, they come out with voracious appetites, and the amount of damage done by them at this time is extraordinary. Old trees may lose all their buds, or, if the leaf buds and blossom buds burst, the foliage itself may be entirely destroyed at a later date. The growth of the larva is rapid, and it reaches full size and begins to spin its cocoon during the last half of June, transforming to pupa and remaining in this condition for approximately 20 days.

Damage to Plants.

As just indicated, the damage to trees and shrubs may be very severe. The list of food plants is very extensive. While there seemed at first to be a preference for pear and apple, the larvæ were found to feed also upon the stone fruits, as well as upon the elm, maple, and several species of oak. Of late years there has been a very extensive infestation of scrub oak and of the larger trees of the genus Quercus. In fact, the caterpillars feed generally upon all deciduous trees, on many shrubs, and even upon herbage. A list of over 80 different food plants was published by Fernald and Kirkland in 1903. Thousands of fruit trees in the vicinity of Boston have been killed by this insect. Injury to woodlands and forests has not been as severe as that accomplished by the gipsy moth, and coniferous trees do not seem to be attacked, but the damage to oak, maple, and elm in the wooded region has been sufficient to cause the forests to appear brown in June in places, and complete defoliation for a series of three or four years has brought about the death of many trees. Even where the tree survives, its growth has been checked, and there is a timber loss.

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Issued July 31, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 459.

HOUSE FLIES.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., May 23, 1911.

SIR: I have the honor to transmit for publication a paper dealing with the subject of the house fly or typhoid fly. Previous publications of this department concerning this insect have been in circular form, but it is desired to make this information more widely available through the medium of a Farmers' Bulletin. With this intention this manuscript has been prepared, being modified and amplified from Circular No. 71 of this bureau, and I respectfully recommend its publication as a Farmers' Bulletin.

Respectfully,

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

HON. JAMES WILSON,
Secretary of Agriculture.

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HOUSE FLIES.

INTRODUCTION.

There are several species of flies which are commonly found in houses, although but one of these should be called the house fly proper. This is the *Musca domestica* L. (fig. 1) and is a medium-sized, grayish fly, with its mouth parts spread out at the tip for sucking up liquid substances. It is found in nearly all parts of the world. On account of the conformation of its mouth parts, the house fly can not bite, yet no impression is stronger in the minds of most people than that this insect does occasionally bite. This impression is due to the

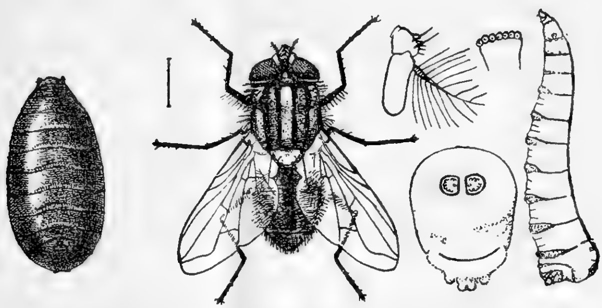

FIG. 1.—The common house fly (*Musca domestica*): Puparium at left; adult next; larva and enlarged parts at right. All enlarged. (Author's illustration.)

frequent occurrence in houses of another fly (*Stomoxys calcitrans* L.) (fig. 2), which is called the stable fly, and which, while closely resembling the house fly (so closely, in fact, as to deceive anyone but an entomologist), differs from it in the important particular that its mouth parts are formed for piercing the skin. It is perhaps second in point of abundance to the house fly in most portions of the Northeastern States. It breeds in horse manure, cow manure, and in warm decaying vegetation like old straw and grass heaps.

A third species, commonly called the cluster fly (*Pollenia rudis* Fab.), is a very frequent visitant of houses, particularly in the spring and fall. This fly is somewhat larger than the house fly, with a dark-colored, smooth abdomen and a sprinkling of yellowish hairs. It is not so active as the house fly and, particularly in the fall, is very sluggish. At such times it may be picked up readily and is very subject to the attacks of a fungous disease which causes it to die upon window panes, surrounded by a whitish efflorescence. Occasionally this fly occurs in houses in such numbers as to cause great annoyance, but such occurrences are comparatively rare. It is said in its earlier stages to be parasitic on certain angleworms.

A fourth species is another stable fly, known as *Muscina stabulans* Fall. (fig. 3), a form which almost exactly resembles the house fly in general appearance, and which does not bite as does the biting stable fly. It breeds in decaying vegetable matter and in excrement.

Several species of metallic greenish or bluish flies are also occasionally found in houses, the most abundant of which is the so-called blue-bottle fly (*Calliphora erythrocephala* Meig.). This insect is also called the blow-fly or meat-fly and breeds in decaying animal material. A

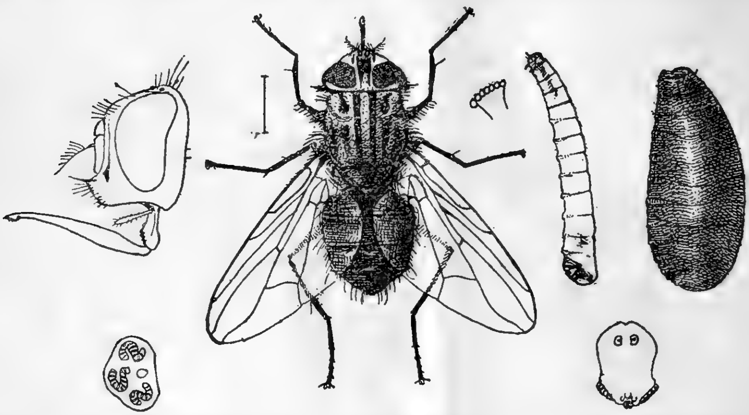

FIG. 2.—The stable fly or biting house fly (*Stomoxys calcitrans*): Adult, larva, puparium, and details. All enlarged. (Author's illustration.)

smaller species, which may be called the small blue-bottle fly, is *Phormia terrænovæ* Desv. (fig. 4); and a third, which is green or blue in color and a trifle smaller than the large blue-bottle, is *Lucilia cæsar* L. (fig. 5).

There is still another species, smaller than any of those so far mentioned, which is known to entomologists as *Homalomyia canicularis* L., sometimes called the small house fly. A related species, *H. brevis* Rond., is shown in figure 6. *H. canicularis* is distinguished from the ordinary house fly by its paler and more pointed body and conical shape. The male, which is much commoner than the female, has large pale patches at the base of the abdomen, which are translucent when the fly is seen on a window pane. It is this species that is largely responsible for the prevalent idea that flies grow after gaining wings. Most people think that these little Homalomyias are the young of the larger flies, which, of course, is distinctly not the case. They breed in decaying vegetable material, in the excreta of animals, and in dead insects.

Still another fly, and this one is still smaller, is a jet-black species known as the window fly (*Scenopinus fenestralis* L.), which in fact has become more abundant of later years. Its larva is a white, very slender, almost thread-like creature, and is found in cracks of the floor in buildings, where it feeds on other small insects.

In the autumn, when fruit appears on the sideboard, many specimens of a small fruit-fly (*Drosophila ampelophila* Loew) (fig. 7) make their appearance, attracted by the odor of overripe fruit.

A small, slender fly is not infrequently seen in houses, especially upon window panes. This is *Sepsis violacea* Meig., shown enlarged in figure 8.

All of these species, however, are greatly dwarfed in numbers by

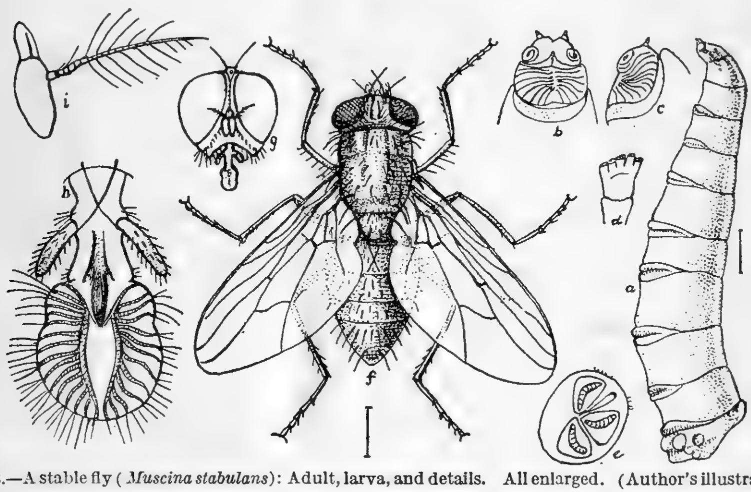

FIG. 3.—A stable fly (*Muscina stabulans*): Adult, larva, and details. All enlarged. (Author's illustration.)

the common house fly. In 1900 the writer made collections of the flies in dining rooms in different parts of the country, and out of a total of 23,087 flies 22,808 were *Musca domestica*—that is, 98.8 per cent of the whole number captured. The remainder, consisting of 1.2 per cent of the whole, comprised various species, including those mentioned above.

LIFE HISTORY OF THE TRUE HOUSE FLY.

Musca domestica commonly lays its eggs upon horse manure. This substance seems to be its favorite larval food. It will oviposit on cow manure, but we have not been able to rear it in this substance. It will also breed in human excrement, and from this habit it becomes very dangerous to the health of human beings, carrying, as it does, the germs of intestinal diseases such as typhoid fever and cholera from excreta to food supplies. It will also lay its eggs upon other decaying vegetable and animal material, but of the flies that infest dwelling houses, both in cities and on farms, a vast proportion comes from horse manure.

It often happens, however, that this fly is very abundant in localities where there is little or no horse manure, and in such cases it will be found breeding in other manure or in slops or fermenting vegetable material, such as spent hops, or bran, or ensilage.

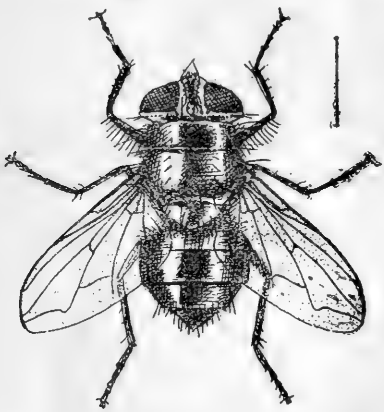

FIG. 4.—One of the blue-bottle flies (*Phormia terrænovæ*): Adult, enlarged. (Author's illustration.)

At Salem, Mass., Packard states that he reared a generation in 14 days in horse manure. The duration of the egg state was 24 hours, the larval state from 5 to 7 days, and the pupal state from 5 to 7 days. At Washington the writer has found in midsummer that each female lays at one time about 120 eggs, which hatch in 8 hours, the larval period lasting 5 days and the pupal 5 days, making the total time for the development of the generation 10 days. This was at the end of June. The periods of development vary with the climate and with the season, and the insect hibernates in the puparium condition in manure or at the surface of the ground under a manure heap. It also hibernates in houses as adult, hiding in crevices.

The Washington observations indicate that the larvæ molt twice, and that there are thus three distinct larval stages.

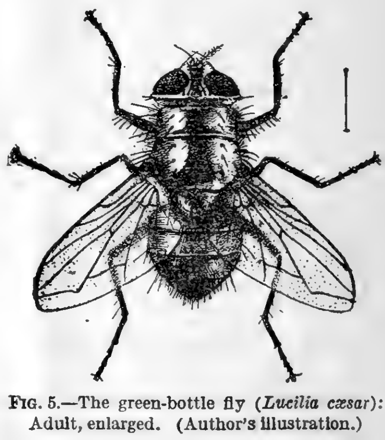

FIG. 5.—The green-bottle fly (*Lucilia cæsar*): Adult, enlarged. (Author's illustration.)

The periods of development were found to be about as follows: Egg from deposition to hatching, one-third of a day; hatching of larva to first molt, 1 day; first to second molt, 1 day; second molt to pupation, 3 days; pupation to issuing of adult, 5 days; total life round, approximately 10 days. There is thus abundance of time for the development of 12 or 13 generations in the climate of Washington every summer.

The number of eggs laid by an individual fly at one time is undoubtedly large, averaging about 120, and a single female may lay 4 such batches, so that the enormous numbers in which the insects occur is thus plainly accounted for, especially when the abundance and universal occurrence of appropriate larval food is considered. In order to ascertain the numbers in which house-fly larvæ occur in horse-manure piles, a quarter of a pound of rather well-infested horse manure was taken on August 9, and in it were counted 160 larvæ and 146 puparia. This would make about 1,200 house flies to the pound of manure. This, however, can not be taken as an average, since no larvæ are found in perhaps the greater part of ordinary horse-manure piles. Neither, however, does it show the limit of what can be found, since about 200 puparia were found in less than 1 cubic inch of manure taken from a spot 2 inches below the surface of the pile where

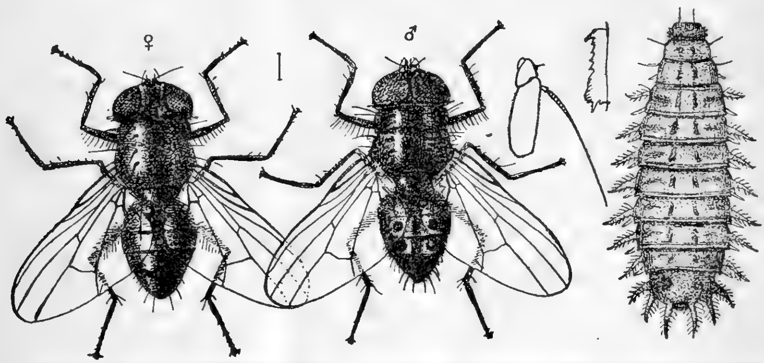

FIG. 6.—The little house fly (*Homalomyia brevis*): Female at left; male next, with enlarged antenna; larva at right. All enlarged. (Author's illustration.)

the larvæ had congregated in immense numbers. The different stages of the insect are well illustrated in figure 1 and need no description.

CARRIAGE OF DISEASE.

In army camps, in mining camps, and in great public works, bringing together large numbers of men for a longer or shorter time, there is seldom the proper care of excreta, and the carriage of typhoid germs from the latrines and privies to food by flies is common and often results in epidemics of typhoid fever.

And such carriage of typhoid by flies is by no means confined to these great temporary camps. In farmhouses in small communities and even in the badly cared-for portions of large cities typhoid germs are carried from excrement to food by flies, and the proper supervision and treatment of the breeding places of the house fly become most important elements in the prevention of typhoid.

In the same way other intestinal germ diseases are carried by flies. The Asiatic cholera, dysentery, and infantile diarrhea are all so carried.

Nor are the disease-bearing possibilities of the house fly limited to intestinal germ diseases. There is strong circumstantial evidence that tuberculosis, anthrax, yaws, ophthalmia, smallpox, tropical sore, and parasitic worms may be and are so carried. Actual laboratory proof exists in the cases of a number of these diseases, and where lacking is replaced by circumstantial evidence amounting almost to certainty.

REMEDIES AND PREVENTIVES.

A careful screening of windows and doors during the summer months, with the supplementary use of sticky fly papers, is a preventive measure against house flies known to everyone, and there seems to be little hope in the near future of much relief by doing away with the breeding places. A single stable in which a horse is kept will supply house flies for an extended neighborhood. People living

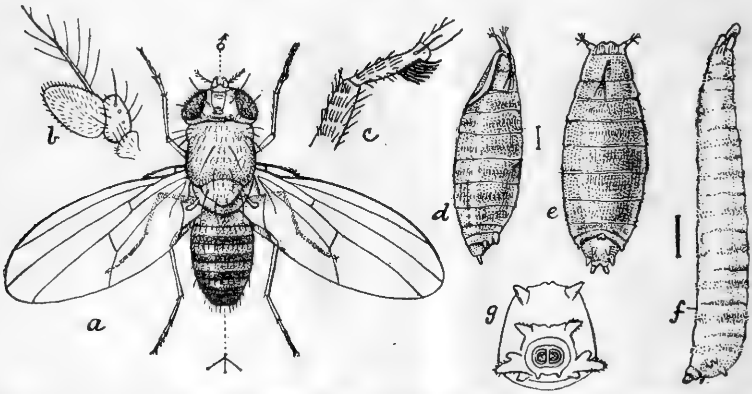

FIG. 7.—The fruit fly (*Drosophila ampelophila*): *a*, Adult; *b*, antenna of same; *c*, base of tibia and first tarsal joint of same; *d*, puparium, side view; *e*, puparium from above; *f*, full-grown larva; *g*, anal spiracles of same. All enlarged. (Author's illustration.)

in agricultural communities will probably never be rid of the pest, but in cities, with better methods of disposal of garbage and with the lessening of the number of horses and horse stables consequent upon electric street railways, bicycles, and automobiles, the time may come, and before very long, when window screens may be discarded. The prompt gathering of horse manure, which may be variously treated or kept in a specially prepared receptacle, would greatly abate the fly nuisance, and city ordinances compelling horse owners to follow some such course are desirable. Absolute cleanliness, even under existing circumstances, will always result in a diminution of the numbers of the house fly, and, in fact, most household insects are less attracted to the premises of what is known as the old-fashioned housekeeper than to those of the other kind.

Not only must all horse stables be cared for, but chicken yards, piggeries, and garbage receptacles as well, and absolutely sanitary privies are prime necessities. Directions for building and caring for such privies will be found in Farmers' Bulletin No. 463. The dry-earth treatment of privy vaults is unsatisfactory. Kerosene should be used.

During the summer of 1897 a series of experiments was carried out with the intention of showing whether it would be possible to treat a manure pile in such a way as to stop the breeding of flies. The writer's experience with the use of air-slaked lime on cow manure to prevent the breeding of the horn fly (*Hæmatobia serrata* Rob.-Desv.) suggested

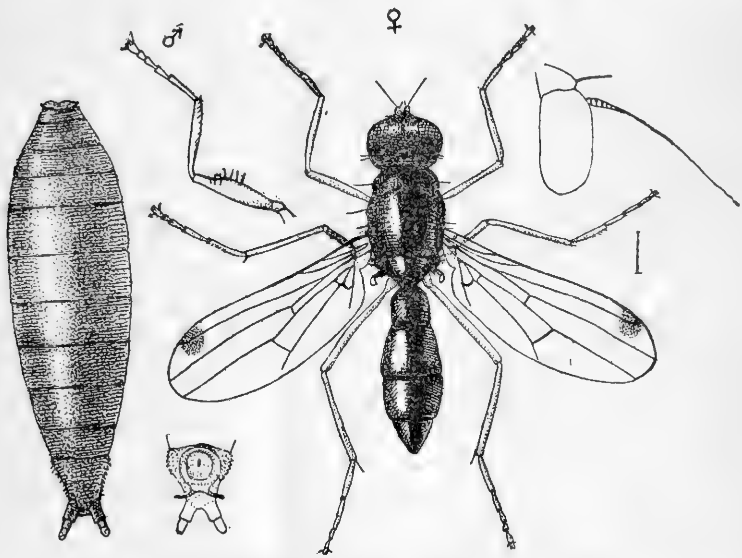

FIG. 8.—The dung fly (*Sepsis violacea*): Adult, puparium, and details. All enlarged. (Author's illustration.)

experimentation with different lime compounds. It was found to be perfectly impracticable to use air-slaked lime, land plaster, or gas lime with good results. Few or no larvæ were killed by a thorough mixing of the manure with any of these three substances. Chlorid of lime, however, was found to be an excellent maggot killer. Where 1 pound of chlorid of lime was mixed with 8 quarts of horse manure, 90 per cent of the maggots were killed in less than 24 hours. At the rate of one-fourth of a pound of chlorid of lime to 8 quarts of manure, however, the substance was found not to be sufficiently strong. Chlorid of lime, though cheap in Europe, costs at least 3½ cents a pound in large quantities in this country, so that the frequent treatment of a large manure pile with this substance would be out of the question in actual practice.

Experiments were therefore carried on with kerosene. It was found that 8 quarts of fresh horse manure sprayed with 1 pint of kerosene, which was afterwards washed down with 1 quart of water, was thoroughly rid of living maggots. Every individual was killed by the treatment. This experiment and others of a similar nature on a small scale were so satisfactory that it was considered at the close of the season that a practical conclusion had been reached, and that it was perfectly possible to treat any manure pile economically and in such a way as to prevent the breeding of flies.

Practical work in the summer of 1898, however, demonstrated that this was simply another case where an experiment on a small scale has failed to develop points which in practical work would vitiate the results.

The stable of the United States Department of Agriculture, in which about 12 horses were kept, was situated about 100 yards behind the main building of the department and about 90 yards from the building in which the Bureau of Entomology is situated. This stable was always very carefully kept. The manure was thoroughly swept up every morning, carried outside of the stable, and deposited in a pile behind the building. This pile, after accumulating for a week or 10 days, or sometimes 2 weeks, was carried off by the gardeners and spread upon distant portions of the grounds. At all times in the summer this manure pile swarmed with the maggots of the house fly. It is safe to say that on an average many thousands of perfect flies issued from it every day, and that at least a large share of the flies which constantly bothered the employees in the two buildings mentioned came from this source.

On the basis of the experiments of 1897, an attempt was made, beginning early in April, 1898, to prevent the breeding of house flies about the department by the treatment of this manure pile with kerosene. The attempt was begun early in April and was carried on for some weeks. While undoubtedly hundreds of thousands of flies were destroyed in the course of this work, it was found by the end of May that it was far from perfect, since if used at an economical rate the kerosene could not be made to penetrate throughout the whole pile of manure, even when copiously washed down with water. A considerable proportion of house-fly larvæ escaped injury from this treatment, which at the same time was found, even at an economical cost, to be laborious, and such a measure, in fact, as almost no one could be induced to adopt.

There remained, however, another measure which had been suggested by the writer in an article on the house fly published in 1895, namely, the preparation of an especial receptacle for the manure; and this was very readily accomplished. A closet 6 by 8 feet had been built in the corner of the stable nearest the manure pile. It had a door opening into the stable proper, and also a window. A door was built in the outside wall of this closet, and the stablemen were directed to place no more manure outside the building; in other words, to abolish the outside manure pile, and in the future to throw all of the manure collected each morning into this closet, the window of which in the meantime had been furnished with a wire screen. The preparations were completed by the middle of June, and a barrel of chlorid of lime was put in the corner of the closet. Since that time every morning the manure of the stable is thrown into the closet, and a small shovelful of chlorid of lime is scattered over it. At the expiration of 10 days or 2 weeks the gardeners open the outside door, shovel the manure into a cart, and carry if off to be thrown upon the grounds.

Judging from actual examination of the manure pile, the measure is eminently successful. Very few flies are breeding in the product of the stable which formerly gave birth to many thousands daily. After this measure had been carried on for two weeks, employees of the department who had no knowledge of the work that was going on were asked whether they had noticed any diminution in the number of flies in their offices. Persons in all of the offices on the first floor of the two buildings were asked this question. In every office except one the answer was that a marked decrease had been noticed, so that the work must be considered to have been successful.

The account of this remedial work has been given with some detail, since it shows so plainly that care and cleanliness combined with such an arrangement as that described will in an individual stable measurably affect the fly nuisance in neighboring buildings

With the combined efforts of the persons owning stables in a given community, much more effective results can undoubtedly be gained.

In the consideration of these measures we have not touched upon the remedies for house flies breeding in human excrement. On account of the danger of the carriage of typhoid fever, the dropping of human excrement in the open in cities or towns, either on vacant lots or in dark alleyways, should be made a misdemeanor, and the same care should be taken by the sanitary authorities to remove or cover up such depositions as is taken in the removal of the bodies of dead animals. The box privy is always a nuisance from many points of view, and is undoubtedly dangerous as a breeder of flies which may carry the germs of intestinal disease. No box privies should be permitted to exist unless they are conducted on the kerosene principle. With a proper vault or other receptacle, closed except from above, and a free use of kerosene and water, the breeding of house flies can be prevented.

A Parisian journal, the Matin, during the winter of 1905–6, established a prize of 10,000 francs for the best essay on the destruction of the house fly. The jury of competent scientific men awarded the prize to the author of a memoir in which it was proposed to use residuum oil in the destruction of the eggs and larvæ of the fly. This oil is to be used in privies and cesspools. Two liters per superficial meter of the pit is mixed with water, stirred with a stick of wood, and then thrown into the receptacle. It is said to form a covering of oil which kills all the larvæ, preventing the entrance of flies into the pit and, at the same time, the hatching of eggs. It makes a protective covering for the excrement, and this is said to hasten the development of anærobic bacteria as in a true septic pit, leading in this way to the rapid liquefaction of solid matters and rendering them much more unfit for the development of other bacteria. For manure it is recommended to mix this residuum oil with earth, with lime, and with phosphates, and to spread it at different times, in the spring by preference, upon the manure of farms and stables and so on.

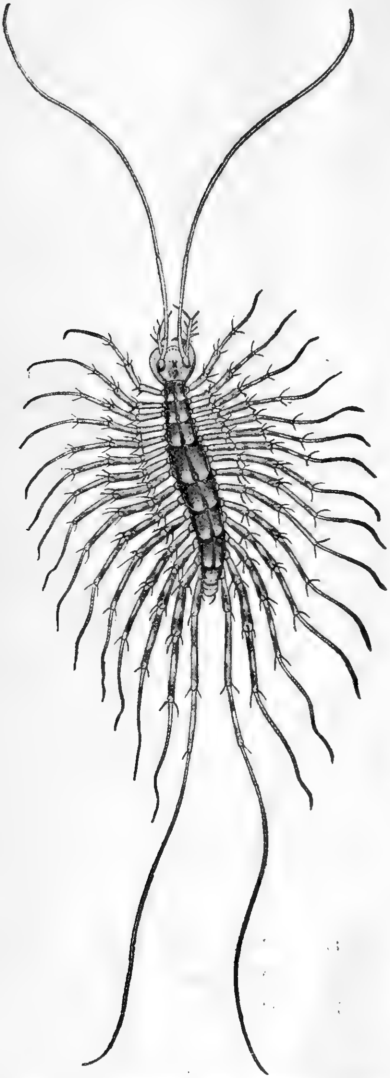

FIG. 9.—The house centipede (*Scutigera forceps*). Adult natural size (After Marlatt.)

There seems to be a definite period of perhaps 10 days between the issuing of the adult flies and the laying of eggs. During this period, and especially in the early spring, it becomes important to trap as many flies as possible. With this end in view, Prof. C. F. Hodge, of Clark University, Worcester, Mass., has devised certain flytraps which he attaches to garbage cans and to screened stable windows, and which he places in the neighborhood of possible fly-breeding places.

So many cheap flytraps are on the market that it is unnecessary and undesirable to specify any particular kind. Many of them are good.

NATURAL ENEMIES.

The house fly has a number of natural enemies. The common house centipede (fig. 9) destroys it in considerable numbers, there is a small reddish mite which frequently covers its body and gradually destroys it, it is subject to the attacks of hymenopterous parasites in its larval condition, and it is destroyed by predatory beetles at the same time.

The most effective enemy, however, is a fungous disease known as *Empusa muscæ,* which carries off flies in large numbers, particularly toward the close of the season. The epidemic ceases in December, and although many thousands are killed by it, the remarkable rapidity of development in the early summer months soon more than replaces the thousands thus destroyed.

WHAT CITIES AND TOWNS CAN DO.

It would appear, from what we know of the life history of the common house fly and from what remedial experimentation has already been carried on, that it is perfectly feasible for cities and towns to reduce the numbers of these annoying and dangerous insects so greatly as to render them of comparatively slight account. The health departments of most of our cities have the authority to abate nuisances dangerous to health, and it is easy for the health authorities of any city to formulate rules concerning the construction and care of stables and the keeping and disposal of manure which, if enforced, will do away with the house-fly nuisance. Such a series of rules was formulated in the spring of 1906 by the Health Department of the city of Asheville, N. C., and an effort is being made during this summer to see that they are enforced. On the 3d of May, 1906, the Health Department of the District of Columbia also issued a series of orders of this nature, on the authority of the Commissioners of the District, and these orders, which may well serve as a model to other communities desiring to undertake similar measures, may be briefly condensed as follows:

All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain, in connection therewith, a bin or pit for the reception of manure, and, pending the removal from the premises of the manure from the animal or animals, shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water, and shall in all other respects be water tight except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon any portion of the premises other than the bin or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in any of the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1 and October 31, and at least once every week between November 1 and May 31 of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle which, if not inclosed, must be effectually covered with canvas, so as to prevent the manure from being dropped. No person shall deposit manure removed from the bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of the provisions shall, upon conviction thereof, be punished by a fine of not more than $40 for each offense.

As with all such measures, the test comes with the enforcement, and these regulations have not been well enforced, owing to the extremely small corps of inspectors allowed to the Health Department, and to other more pressing work. They can be made effective, however, and it is earnestly hoped that not only Washington but other communities as well will very soon be brought to a realization of the ease of house-fly eradication and its very great desirability.

The insect we now call the "house fly" should in the future be termed the "typhoid fly," in order to call direct attention to the danger of allowing it to continue to breed unchecked.—L. O. Howard.

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Issued August 22, 1911.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 463.

THE SANITARY PRIVY.

BY

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AND

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WASHINGTON
GOVERNMENT PRINTING OFFICE.
1911.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., June 6, 1911.

To the farmers of the United States:

Nothing is more important to the farmer than good health. Good health can not be preserved if the sanitary conditions of the farm are bad. Among the worst conditions ever to be found about any home is a soil that has become polluted with excrement from the human body. A number of widely prevalent diseases have been spread by means of such polluted soil, simply because the facts have not been generally known. This bulletin treats of such soil pollution and certain simple plans for avoiding it.

Having at heart the best interests of the American farmer and his family, I consider it my personal duty to appeal to every American farmer to weigh well the facts here presented, to do all in his power to remove any insanitary conditions that he may find on his farm or in his neighborhood, and thus, by protecting the members of his family, perform one of his highest patriotic duties.

JAMES WILSON,
Secretary of Agriculture.

LETTER OF TRANSMITTAL.

UNITED STATES TREASURY DEPARTMENT,
PUBLIC HEALTH AND MARINE-HOSPITAL SERVICE,
Washington, D. C., April 20, 1911.

SIR: With the approval of the Secretary of the Treasury, I have the honor to transmit herewith a manuscript entitled "The Sanitary Privy," prepared by C. W. Stiles and L. L. Lumsden, of the Hygienic Laboratory of this service. Professor Stiles is also consulting zoologist in the Bureau of Animal Industry, Department of Agriculture. For some years past these two officers have been making a special study of certain diseases which are particularly incident to farm life and of the methods by which these infections are spread, and their reports thereon have appeared in the publications of the Public Health and Marine-Hospital Service. These have been revised, and the manuscript, with the description of additional research work, is submitted, that it may become available through the Department of Agriculture to those living on farms, who naturally look to your department for such information.

Respectfully,

WALTER WYMAN,
Surgeon General.

HON. JAMES WILSON,
Secretary of Agriculture.

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ILLUSTRATIONS.

THE SANITARY PRIVY.

SOIL POLLUTION.

It is common knowledge among intelligent farmers that in many instances when live stock, such as horses, cattle, sheep, or hogs, are pastured year after year in the same field, the animals do not thrive; in fact, that, sooner or later, many sicken and die; this is especially true of the young animals.

The explanation of this fact is clear. Animals harbor parasitic worms and germs in their intestines; the worms lay eggs, which are passed in the droppings; the eggs develop into young worms, which in turn reinfect the live stock. If a pasture is in constant use the ground becomes heavily infested with young worms and other germs; the smaller the pasture in proportion to the number of animals kept in it, the more intensified the soil pollution becomes. Warmth and moisture are especially favorable to the hatching out of worms from the eggs passed in the droppings, hence, during warm, moist seasons, or in warm, moist localities, the infection of the stock is likely to be more severe. The more heavily the animals are infected with parasites, the less they thrive; their digestion is weakened and their blood becomes watery, so that a considerable proportion of the food given them is wasted in that it does not go to make meat; their growth is retarded and their fertility is lessened; and finally infection reaches such a degree that many of the animals can no longer withstand it, and they sicken and die. Thus, the soil pollution of a field by the live stock eventually renders the pastures unfavorable for raising animals. The practical farmer, having observed this fact, moves his stock to other ground in order "to give the old pasture a rest;" by so doing he removes his animals from exposure to infection, allowing the infectious germs and young worms in the old pasture to die out.

The foregoing facts regarding the effects of soil pollution upon the health of animals, such as horses, sheep, cattle, swine, and chickens, apply with equal force to human beings, because human beings also harbor parasitic worms and germs, which are discharged in the excreta, pollute the soil, are again conveyed to people, and thus continue the round of infection at an increasing rate. Soil pollution by

NOTE.—A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.

human excreta endangers the health of a family, just as soil pollution of a pasture by the droppings of animals endangers the live stock.

In order to prevent the evil effects of soil pollution from extending to his live stock, the farmer must resort to more or less expensive methods, such as purchase of additional pasture lands or burning the pasture. But since human beings, on account of their superior intelligence, can be taught to frequent an appointed place to deposit their excreta, it is possible (by the expenditure of a few dollars for a sanitary privy) to prevent soil pollution with human excreta, thereby protecting the family, and enabling it to live year after year on the same premises (family pasture) without danger, at the same time saving doctors' bills and avoiding unnecessary sickness and death.

DISEASES SPREAD FROM MAN BY SOIL POLLUTION.

It is especially the diseases caused by parasites (both animal and bacterial) of the intestine, lungs, liver, kidneys, and bladder that are spread by soil pollution. Some of these diseases are spread from human being to human being; others are spread from human beings to the farm animals. Therefore, in preventing soil pollution by persons, both families and live stock are protected.

The proper disposal of human excreta is recognized by sanitarians as the most important measure needed to prevent the spread of typhoid fever, hookworm disease, the dysenteries, and certain other widely prevalent diseases.

DISEASES SPREAD FROM MAN TO MAN.

Some of the diseases which come under this heading are caused by microscopic parasites known as bacteria; others by animal parasites, which are considerably larger than the bacteria.

BACTERIAL DISEASES.

Among the most important diseases under this heading may be mentioned typhoid fever, dysentery and diarrhea ("summer complaint"), and tuberculosis ("consumption").

Typhoid fever.—Every person who contracts typhoid fever does so because he has recently swallowed some typhoid germs that have been passed in the stools or urine of some other person, who either (as a patient) was suffering from typhoid or (as a "carrier") was carrying the germs without showing symptoms.

The germs (bacilli) of typhoid fever are of very minute size, a single germ (bacillus) being only about $\frac{1}{12000}$ of an inch in length and only about $\frac{1}{36000}$ of an inch in thickness. Like molds and yeasts, they are plants, and under favorable conditions (as in milk, for instance) they multiply at a very rapid rate, so that in a few hours a single germ may increase to thousands. Thousands of these little germs may be contained in a particle of feces no larger than the head of an ordinary pin, or in a small drop of urine, and hundreds may be carried on the leg of a fly (fig. 1). A person suffering from typhoid fever discharges myriads of these germs in the stools and urine. Therefore, the excreta from typhoid patients should be regarded as highly poisonous, and everything which may become soiled with the smallest quantity of feces or urine should be thoroughly disinfected by heat or chemicals.

After being discharged in the excreta from the bodies of persons, typhoid germs gradually die out, but the length of time during which they will survive in the excreta is affected by a number of conditions; in some instances they have been found to live for over a year in the contents of privies and privy vaults and in excreta mixed with earth. Therefore, excreta which have been passed through a septic tank or which have been stored for months in a privy or privy vault should not be regarded as being free from typhoid germs.

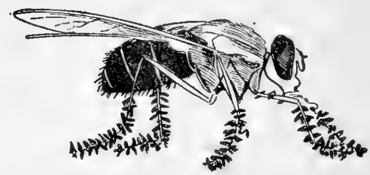

FIG. 1.—A fly with germs (greatly magnified) on its legs.

Persons in the early stages of typhoid fever, before becoming ill enough to take to bed (and some time perhaps before the physician is called in), may discharge typhoid germs in their excreta. Some persons contract infection and though having symptoms of the disease in a mild form ("walking cases of typhoid fever") never become ill enough to give up and take to bed. Other persons contract and harbor the infection for a few days or weeks without showing any symptoms whatever ("temporary typhoid-bacillus carriers"). In many instances the excreta from such persons are as heavily charged with typhoid germs as are those from persons suffering with the severest attacks of the disease. Some persons recovered from attacks of the disease continue to discharge typhoid germs in their stools or urine, or both, for weeks, months, or even years ("chronic typhoid-bacillus carriers"). In view of all these now thoroughly established facts, it is evident that to prevent the spread of typhoid infection from persons it is necessary to dispose properly of the excreta from all persons at all times. This can be done by the use of sanitary privies.

If the excreta are not properly disposed of it is readily understood that the germs may be carried in a number of ways to the water or food supplies, and then be swallowed by and cause infection in persons. They may be carried by drainage or seepage or tracked on the feet of persons, live stock, and poultry to the well or spring. They may be carried directly by flies from the excreta to the foods in the kitchen or dining room. If spread about the place they will from time to time get on the hands of persons, and thence into the water or foods.

Some of the ways in which typhoid germs in the excreta from infected persons may be conveyed to other persons are shown in the following diagram:

Diagram of modes of spread of typhoid fever.

Excreta from	Typhoid patients or Typhoid germ carriers	to	Fingers		to	Mouths of persons
			Flies			
			Water			
			Foods	Milk		
				Raw vegetables and fruits		
				Bread, cake, candy, etc		

The foregoing diagram shows that the easiest way of protecting against typhoid fever is to dispose of the excreta in such a manner that the germs contained therein can not be spread. This can be done by using sanitary privies.

Dysentery and diarrhea ("summer complaint").—Dysentery and similar infections can be prevented in the same way as typhoid fever, as their method of spread is the same.

Tuberculosis.—Although the danger of spreading tuberculosis by spitting must be constantly held in mind, it is important to remember also that many tubercle bacilli may be discharged in the feces, because persons with lung tuberculosis ("consumption") frequently swallow their sputum, and also because some persons have tuberculosis of the bowels. The spread of tuberculosis by soil pollution may be prevented by using sanitary privies.

PARASITIC DISEASES.

Among the diseases caused by animal parasites, and spread by soil pollution from man to man, there may be mentioned, especially, hookworm disease, Cochin-China diarrhea, eelworm infection, pinworm infection, blood-fluke infection, amœbic dysentery, and many other diseases. In some of these maladies the infection is spread in much the same way as is that of typhoid fever, the germs being swallowed; in others the infection may take place through the skin. All of these diseases can be prevented by using sanitary privies.

Hookworm disease.—There are in this country at least 2,000,000 cases of hookworm disease. The parasites, which are about half an inch long, attach themselves to the wall of the bowels, which they wound, and from which they suck blood.

The worms lay eggs which are passed in the stools and which escape from the body in no other way. If the ground is polluted by the human excreta, this disease spreads, but if the excreta are deposited in a sanitary privy, and properly disposed of, the disease can be easily prevented.

Under favorable conditions, from these eggs, which are too small to be seen with the naked eye, hatch out within a few hours tiny worms; these worms grow and shed their skin, much like a snake; when about one to two weeks old, but still only about one-fortieth of an inch long and therefore scarcely visible to the naked eye, they may be swallowed, or they may burrow through the skin, especially of barefooted children, and cause that condition known as "ground itch," "dew itch," "dew sores," "toe itch," etc. Wherever "ground itch" exists, it is proof that somewhere in that locality soil pollution has occurred, because there is a privy which is either not properly built, or not properly taken care of, or not properly used, or because there is no privy at all.

From the skin these tiny worms get into the blood and gradually make their way to the bowels, where they grow to adult worms, and in their turn lay eggs.

If any member of the family or any person on the farm is pale, weak, or sickly, and has had "ground itch" within 10 years past, the family physician should be consulted as to whether the trouble is due to hookworms. In many of the States the State board of health will either make or have made a microscopic examination, free of charge, to determine the point definitely.

Although hookworm disease may have serious effects, even resulting in death, it can be easily cured at a slight expense, and it can be entirely eradicated if sanitary privies are built and used.

Cochin-China diarrhea.—This is a disease which is spread very much in the same way as hookworm disease. It is very difficult to treat successfully, but it can be absolutely prevented by the use of sanitary privies.

Eelworm infection.—The eelworms are about as large as a lead pencil, and are found among children. Whenever found they prove that there is something wrong with the sanitary conditions.

Amœbic dysentery.—This is a very serious disease. It may cause death, but its spread can be prevented by the use of sanitary privies.

PARASITIC DISEASES SPREAD FROM MAN TO LIVE STOCK AND THEN BACK TO MAN.

At least two kinds of tapeworms are spread from man to live stock and back to man because of lack of sanitary privies.

Beef-measle tapeworm.—This tapeworm, when harbored in the intestine of man, lays thousands of eggs, which are discharged in the stools, and if scattered about may be swallowed by cattle. Here they cause "beef measles," reducing the value of the beef. By eating measly beef man may become infected with this tapeworm.

Pork-measle tapeworm.—The eggs of this tapeworm are passed in the stools of man and swallowed by swine, in which they cause "pork measles." By eating such pork man may become infected with tapeworms. This tapeworm is especially dangerous, because if a person harbors it and pollutes the soil with his excreta containing the eggs, these eggs may be swallowed by persons and cause a serious disease known as "pork measles" in man, which may cause blindness, insanity, and death.

Both of these tapeworm infections can be prevented by the use of sanitary privies.

HUMAN EXCREMENT AS A BREEDING PLACE FOR FLIES.

Flies and many other insects feed upon and breed in filth, such as manure and human excrement. Whenever a fly is seen it is positive proof of the existence of some filth in the neighborhood. It is much more filthy and much more dangerous to have flies in the kitchen and dining room than to have bedbugs in the bedroom.

Flies can carry various disease germs to man. By so doing they kill thousands of people, especially babies, every year; therefore kill the flies and save the babies.

If flies have access to human excrement, they not only feed upon it, but they lay their eggs in it. After a few hours the egg hatches out a maggot; this feeds in the filth for several (about five) days and then forms a pupa; after about five days the adult fly comes out of the pupal case, feeds on the filth, and carries disease germs from the filth to the house, depositing these germs on the foods. Thus flies carry disease to people. A fly drops his excrement about once every $4\frac{1}{2}$ minutes and may spread germs not only in this way, but also with his feet, wings, and mouth parts.

Even if excrement containing fly maggots is buried under as much as 6 feet of sand, the maggots can crawl to the surface, bringing disease germs with them.

Thus it is clear that if flies are kept away from human excrement, not only will they decrease in numbers, but they will be prevented from spreading certain diseases, such as typhoid fever. This can be done by the use of sanitary privies.

PRIVY CONDITIONS ON SOME AMERICAN FARMS.

The privy on the American farm possibly has not received the attention that its importance deserves. Some American farms have no privy at all. This means that some farm families are being needlessly exposed to sickness and death. It means that these families are following a custom which not only needlessly increases sickness and death, but which decreases the value and productiveness of their farms. The warmer, more moist, and more shaded the locality, the greater is the danger resulting from lack of sanitary privies.

City health authorities are gradually awakening to the dangers connected with the supplies of milk, fresh vegetables, and fresh fruits from insanitary farms; hence not only from the standpoint of preserving the health of persons living on farms and increasing the productiveness of the farms, but also from the standpoint of marketing farm produce, it is important for farms to be provided with sanitary privies.

DIFFERENT KINDS OF PRIVIES.

The popular idea of the purpose of a privy.—To the popular mind a privy (as indicated by its name) is a structure to which a person may retire in private when responding to the daily calls of nature. In the minds of most persons modesty and privacy are the chief considerations which lead to the construction of a privy. As such privacy may be secured by a clump of bushes or a grove of trees, some persons consider a privy unnecessary.

Modesty and privacy are laudable objects, but all must agree that they are of infinitely less importance than the great object of saving human life by preventing the spread of disease.

The essential parts of a privy.—A privy should consist of two chief parts, namely: First, a receptacle for the excreta; secondly, a room to insure privacy.

The essential problems in constructing a privy.—From the foregoing it is clear that the two great problems to be held in mind in constructing a privy are: First, to protect the receptacle for the excreta in such a way that the germs can not be spread; secondly, to construct the entire outhouse in such a way that persons will seek to use it and not to avoid it—in other words, not only must it insure privacy, but it must not be a disagreeable place in which to be private. This latter point is especially important in warm climates, for many a privy is so disagreeable in warm weather that people, especially men, very frequently avoid it. Still another point must be considered, namely, the cost of construction and maintenance must be brought within the purse limits of the poor as well as of the well-to-do family.

The kinds of privies that are not sanitary.—If the excreta are scattered broadcast, the infection they contain is also scattered far and wide. If the excreta are deposited in one place, the infection they contain is more restricted. Therefore, any kind of privy is better than none. From a faulty privy, however, much infection may be spread in various ways, as, for instance, by drainage and seepage, or by chickens, swine, and dogs, or by the feet of persons, or by insects, especially flies.

Fig. 2.—An insanitary privy, open in back. (Stiles, 1910.)

Figure 2 represents a dangerous type of privy. On a systematic rating it should not be marked higher than 10 on a scale of 100, therefore it is 90 per cent below perfect. The protection afforded by this privy depends in great measure upon the frequency with which the excrement is removed. But even if this privy is cleaned every day, chickens, hogs, and flies have access to the fresh night soil for a number of hours, and, besides that, the ground under and around the outhouse becomes polluted.

Even if such a privy is provided in the back with a tightly fitting trapdoor, so as to exclude domesticated animals and to prevent the toilet paper from being blown about, its efficiency is increased by only about 15 points, so that it should not be ranked more than 25 on a scale of 100. Insects, such as flies, ants, and roaches, still have access to the night soil, which also pollutes the ground under and around the privy.

The kinds of privies that are sanitary.—A sanitary privy must meet the following requirements:

(1) The excreta must not touch the ground; hence some kind of water-tight receptacle (box, pail, tub, barrel, tank, or vault) for the excreta must be used under the seat.

(2) Domesticated animals must not have access to the night soil; therefore the privy should have a trapdoor in the back to exclude them.

(3) Flies and other insects must not have access to the excreta; therefore the entire privy must be made rigidly flyproof, or some substance must be used in the receptacle to protect the contents from insects.

Two types of sanitary privies are generally recognized, namely, the so-called "dry system" and the so-called "wet system."

THE "DRY SYSTEM."

In the "dry-system" privies dry earth, road dust, wood ashes, or lime is kept in the privy, and is scattered on the excreta every time the privy is used.

The dry system, if properly managed, presents the following advantages:

(1) It decreases the offensiveness of the privy contents.

(2) It is cheap.

(3) It decreases the chance of spread of infection by insects.

(4) It is an easy system to manage.

The disadvantages of the dry system are the following:

(1) It is very difficult to make a dry privy rigidly fly proof, hence flies usually do have more or less access to the excreta, on which they feed and on which they lay their eggs.

(2) Its efficiency depends upon the careful and faithful cooperation of all persons (including children) who use the privy, and experience shows that such cooperation can not be relied upon.

(3) It increases the amount of material to be removed; hence it increases the labor and frequency of necessary cleaning.

(4) Experience shows that it is exceptional that the excrement is properly covered with dry earth or lime; hence the system is not so efficient as is popularly supposed.

(5) Neither dry earth nor lime, in practical usage, can be relied upon to destroy all disease germs which may be in the excreta; hence their use is likely to give rise to a false sense of security in the public mind.

(6) If the dejecta at the time of burial contain fly grubs these larvæ may crawl through the earth to the surface, where they can complete their development into adult flies and spread infection from the buried night soil.

Privies of the "dry system" should not be marked more than 75 points on a scale of 100.

Figures 6 and 7 (pages 22 and 23) represent an outhouse which may be used as a dry privy.

THE "WET SYSTEM."

In the "wet-system" privies some fluid is used in the receptacle either (1) to disinfect the excreta, or (2) to act as an insect repellent, or (3) to increase the destruction of disease germs in the excreta by natural fermentation. Figures 6 and 7 represent outhouses which can be used as "wet-system" privies.

The advantages of the "wet system," when applied to outhouses shown in figures 6 and 7, are:

(1) It decreases the offensiveness of the privy contents.

(2) It is cheap.

(3) It greatly decreases the chances of spread of infection by flies because they can not breed in the excreta; hence rigid fly screening is not so necessary.

(4) It kills or renders harmless a considerable proportion of certain infections contained in the excreta.

(5) Its efficiency does not depend upon the intelligence or cooperation of all persons using it.

The disadvantages of the "wet system," as applied to outhouses shown in figures 6 and 7, are:

(1) It is more difficult to keep clean than the "dry system," because of the danger of soiling the floor when the receptacle is emptied.

(2) Unless the receptacle is very deep there is likely to be more or less splashing.

(3) The labor and frequency of cleaning are about the same as in the case of the "dry system."

If the wet system is used it is best to fill the receptacle about one-fourth full of water, on the surface of which a cup of petroleum is poured. The petroleum acts as an insect repellent.

Two sets of receptacles should be provided. While one set is being used under the seat, the other set is covered and permitted to stand so as to lengthen the period of fermentation.

THE L. R. S. PRIVY.[1]

On account of the various objections raised against the different styles of privies now in use, an effort has been made to construct a device which will decrease the disadvantages and at the same time increase the advantages connected with the older types of outhouses. The results obtained from various experiments have been applied to an apparatus known as the L. R. S. privy (figs. 3, 4, and 5).

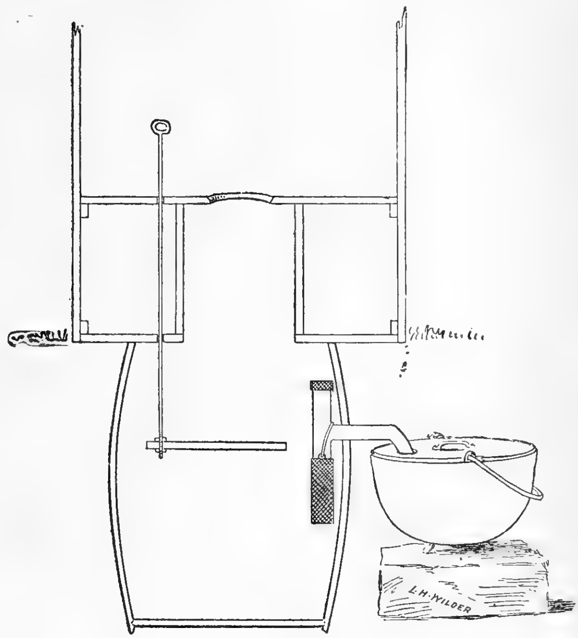

FIG. 3.—Improved L. R. S. privy.

This apparatus consists of the following parts:

(1) A water-tight barrel or other container to receive and liquefy the excreta.

(2) A covered water-tight barrel, can, or other vessel to receive the effluent or outflow.

(3) A connecting pipe about 2½ inches in diameter, about 12 inches long, and provided with an open T at one end, both openings of the T being covered with wire screens.

(4) A tight box, preferably zinc lined, which fits tightly on the top of the liquefying barrel. It is provided with an opening on top for the seat, which has an automatically closing lid.

(5) An antisplashing device consisting of a small board placed horizontally under the seat about an inch below the level of the transverse connecting pipe; it is held in place by a rod, which passes through eyes or rings fastened to the box, and by which the board is

[1] Lumsden, Roberts, and Stiles: Preliminary note on a simple and inexpensive apparatus for use in safe disposal of night soil. Public Health Reports, 1910, Nov. 11, v. 25 (45), pp. 1619–1623, fig. 1.

raised and lowered. The liquefying tank is filled with water up to the point where it begins to trickle into the effluent tank.

As an insect repellent a thin film of some form of petroleum may be poured on the surface of the liquid in each barrel.

Practical working of the apparatus.—When the privy is to be used, the rod is pulled up so that the antisplashing board rises to within about 1 inch below the surface of the water. The fecal material

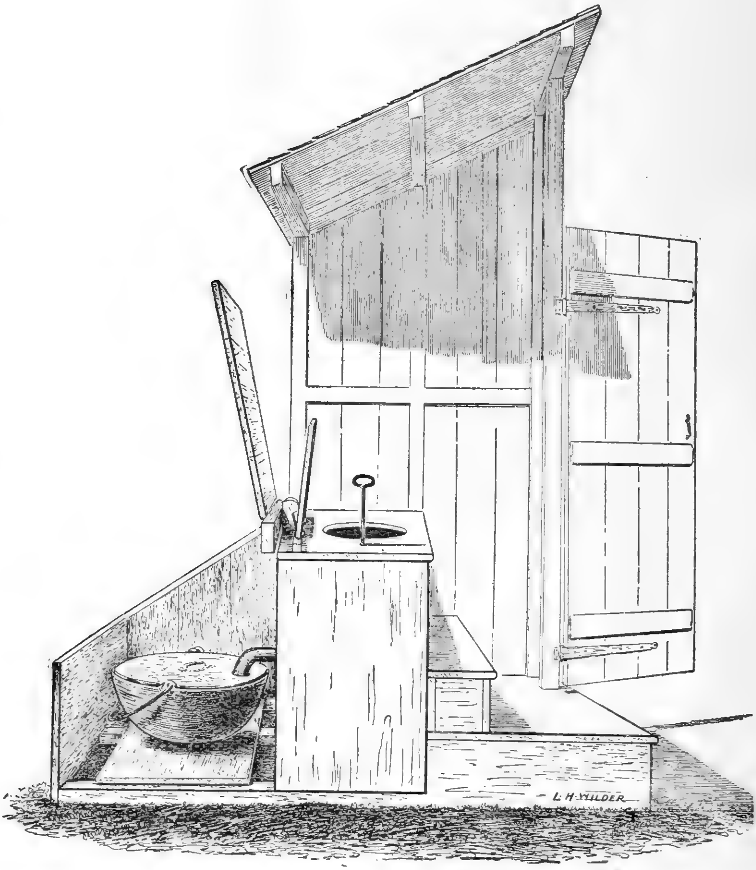

FIG. 4.—Inside view of L. R. S. privy.

falls into the water, but this board prevents splashing, and thus overcomes one of the greatest objections thus far raised to the wet system. After use, the person sinks the antisplashing board by pushing down the rod, and the fecal matter then floats free into the water.

Although some of the fecal matter floats, it is protected both from fly breeding and fly feeding in the following ways: First, by the automatically closing lid; second, by the water; third, by the film of oil; and, fourth, by having the apparatus located in a screened place, which should be done for additional safety. The film of oil also prevents the breeding of mosquitoes in the barrel. Accordingly, so far as the privy as a breeding or feeding place of flies and mosquitoes is concerned, the model in question completely solves the problem.

The fecal material becomes fermented in the water and gradually liquefies; as the excreta settle, the level of the liquid is raised and the excess flows into the effluent tank, where it is protected from insects by the cover and by a film of oil. This effluent may be allowed to collect in the tank until it reaches the level of the connecting pipe, when it may be safely disposed of in various ways to be discussed later.

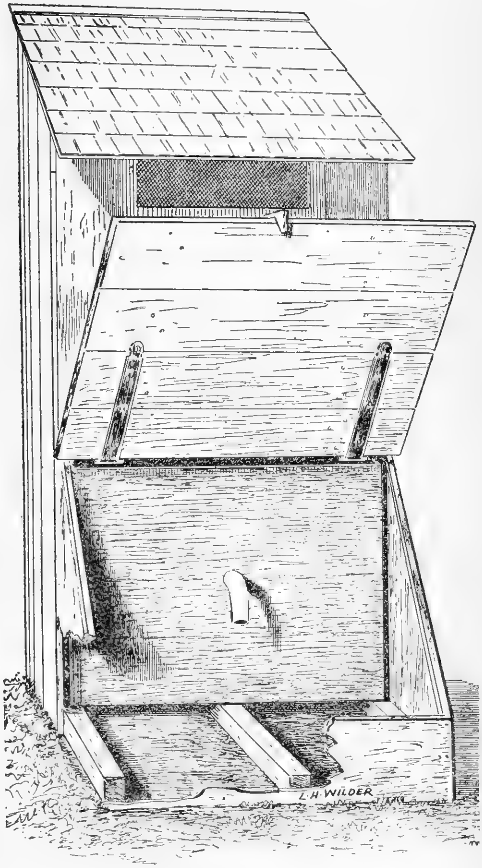

FIG. 5.—Rear view of L. R. S. privy.

It is thus seen that this device appears to meet the following requirements:

(1) It solves the fly problem and the mosquito problem, so far as the privy is concerned.

(2) It liquefies fecal material and reduces its volume, so that it may be safely disposed of more easily and cheaply than the night soil from other types of privies.

(3) It reduces odor.

(4) It reduces the labor of cleaning the privy and makes this work less disagreeable.

(5) It is of simple and inexpensive construction.

This device has been in constant operation in one of the workrooms on the main floor of the Hygienic Laboratory at Washington for 8 months and has been found entirely satisfactory. From July 12, 1910, to April 1, 1911, namely, 262 days, it has been used 738 times, giving an average of $2\frac{4}{5}$ defecations (with urination) per day. The amount of overflow (effluent) from the liquefying tank has been 59 gallons. The liquefying tank itself consists of an ordinary water-tight 40-gallon whisky barrel, and it has not been necessary thus far either to add water or to empty it.

Tests of this device are now being made in out-of-doors privies in order to determine the effect upon it of varying conditions of temperature and humidity. Tests are also being made to bring out whatever objectionable features may arise in connection with its general use and to determine the simplest methods of managing the device so that any family will have no difficulty in keeping it in proper working order.

The handle of the antisplasher should come up through the seat board at the side of the hole. By this arrangement the antisplasher can be raised entirely out of the water and thus used to sink the toilet paper and fecal matter if too much floats on the surface.

As an effluent tank, various receptacles can be utilized. If an iron pot is used, place on stones or provide with legs so that a space is left under it to permit the building of a fire as the effluent can be easily and cheaply disinfected by heat.

As a liquefying tank one may use either a barrel or an iron tank, or a box, or a brick vault, or a concrete vault. Whatever is used for this purpose must be strictly water-tight. Iron or concrete will cost more than wood, but on account of greater durability will be more economical in the long run.

The larger the family the larger the liquefying tank must be. A 40-gallon barrel, such as a whisky or oil barrel, seems sufficient for a family of 3 adults. For a larger family, the capacity should be increased by using two or more barrels or one larger receptacle, in the proportion of about 40 gallons capacity to every 3 to 4 adults in the family.

One advantage the device possesses is that with very little expense it can be put in the outhouses already in use; in fact, it can be placed in any of the outhouses on the farm, such as barn or woodshed, and thus save the expense of building for this special purpose. Wherever put, it is very important to have it in a place screened against flies.

From the out-of-door experiments thus far it can be readily foreseen that two factors come into consideration which have not been found important in the indoor privy, namely, evaporation and changes of temperature.

In cold weather the fermentation is not so rapid as in warm weather, and on this account the contents of the liquefying tank may gradually thicken.

The evaporation out of doors will vary greatly with the wind, humidity, and temperature in different regions, and the greater the evaporation the thicker the material in the liquefying tank becomes. Should such thickening occur, the odor will increase, and it will be necessary to add water to the liquefying tank. In order to prevent such thickening, it may be found necessary in some instances to add water from time to time. Just how often and how much water should be added, under adverse conditions, has not yet been determined, but, so far as can be foreseen at present, probably a bucketfull (about 2 gallons) added once a week will be sufficient for a single barrel used by a family of 3 or 4 adults.

Experiments have conclusively demonstrated that the principle of the L. R. S. privy is good. The details regarding the addition of water must be determined experimentally in different localities. Any intelligent farmer should be able to determine this point for his own locality.[1]

If this type of privy is managed fairly intelligently, the indications are that the liquefying tank will rarely need cleaning, probably not oftener than once in several years. When cleaning does become necessary, this can be done in several ways: The barrel may be taken out, and its contents burned; or the contents may be pumped or dipped out, and burned; or a considerable amount (several barrelfuls) of water can be poured gradually into the liquefying tank, and the sludge thoroughly stirred until it runs over into the effluent tank.

In the experimental L. R. S. privy the only paper used has been the regular toilet paper. This has liquefied with sufficient promptness. If heavier paper (such as newspaper) were used, this would break up more slowly, and allowance for it might have to be made by increasing the capacity of the tank. It is well to bear in mind that the ink on newspaper is likely to irritate the skin. Corncobs and similar objects would certainly interfere materially with the successful working of any apparatus of this kind.

DIRECTIONS FOR BUILDING A SANITARY PRIVY.

There are many different ways that a privy building can be constructed. The details of construction are here appended for only one of the many different styles.

In order to put the construction of a sanitary privy for the home within the carpentering abilities of boys, a practical carpenter has been requested to construct models to conform to the general ideas expressed in this article and to furnish estimates of the amount of

[1] It should be understood that the L. R. S. privy is described simply as a type, and may be modified to suit varying conditions.

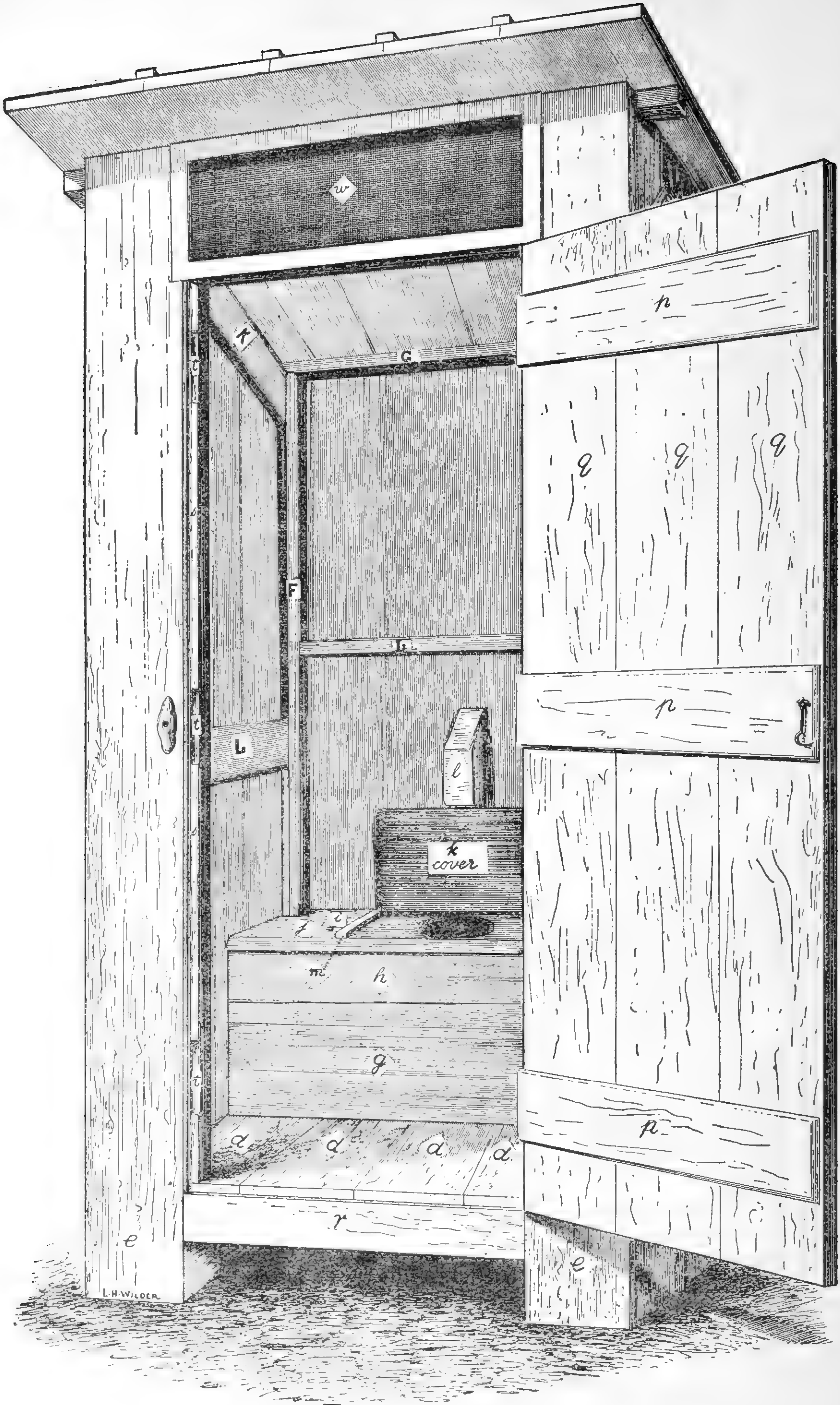

FIG. 6.—A single-seated sanitary privy. Front view. (Stiles, 1910.)

lumber, hardware, and wire screening required. Drawings of these models have been made during the process of construction (figs. 8, 9) and in completed condition (figs. 6, 7). The carpenter was requested to hold constantly in mind two points, namely, (1) economy and (2) simplicity of construction. It is believed that any 14-year-

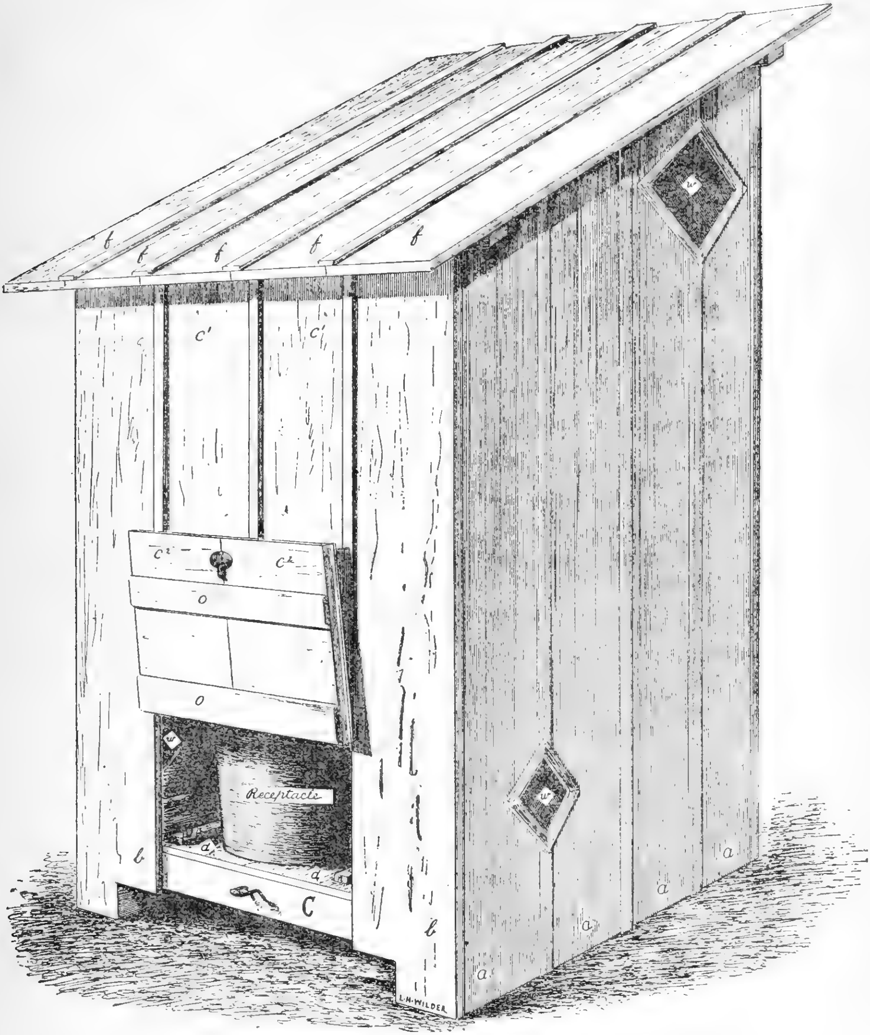

FIG. 7.—Rear and side view of a single-seated sanitary privy.

old school boy of average intelligence and mechanical ingenuity can, by following these plans, build a sanitary privy for his home at an expense for building materials, exclusive of receptacle, of $5 to $10, according to locality. It is further believed that the plans submitted cover the essential points to be considered. They

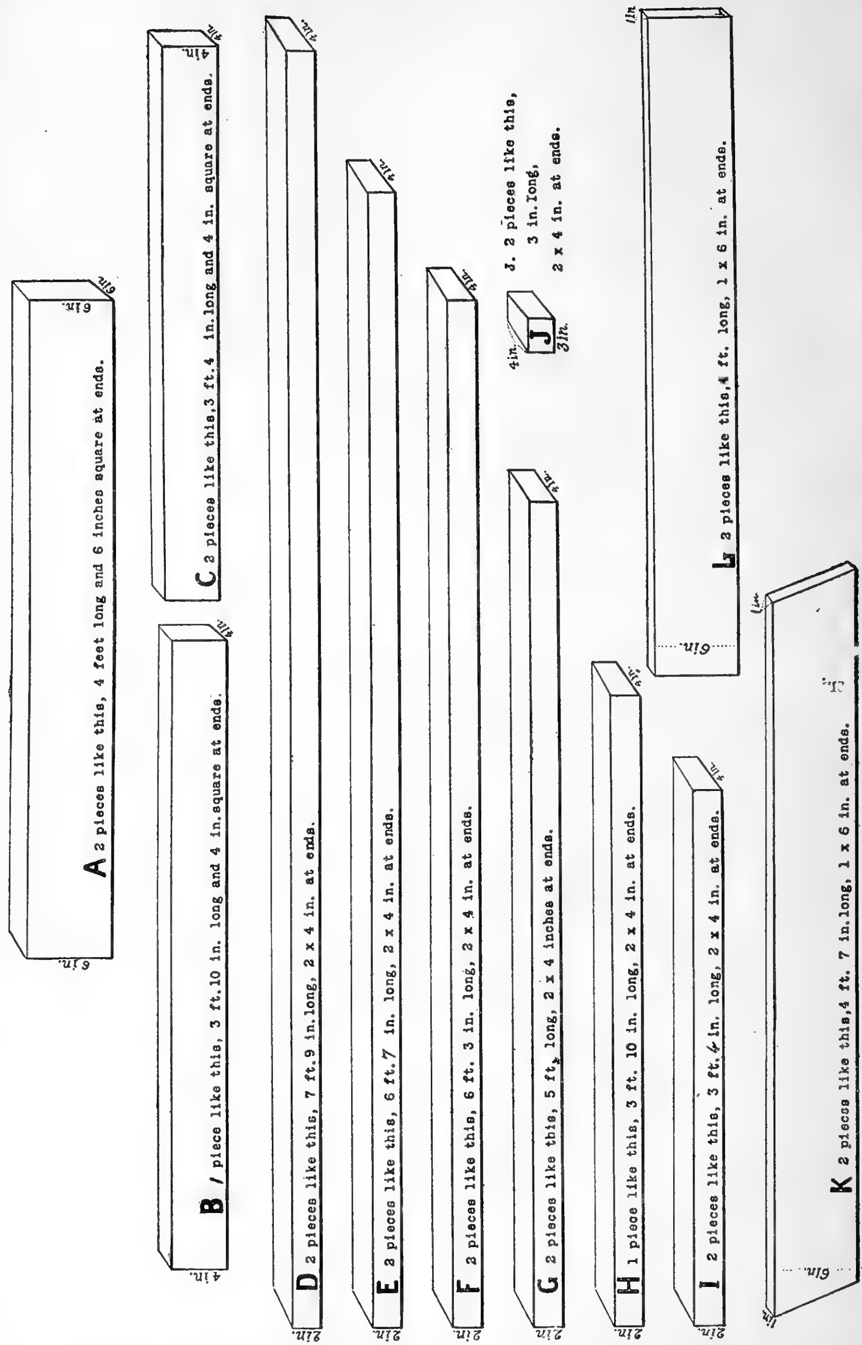

FIG. 8.—The scantling necessary for the framework of a single-seated sanitary privy, fig. 6. (Stiles, 1910.)

can be elaborated to suit the individual tastes of persons who prefer a more elegant and more expensive structure. For instance, the roof can have a double instead of a single slant, and can be shingled; the sides, front, and back can be clapboarded, or they can be shingled. Instead of one seat (figs. 6, 7), there may be two, three, four, five, or six seats, according to need.

A SINGLE-SEATED PRIVY.

Nearly all privies for the home have seats for two persons, but a single-seated privy can be made more economically.

Framework.—The lumber required for the framework of the outhouse shown in figure 6 is as follows (see figs. 8, 9):

A, two pieces, 6 by 6 inches, 4 feet long.
B, one piece, 4 by 4 inches, 3 feet 10 inches long.
C, two pieces, 4 by 4 inches, 3 feet 4 inches long.
D, two pieces, 2 by 4 inches, 7 feet 9 inches long.
E, two pieces, 2 by 4 inches, 6 feet 7 inches long.
F, two pieces, 2 by 4 inches, 6 feet 3 inches long.
G, two pieces, 2 by 4 inches, 5 feet long.
H, one piece, 2 by 4 inches, 3 feet 10 inches long.
I, two pieces, 2 by 4 inches, 3 feet 4 inches long.
J, two pieces, 2 by 4 inches, 3 inches long.
K, two pieces, 1 by 6 inches, 4 feet 7 inches long. The ends of K should be trimmed after being nailed in place.
L, two pieces, 1 by 6 inches, 4 feet long.

First lay down the sills marked A, and join them with the joist marked B; then nail in position the two joists marked C, with their ends 3 inches from the outer edge of A; raise the corner posts (D and F), spiking them at bottom to A and C, and joining them with L, I_2, G, and K; raise doorposts E, fastening them at J, and then spike I_1 in position; H is fastened to K.

Sides.—Each side (fig. 7) requires four boards (*a*) 12 inches wide by 1 inch thick and 8 feet 6 inches long; these are nailed to K, L, and A. The corner boards must be notched at G, allowing them to pass to bottom of roof; next draw a slant from front to back at G–G on the outside of the boards, and saw the four side boards to correspond with this slant.

Back.—The back (fig. 7) requires two boards (*b*) 12 inches wide by 1 inch thick and 6 feet 11 inches long, and two boards (*c*) 12 inches wide by 1 inch thick and 6 feet 5 inches long. The two longest boards (*b*) are nailed next to the sides; the shorter boards (*c*) are sawed in two, so that one piece (c^1) measures 4 feet 6 inches, the other (c^2) 1 foot 11 inches; the longer portion (c^1) is nailed in position above the seat; the shorter portion (c^2) is later utilized in making the back trapdoor.

Floor.—The floor (fig. 6) requires four boards (d) which (when cut to fit) measure 1 inch thick, 12 inches wide, and 3 feet 10 inches long.

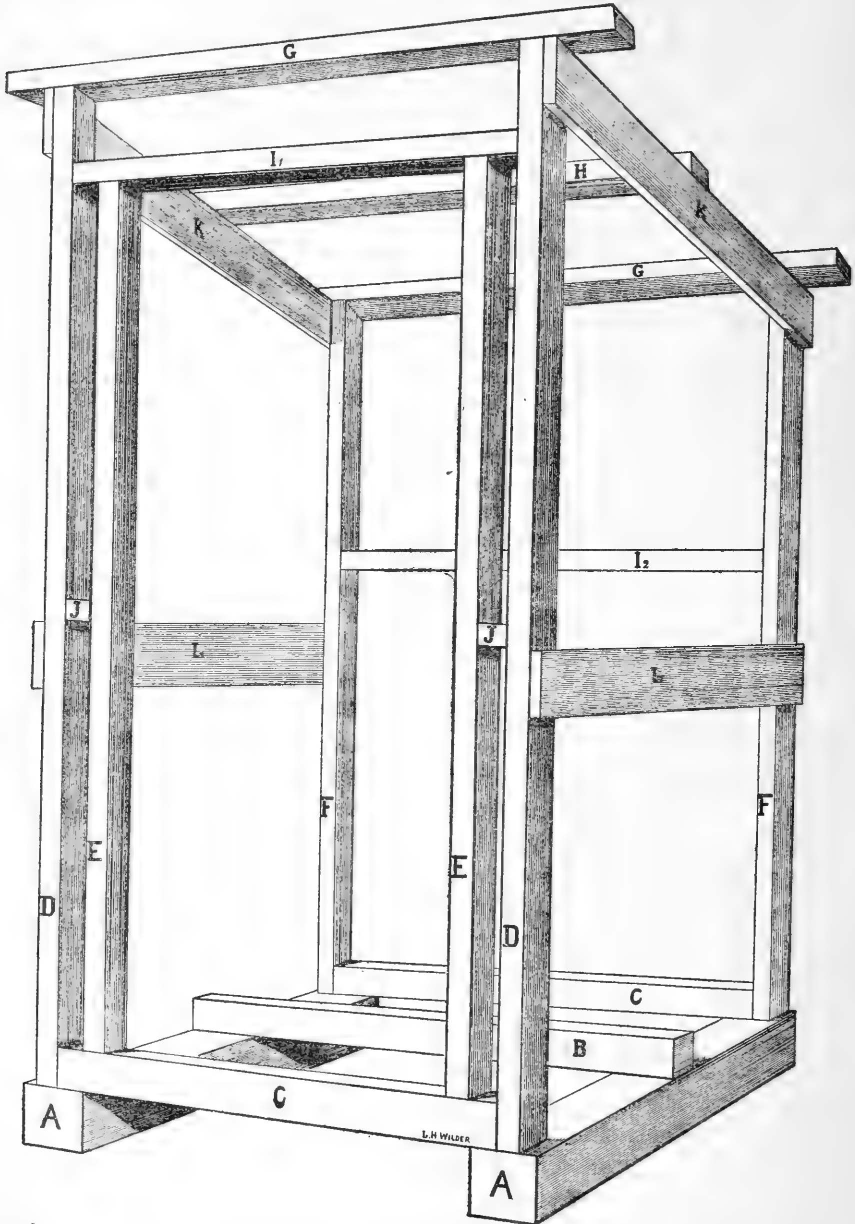

FIG. 9.—The framework (assembled) for a single-seated sanitary privy. (Stiles, 1910.)

Front.—The front boards may next be nailed on. The front (fig. 6) requires (besides the door) two boards (e), which (when cut to fit) measure 1 inch thick, 9 inches wide, and 8 feet 5 inches long; these are nailed next to the sides.

Roof.—The roof (fig. 7) may now be finished. This requires five boards (*f*) measuring (when cut to fit) 1 inch thick, 12 inches wide, and 6 feet long. They are so placed that they extend 8 inches beyond the front. The joints (cracks) are to be broken (covered) by laths ½ inch thick, 3 inches broad, and 6 feet long.

Box.—The front of the box (fig. 6) requires two boards, 1 inch thick and 3 feet 10 inches long. One of these (*g*) may measure 12 inches wide, and the other (*h*) 5 inches wide. These are nailed in place, so that the back of the boards is 18 inches from the inside of the back boards. The seat of the box requires two boards, 1 inch thick, 3 feet 10 inches long; one of these (*i*) may measure 12 inches wide, the other (*j*) 7 inches wide. One must be jogged (cut out) to fit around the back corner posts (F). An oblong hole, 10 inches long and 7½ inches wide, is cut in the seat. The edge should be smoothly rounded or beveled. An extra (removable) seat for children may be made by cutting a board 1 inch thick, 15 inches wide, and 20 inches long; in this seat a hole is cut, measuring 7 inches long by 6 inches wide; the front margin of this hole should be about 3 inches from the front edge of the board. To prevent warping, a cross cleat is nailed on top near or at each end of the board.

A cover (*k*) to the seat should measure 1 inch thick by 15 inches wide by 20 inches long; it is cleated on top near the ends to prevent warping; it is hinged in back to a strip 1 inch thick, 3 inches wide, and 20 inches long, which is fastened to the seat. Cleats (*m*) may also be nailed on the seat at the sides of the cover. On the inside of the back board, 12 inches above the seat, there should be nailed a block (*l*), 2 inches thick, 6 inches long, extending forward 3¼ inches; this is intended to prevent the cover from falling backward and to make it fall down over the hole when the occupant arises.

On the floor of the box, underneath the seat (fig. 7), two or three cleats (*n*) are nailed in such a position that the tub will always be in the center; the position of these cleats depends upon the size of the tub.

Back trapdoor.—In making the back of the privy (fig. 7), the two center boards (*c*) were sawed at the height of the bottom of the seat. The small portions (c^2) sawed off (23 inches long) are cleated (*o*) together so as to form a back trapdoor which is hinged above; a bolt or a button is arranged to keep the door closed.

Front door.—The front door (fig. 6) is made by cleating (*p*) together three boards (*q*) 1 inch thick, 10 inches wide, and (when finished) 6 feet 7 inches long; it is best to use three cross cleats (*p*) (1 inch thick, 6 inches wide, 30 inches long), which are placed on the inside. The door is hung with two hinges (6-inch "strap" hinges will do), which are placed on the right as one faces the privy, so that the door opens from the left. The door should close with a coil spring (cost about 10 cents) or with a rope and weight, and may fasten on the inside with a catch or a cord. Under the door a cross-piece (*r*) 1 inch thick, 4 inches wide, 30 inches long (when finished) may be nailed to the joist. Stops (*s*) may be placed inside the door as shown in figure 6. These should be 1 inch thick, 3 inches wide, and 6 feet 6 inches long, and should be jogged (cut out) (*t*) to fit the cross cleats (*p*) on the door. Close over the top of the door place a strip 1 inch thick, 2 inches wide, 30 inches long, nailed to I (fig. 9). A corresponding piece (*v*) is placed higher up directly under the roof, nailed to G. A strap or door pull is fastened to the outside of the door.

Ventilators.—There should be 5 ventilators (*w*). One is placed at each side of the box, directly under the seat; it measures 6 to 8 inches square. Another (12 inches square) is placed near the top on each side of the privy. A fifth (30 inches long, 8½ inches wide) is placed over the door, between G and I_1 (figs. 6, 9). The ventilators are made of 15-mesh copper wire, which is first tacked in place and then protected at the edge with the same kind of lath that is used on the cracks and joints.

If the L. R. S. system (p. 17) is used and the barrel or tank brought close to the seat, the ventilators at the sides of the box may be done away with, and the barrel may be ventilated by a pipe (such as a joint of stove pipe), extending through the seat to the roof or through the back of the house; this ventilator should be screened.

Lath.—Outside cracks (joints) are covered with lath ½ inch thick by 3 inches wide.

Receptacle.—For a receptacle, saw a water-tight barrel to fit snugly under the seat; or purchase a can or tub, as deep (17 inches) as the distance from the under surface of the seat to the floor. If it is not possible to obtain a tub, barrel, or can of the desired size, the receptacle used should be elevated from the floor by blocks or boards so that it fits snugly under the seat. A galvanized can measuring 16 inches deep and 16 inches in diameter can be purchased for about $1, or even less. An empty candy bucket of about the same size can be purchased for about 10 cents.

This same outhouse may be used for the L. R. S. privy (p. 17), in which case it is not necessary to extend the floor under the seat; instead of doing this, a hole is dug deep enough to receive the barrel or vault; or if preferred, the house can be elevated high enough to make room for the barrel (see fig. 3).

Order for material.—The carpenter has made out the following order for lumber (pine, No. 1 grade) and hardware to be used in building a privy such as is shown in figure 6:

1 piece, 6 by 6 inches by 8 feet long, 24 square feet.
1 piece, 4 by 4 inches by 12 feet long, 16 square feet.
5 pieces, 2 by 4 inches by 16 feet long, 54 square feet.
3 pieces, 1 by 6 inches by 16 feet long, 24 square feet.
2 pieces, 1 by 9 inches by 9 feet long, 14 square feet.
3 pieces, 1 by 10 inches by 7 feet long, 18 square feet.
15 pieces, 1 by 12 inches by 12 feet long, 180 square feet.
12 pieces, ½ by 3 inches by 16 feet long, 48 square feet.
2 pounds of 20-penny spikes.
6 pounds of 10-penny nails.
2 pounds of 6-penny nails.
7 feet screen, 15-mesh, copper, 12 inches wide.
4 hinges, 6-inch "strap," for front and back doors.
2 hinges, 6-inch T, or 3-inch "butts," for cover.
1 coil spring for front door.

According to the carpenter's estimate these materials will cost from $5 to $10, according to locality.

There is some variation in the size of lumber, as the pieces are not absolutely uniform. The sizes given in the lumber order represent the standard sizes which should be ordered, but the purchaser need not expect to find that the pieces delivered correspond with mathematical exactness to the sizes called for. On this account the pieces must be measured and cut to measure as they are put together.

ESTIMATE OF MATERIAL FOR SCHOOL OR CHURCH PRIVY.

The following estimate of building materials has been made, by a carpenter, for the construction of a six-seated school or church privy. The estimated cost of these materials is $25 to $50, according to locality; this does not include the pails or barrels:

3 pieces, 6 by 6 inches by 20 feet, 180 square feet.
1 piece, 6 by 6 inches by 8 feet, 24 square feet.
Scantling, 2 by 4 inches, 165 square feet.
Boards, 1 by 12 inches, 600 square feet.
Boards, 1 by 10 inches, 185 square feet.
Boards, 1 by 8 inches, 100 square feet.
Boards, 1 by 6 inches, 80 square feet.
Boards, ½ by 3 inches, 100 square feet.
Flooring, 80 square feet.
40 feet 15-mesh copper wire screen, 12 inches wide.
12 pairs of hinges, 6-inch "strap."
6 pairs of hinges, 6-inch T.
3 pounds of 20-penny spikes.
15 pounds of 10-penny nails.
8 pounds of 6-penny nails.
6 coil springs for front doors.
6 knobs or latches.

HOW TO KEEP A PRIVY SANITARY.

It is necessary not only to build a privy properly but also to keep it in proper condition. This involves cleaning out and disposing of the excreta in such a way as to prevent all possibility of the spread of disease germs from the material. The disagreeable labor involved varies according to the kind of privy in use, but is less with the L. R. S. privy than with the other types.

Wrong ways of disposing of night soil.—(1) The point can not be emphasized too strongly that the use of fresh night soil as fertilizer endangers the health and life not only of every person on the farm itself, but of all people who handle or who consume the fresh vegetables and fresh milk from such a farm. The custom is forbidden by law in some States.

(2) If the fresh night soil is simply buried, germs of disease may later be brought to the surface, and thus infection may be spread. Further, the popular idea that all the fly grubs in the night soil are killed by burial is not correct, for these grubs can crawl up through as much as 6 feet of sand, reach the surface, develop into flies, and carry filth and disease germs to the food. Further, also, if the fresh night soil is buried, it may infect the water supply (springs, wells, etc.), and thus spread disease. Widespread as is the custom of burying fresh excreta, it is a custom which in the light of present-day knowledge must be viewed as being far from safe, although when done with great care it does decrease the dangers to some extent.

(3) Mixing night soil with manure is especially dangerous, and feeding it to chickens and hogs is both filthy and dangerous.

(4) To leave the night soil on the ground near the privy is deliberately to expose the family and neighbors to sickness.

(5) In some instances farmers collect the fresh night soil from towns and villages, and haul it to their farms, under the impression that if it is promptly plowed under it will enrich the land and no harm can result. Farmers should thoroughly understand that the following of such a practice is attended with great danger, as typhoid fever, hookworm disease, and other infections may thereby be introduced from the town to a healthful farm.

(6) In some instances, the privy is built over a creek, or the fresh excreta are thrown into a stream or lake. Such practices may endanger the lives of persons living downstream.

The right way to dispose of night soil.—Since it is not known, at any given time, which members of a community harbor disease germs in their intestines, the invariable rule should be adopted to consider all fresh night soil as a virulent poison and to dispose of it accordingly.

The only safe way of disposing of fresh night soil from the style of privy shown in figures 6 and 7 is to burn it or disinfect it by means of heat. Any other method, such as burial or any practicable treatment with chemical disinfectants (lime, etc.), although lessening the danger to some extent, still carries with it risks involving human life.

If the wet method (p. 16) be used in the style of privy shown in figures 6 and 7, the excreta had best be heated to 212° F., after which the material may safely be used as fertilizer. A second method is to permit the filth to ferment in water in covered tubs or barrels for not less than a week after removal from the privy; then pour in a disinfectant (such as chloride of lime, one-fourth pound to the gallon of excreta); the material should then be buried. This second method greatly reduces but does not entirely remove the danger of the spread of disease.

Effluent (overflow) from the L. R. S. privy.—From what has been said above, it is clear that the proper disposal of night soil always involves some labor and trouble, but it is important constantly to hold in mind the truth that the results obtained, in better health, smaller doctors' bills, and the saving of human life, more than justify the efforts expended.

The L. R. S. privy reduces the volume of the excreta and converts the material into an easily manageable fluid, so that the disposal of night soil from this type of privy is much simplified. The methods of disposal which come into consideration are the following:

(1) Heat: If a suitable (metallic) vessel is provided to receive the effluent, a fire may be built under the vessel and the effluent heated to 212° F. Or if a wooden or concrete effluent tank is used, the effluent may be transferred to some other vessel for heating.

After such treatment the fluid may be safely used for fertilizer under any conditions.

Heat disinfection is the only measure which can to-day be recommended unreservedly.

(2) Burial: Burial will unquestionably decrease the danger of spreading infection, but in the present state of knowledge this method of disposal can not be relied upon as safe. If burial of the effluent is practiced, the fluid should be disposed of not less than 300 feet from and downhill from any neighboring water supply and not less than 2 feet underground, and then only provided the soil itself is a good filter. Burial in a limestone region may contaminate water supplies miles away.

(3) Chemical disinfection: Chemical disinfectants, such as chlorinated lime and certain coal-tar derivatives, have the great advantage of cheapness and can be relied upon to destroy the disease-causing bacteria in the night soil. The knowledge regarding the action of chemical disinfectants upon the eggs and spores of the various animal parasites is at present very rudimentary, but, so far as results are known, their practicable use does not seem to be so efficient in the

destruction of the animal parasites as of the bacteria. Therefore, pending further investigations, the use of chemically treated excrement as fertilizer should not be regarded as unqualifiedly safe.

(4) Chemical disinfection, with subsequent burial: Inasmuch as chemical disinfection can be relied upon to destroy the disease-producing bacteria in night soil, and inasmuch as burial greatly reduces the danger from animal parasites, a suitable combination of the two methods (chemical disinfection and burial) can be used with reasonable safety.

(5) Sewers: In partially sewered towns the effluent from these privies may be emptied into the sewers. If conditions are such that the addition of this material to the sewage is dangerous, then the entire sewer system needs correction.

THE PRIVY AT THE COUNTRY SCHOOL AND CHURCH.

Although a farmer may prevent soil pollution on his own farm by the use of sanitary privies, his children may be exposed to the dangers of soil pollution at the schools which they attend, and his entire family may be so exposed even when they attend church, unless the schools and churches are provided with sanitary privies. In fact, schools and churches not provided with such outhouses necessarily form distributing centers from which certain diseases spread to clean farms.

CIVIC RESPONSIBILITY IN RESPECT TO PRIVIES.

Lack of sanitary privies on neighboring farms may be responsible for cases of typhoid fever, hookworm disease, and other infections on farms which are provided with sanitary privies, because disease germs may be carried for considerable distances by flies, by animals, by feet of persons, by wagon wheels, or by drainage from one farm to another.

In view of these well-established facts it is evident that among the highest duties that rest upon a farmer, as a father and citizen, is not only to have a sanitary privy on his farm, but to insist that the pollution of soil with human excreta be prevented throughout the entire neighborhood by the use of sanitary privies.

In the United States about 400,000 persons suffer from and about 35,000 die from typhoid each year; over 2,000,000 persons have hookworm disease. Thousands of these deaths and many thousands of these cases of disease might be prevented by the simple use of sanitary privies. A compulsory sanitary privy law or ordinance should therefore be enacted and be strictly enforced in every locality not provided with a properly maintained sewer system.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN NO. 476.

THE DYING OF PINE IN THE SOUTHERN STATES: CAUSE, EXTENT, AND REMEDY.

BY

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Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., October 3, 1911.

Sir: I have the honor to transmit herewith for publication a paper dealing with the Dying of Pine in the Southern States—Cause, Extent, and Remedy. It consists of a series of revised circular letters which have been used during the present year in an active campaign by this bureau through a forest-insect field station located at Spartanburg, S. C., the purpose of which has been to study the character and extent of the dying pine and to give instructions and demonstrations to the owners within the worst affected areas on the most economical and effectual means of control.

The known destructive habits of the southern pine beetle, which is the cause of the trouble, and the threatening character of the present outbreak render its immediate control of the greatest importance to the people of the South Atlantic and Gulf States. It is perfectly capable of killing a large percentage of the young and matured trees of the pine forests of the entire South, as it did in West Virginia and Virginia in 1890 to 1893.

The paper gives the essential facts relating to the insect, its work, practical methods of control, and how to protect the pine from its depredations in the future.

It is absolutely necessary that the owners of farmers' woodlots, as well as the individual and organized owners of large areas of growing and matured pine, should be familiar with the essential requirements of locating and disposing of the infested timber in order to meet with success in any effort to control it. Therefore, I recommend the publication of this paper as a Farmers' Bulletin.

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

Hon. James Wilson,
Secretary of Agriculture.

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ILLUSTRATIONS.

THE DYING OF PINE IN THE SOUTHERN STATES: CAUSE, EXTENT, AND REMEDY.

During the past few years the dying of pine in the southern Atlantic and Gulf States, from Maryland to Texas, inclusive, has attracted attention and has been the subject of special investigation and extensive correspondence.

CAUSE OF THE DYING OF PINE.

In the areas designated as the shortleaf pine and loblolly pine belts, as well as in parts of the longleaf pine belt, the death of the pine has been caused by the southern pine beetle, while in Florida and certain other sections it is apparently due to a combination of other but similar bark-boring beetles.

THE SOUTHERN PINE BEETLE.

The southern pine beetle was described in 1868 under the technical name *Dendroctonus frontalis* from specimens collected in North Carolina or South Carolina.

It is a small brownish or black beetle, somewhat smaller than a grain of rice. It flies in 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 and spruce trees, causing their death by excavating long, winding burrows or egg galleries (figs. 1, 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 time all of the trees that were attacked during the previous fall and early winter are completely dead and abandoned by the beetles.

There are from three to five generations 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.

At all times there is a more or less complex overlapping of generations, so that there is a continuous emergence and attack during

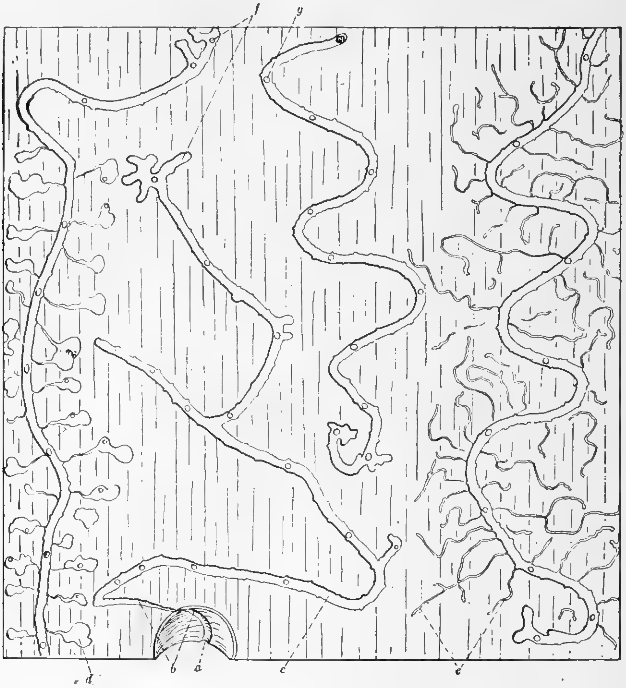

FIG. 1.—Egg galleries and larval mines of the southern pine beetle: *a*, Entrance; *b*, entrance burrow; *c*, egg gallery; *d*, normal larval mine; *e*, abnormal larval mine; *f*, terminal; *g*, ventilating burrows. Slightly reduced. (Author's illustration.)

the entire period of activity; consequently 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 nearly every county throughout the Southern States where the pine is common. If, however, there are from any cause favorable conditions for the multiplication of the insect, it is thus 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 depredations. Therefore it is a most destructive enemy of the pine within its range—in fact, it is, as has been frequently stated during the past 10 years, a constant menace to the living pine of all of the Southern States, from Maryland to Missouri and southward to the Gulf of Mexico. (See fig. 4.)

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.

FIG. 2.—Section of pine trunk with bark removed, showing the marks of the egg galleries on the surface. (Author's illustration.)

EXTENT OF LOSSES.

Extended observations in all of the Southern States during the past 20 years lead the writer to conclude that if all of the pine that has been killed during this time by this beetle was living to-day its stumpage value would amount to from $10,000,000 to $20,000,000 or more. Recent studies of the depredations wrought by it in the South Atlantic and Gulf States during the past three years indicate that at least $2,000,000 worth of pine has been killed. It is also evident that

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. (Author's illustration.)

if active steps are not taken this winter by the principal owners in the infested areas this loss will be increased to another million dollars within the next year.

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 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 the entire South.

THE METHOD OF CONTROL.

Broadly stated, the method of control is to locate the infested trees during November, December, January, February, and March, and

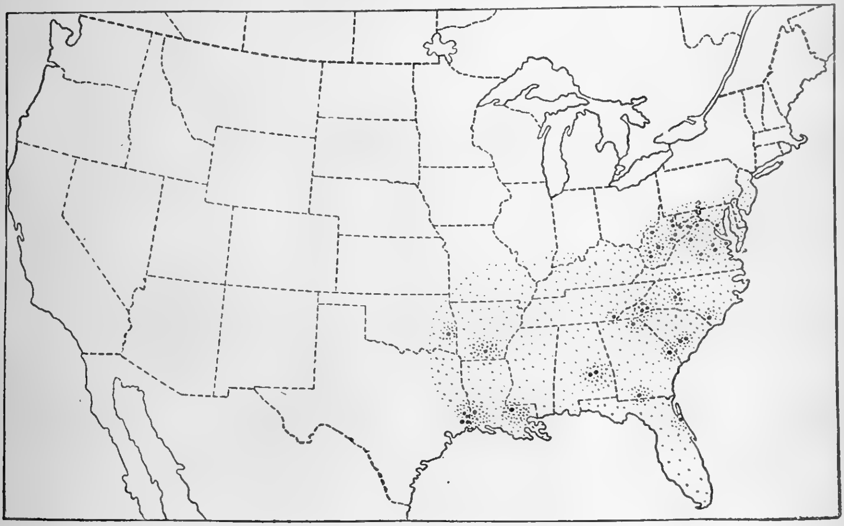

FIG. 4.—Map showing distribution of the southern pine beetle. (Author's illustration.)

destroy the overwintering broods in the bark of the main trunks, according to the recommendations on pages 13 and 14 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 16 cents per 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 started 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 the present time.

The results of these investigations have shown that the death of a large percentage of the pine of Virginia and West Virginia in 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 40 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 has been 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 is now a general and widespread interest manifested throughout the worst affected sections, and there is every prospect that if general action is taken by the owners, in the utilization or treatment of infested trees according to the recommendations of the experts of the Bureau of Entomology, the beetles can be controlled this winter at slight expense, and that the remaining living pine will thus be protected from further depredations.

CHARACTER AND RANGE OF DEPREDATIONS DETERMINED.

Since the location of forest-insect field station 7 at Spartanburg, S. C., on July 5, 1911, the agents of the Bureau of Entomology, United States Department of Agriculture, detailed to the station have been very active in the study 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. Observations by the agents and information conveyed by correspondents from all sections of the South show that in the aggregate a vast amount of timber has been killed by the southern pine beetle during the past two years. The dying and dead trees occur as scattering individuals or in clumps, large patches, and in some places whole forests. All are 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 has been 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 is 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 begins 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 do before definite plans are made for the active work of cutting the trees. Some of the essential things to remember 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, reddish boring-dust around the base, or there may be no external evidence of attack until the leaves begin 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 beetles 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.

(5) By the time the tops have changed from pale green to greenish brown the broods of the southern pine beetle are 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 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;* 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 10 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 groove or 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 3 or 4 miles and result in the starting of a new center of infestation and in the death of a large number of trees.

(*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.

The requirements for success in any effort to protect the living pine from the destructive attacks of the southern pine beetle are the destruction of the broods of the beetle in the bark of the main trunk of the dying infested trees before they leave the bark. This is accomplished by the adoption of one or more different methods of direct utilization of the infested trunk, or 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.

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 is between the 1st of November and the 1st of the following March, but in some cases the period may be extended to the 1st of May.

The adoption of 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 in regard to 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.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 492.

THE MORE IMPORTANT INSECT AND FUNGOUS ENEMIES OF THE FRUIT AND FOLIAGE OF THE APPLE.

BY

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Of the Bureau of Entomology,

AND

W. M. SCOTT,
Of the Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., February 3, 1912.

SIR: We have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a manuscript entitled "The more Important Insect and Fungous Enemies of the Fruit and Foliage of the Apple," by A. L. Quaintance, of the Bureau of Entomology, and W. M. Scott, of the Bureau of Plant Industry.

During the past few years the summer spraying of apple orchards has undergone important improvements, and many questions of detail have thus been raised in the minds of growers. The present paper, based upon results of the department's investigations of the subject during the past several years, is intended to answer these questions and to furnish information which will enable the orchardist to obtain the maximum benefits for his outlay in time and money in spraying operations.

Respectfully,

L. O. HOWARD,
Chief, Bureau of Entomology.
B. T. GALLOWAY,
Chief, Bureau of Plant Industry.

HON. JAMES WILSON,
Secretary of Agriculture.

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THE MORE IMPORTANT INSECT AND FUNGOUS ENEMIES OF THE FRUIT AND FOLIAGE OF THE APPLE.

INTRODUCTION.

The spraying of apple orchards has received a great impetus during the past few years by reason of the increased demand for good fruit and the satisfactory prices received therefor. While most commercial orchardists have been spraying for a good many years, the practice has not been as general among small orchardists as is desirable, and the present profitableness of apple culture has been the principal factor in awakening an interest in a crop heretofore much neglected by them.

A few years ago it was felt that orchard spraying was on a rather definite basis, but recent improvements in spray materials and apparatus for their application have contributed to raise many questions of detail in the minds of fruit growers. These questions have to do with the best spray to use; times of making applications; grade of chemicals to purchase; the desirability of preparing sprays at home in preference to use of commercial preparations, etc.

It is the aim of the present paper to furnish the orchardist necessary information for summer spraying, or spraying trees in foliage, as opposed to treatments during the dormant period of trees, as for the San Jose scale, blister mite, etc. The principal insects and diseases affecting the fruit and foliage of the apple are first considered, and with the illustrations should be easy of recognition. This is followed by a consideration of the sprays recommended, and directions for their preparation and use. Owing to the extended area in the United States over which the apple is cultivated, it is necessary to refer to certain insects and diseases which are of interest in more or less restricted localities, and to indicate the appropriate treatment for the same in the sprays schedule. It is believed, however, that the orchardists in the New England States, as well as the orchardists in the Ozark regions of Arkansas and Missouri, will have no difficulty in determining the particular applications necessary under their respective conditions.

THE CODLING MOTH.

The larva of the codling moth (*Carpocapsa pomonella* L.), sometimes called the apple worm, is well known alike to growers and consumers of apples. It is the principal cause of wormy apples, and its control must be secured in profitable apple growing; otherwise from one-half to three-fourths or even a larger proportion of the crop will be wormy and unfit for market. No orchard insect, perhaps, is more successfully controlled than this one; and by careful spraying the fruit grower may expect to protect from its injuries from 90 to 95 per cent of the crop. Owing to the great extent of the apple-growing industry, there is, however, in the aggregate a large shrinkage in the quantity of marketable fruit, resulting from injuries by the codling moth. This shrinkage in the United States each year represents a loss of about $12,000,000, and some $3,000,000 or $4,000,000 are annually spent for sprays and labor in its control.

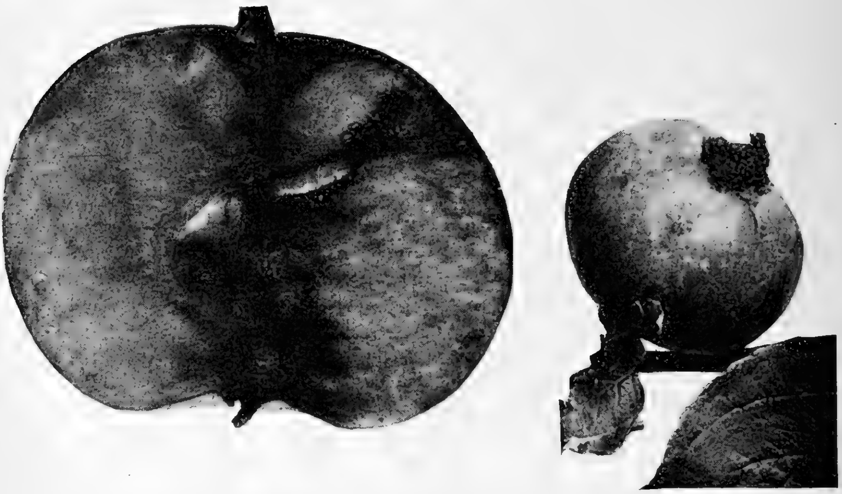

Fig. 1.—The codling moth larva (*Carpocapsa pomonella*) and its work: On the left, mature apple, showing full-grown larva and its work; on the right, frass from calyx end of young apple, infested with first-brood larvæ.

CHARACTER OF INJURY.

Wormy apples are shown in figure 1. The presence in apples of the apple worm early in the season is usually indicated by the occurrence at the calyx end of more or less frass. Fruit injured early in the season and while it is small mostly falls to the ground. Larvæ of the second and later broods occur when the fruit is more nearly grown, and it is the injuries of these broods that are observed in fruit on the market. The severity of attacks varies somewhat from season to season, and especially in different parts of the country, depending upon the number of broods of larvæ produced in the region in question.

NUMBER OF GENERATIONS.

The number of broods of larvæ of the codling moth for the country as a whole varies from practically one to three. Throughout the New England States and southward, at least to about the latitude of Washington, there is one full brood of larvæ each year and a partial second. In the northernmost part of the territory indicated, as in Maine and New York, the second brood of larvæ will be slight, varying in extent from season to season; while in the southern portion of this territory it is normally quite large, and during certain years there are practically two full broods. In the more southern States, as the Carolinas on the east and Arkansas on the west, there are probably three broods of larvæ each year. This has been determined to be true for Arkansas and Kansas. In New Mexico it is thought that the insect is three-brooded also.

It has been determined that there are two full broods of larvæ in States of the far West: Washington, Oregon, Idaho, Utah, and Colorado. The effect of such seasonal conditions as drought and temperature on the number of first-brood larvæ transforming for a given locality is quite marked. Thus, in Erie County, Pa., in 1907, with an abnormally late spring, only 3 per cent of the first-brood larvæ transformed, as compared with 68 per cent which transformed the following year and 23 per cent the next year.

DESCRIPTION AND LIFE HISTORY.

How the insect passes the winter.—Upon leaving the fruit in late summer or fall larvæ seek protected places upon the trees, such as holes, cracks, crotches of limbs, or under bark scales, or even underneath trash on the ground, construct tough silken cocoons, and here pass the winter in the larval condition. Large numbers of larvæ are carried to storage houses in apples in the fall, where later they spin cocoons in the boxes, bins, or barrels, or in cracks in the floor or sides of the house. In the orchard large numbers of larvæ are destroyed during the winter by birds, principally woodpeckers, but in storage houses a large proportion doubtless survive, the moths from which fly to the orchards in the spring and constitute an important source of infestation.

With the coming of spring the larvæ enter the pupal stage, and about the period of blooming of the apple, or somewhat later, the moths begin to appear, continuing to emerge for three or four weeks, while belated moths may not emerge until considerably later.

The moth.—The adult, or miller (fig. 2, *a*), is rather variable in size, but the maximum wing expanse rarely exceeds three-fourths of an inch. The forewings above are of a brownish gray color, with numerous cross lines of gray. Near the tip of each wing is a conspicuous brown spot, or ocellus, in which are two irregular broken lines of a metallic coppery or golden color. The hind wings above are grayish brown, becoming darker toward the margin, which bears a delicate fringe, at the base of which is a narrow dark line. When at rest on the grayish bark of an apple tree, the moth in color so harmonizes with its surroundings that it is not readily distinguished, and the insect in this stage is perhaps little known to orchardists.

The egg.—The eggs are small, flat, somewhat oval in shape, and of about the size of a pinhead. When recently deposited they are of a

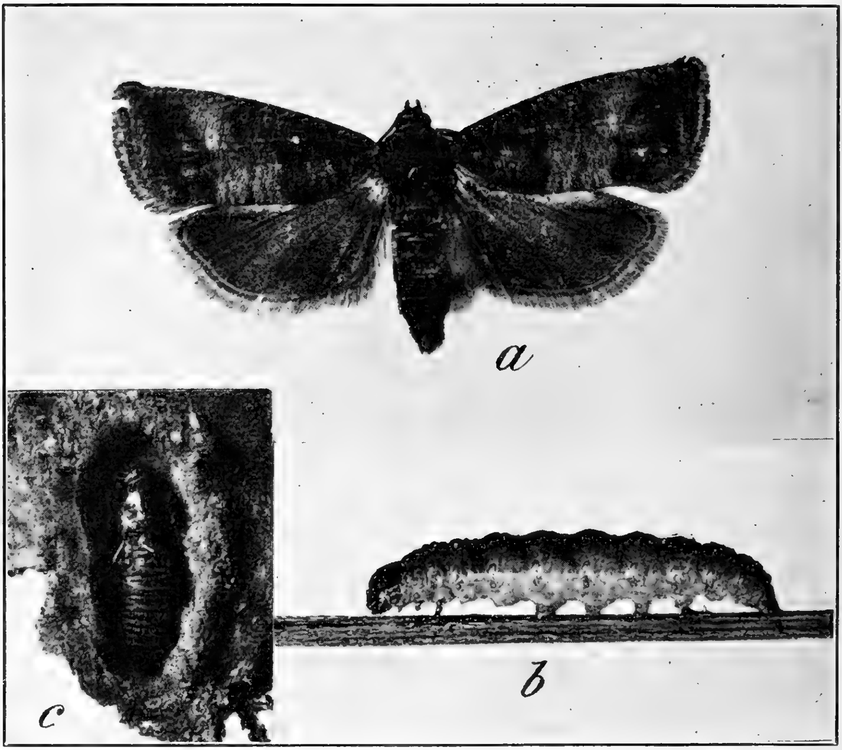

FIG. 2.—Stages of the codling moth: *a*, Moth; *b*, larva; *c*, pupa in its cocoon. Much enlarged.

pearl-white color, but become darker with the development of the embryo, which after a few days is easily distinguished as a reddish ring within the egg. Under a lens the surface is seen to be covered with a network of ridges, coarser toward the edge. The eggs of the first generation of moths are deposited mainly on the leaves and twigs, comparatively few being placed on the apple, possibly on account of the fine hairs with which this fruit is covered when small. More of the eggs of the second generation, however, are placed on the fruit, which by this time is much larger and presents a comparatively smooth surface. The average time required for the egg to hatch is about 11 days, the time varying considerably, however, with the temperature.

The larva.—It is in the larval or "worm" stage that injury is done to the apple. The larva as it hatches from the egg is very small, from one-twentieth to one-sixteenth of an inch in length, but it soon begins to search for the fruit. If hatched from eggs placed here and there on the foliage, the larvæ chew more or less into the leaf or other portions of the plant in their wandering around and may thus be poisoned, if poison be present on the plants. If the eggs have been deposited on the fruit itself the larvæ are much more likely to gain entrance to the fruit. Larvæ entering the fruit by the calyx end feed within the calyx cavity for a few days before penetrating the fruit. Hence the advantage of thoroughly spraying trees shortly after the petals have fallen and while the calyx lobes are still spread, in order to place in each calyx cavity a small particle of poison to be eaten later by the larva as it seeks to enter the fruit.

After entering the apple the larva feeds and grows rapidly and in the course of about 20 days has become full grown. (See fig. 2, *b*.) At this time the "worms" are about three-fourths of an inch long, and the majority of them are pinkish or flesh colored on the upper surface and whitish below.

The pupa.—The full-grown larva, upon leaving the fruit and finding a protected place, constructs a whitish silken cocoon within which, in the course of a few days, it may change to pupa, or it may remain in the larval condition until the following spring, as already explained. The pupa (fig. 2, *c*) is about one-half inch long, at first yellowish or brownish, but later becoming quite dark brown, and shortly before emergence of the moth assuming a distinct bronze color. The pupal stage varies much in length, but on the average about 20 days elapse from the spinning of the cocoon until the emergence of the month. After emergence the moths, in the course of a few days, begin egg laying, the entire life cycle, from egg to egg, requiring, on the average, some 50 days.

TREATMENT.

The treatment for the codling moth is limited almost entirely to spraying the trees with arsenicals, such as Paris green or arsenate of lead; the latter is now principally used. In the East the poison is usually combined with a fungicide. In some sections banding of trees is also employed and under special conditions is a valuable adjunct to spraying. From two to five spray applications are given, according to the section of country.

First application.—Of all treatments, the first is much the most important; this is given as soon as the blossoms have fallen and has for its object the placing of poison in the calyx cup of each little apple. This treatment may be successfully given during the eight or ten days between the dropping of the petals and the closing of the calyx lobes. After the calyx lobes have drawn together it is difficult to force the poison into the calyx cup. (See fig. 3.) Very thorough work is necessary at this time, and carelessness in making the first application can not be counteracted by subsequent treatments. Good results, in fact, have been obtained where this application alone has been given; and in portions of the West, where it is unnecessary to spray for fungous diseases, a single treatment is held by some to be sufficient. While excellent results have been obtained in the East from this so-called "one-spray" method, yet

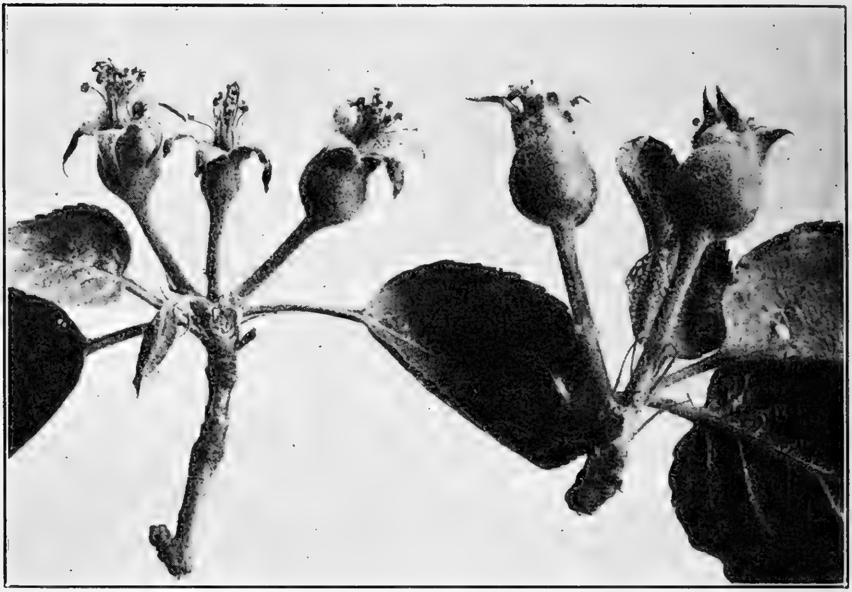

FIG. 3.—Apple clusters, showing, on the left, young fruit with calyx lobes spread, and in right condition for spraying; on the right, apples with calyx lobes closed, and too late for satisfactory spraying.

the necessity of using fungicides in this territory renders the use of arsenicals in addition comparatively inexpensive.[1]

Second application.—The second application for the codling moth is given from three to four weeks after the blossoms have fallen and has for its purpose the destruction of the young larvæ as they are hatching from the eggs spread promiscuously over the foliage and fruit.

Third application.—Eight or nine weeks following the dropping of the petals the third treatment is given, at which time the second-brood larvæ are hatching in numbers.

[1] Those interested in the one-spray method should obtain copies of Bulletin 80, Part VII, and Bulletin 115, Part II, Bureau of Entomology.

These three treatments, if properly applied, should be sufficient to control the insect effectively in any region; but in a territory where bitter rot and apple blotch are prevalent, and where later fungicidal treatments are necessary, it will be advisable to add an arsenical for further insurance against the codling moth, as stated under the caption "Spraying schedule," pages 43–44.

THE PLUM CURCULIO.

The plum curculio (*Conotrachelus nenuphar* Herbst), over a great deal of its range, is easily second in importance as an apple pest to the codling moth. It occurs quite generally from Canada south to Florida and west to about the one-hundredth meridian. The insect is a small snout beetle, of the family Curculionidæ, and many of its near relatives, as the cotton-boll weevil, strawberry weevil, plum gouger, alfalfa weevil, etc., are very serious enemies of cultivated crops. The species attacks most cultivated pome and stone fruits, as apple, pear, peach, plum, cherry, etc., and it is especially troublesome to the peach.[1] In the present connection the insect is considered in reference to its injuries to apple.

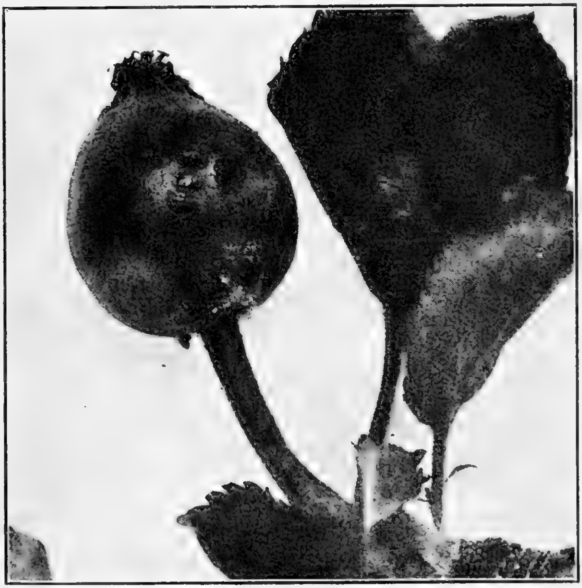

FIG. 4.—Egg scars of the plum curculio (*Conotrachelus nenuphar*) on young apples.

CHARACTER OF INJURY.

The overwintering beetles attack the young apples in the spring, shortly after these are well set. Both sexes puncture the fruit with their snout-like proboscis for feeding, and the females also in egg laying. Feeding and egg laying continue for several weeks or months in the case of the hardier individuals. Much of the fruit, punctured while small, falls to the ground, but after it has become about the size of a large marble or larger (see fig. 4), it may remain

[1] See Farmers' Bulletin 440, U. S. Department of Agriculture, Spraying Peaches for the Control of Brown-rot, Scab, and Curculio.

on the trees. The effect of the punctures when abundant, however, is to cause the fruit to become knotty and misshapen as it grows, the extent of the deformity varying with the severity of the injury

FIG. 5.—Duchess apples at picking time, showing deformed condition from egg and feeding punctures of the plum curculio.

and also with the variety. Rapidly growing summer or fall varieties of apples show the injury perhaps worst, while in the case of slower-growing winter apples the injury is more likely to be outgrown, the egg punctures showing in the fall as more or less nail-shaped scars, not affecting the quality of the fruit, though detracting from its appearance. (See fig. 5, showing deformed Duchess apples.)

FIG. 6.—Fall feeding punctures of the plum curculio in ripe apple.

When beetles of the new generation appear in late summer and fall they feed upon the fruits, producing injuries shown in figure 6. With the snout a hole is excavated in the apple, and the flesh is eaten out under the skin surrounding the puncture as far as this organ will reach. This "fall" feeding puncture is often very much in evidence in orchards where the insect is abundant, and the injury is at times considerable. Decay of the fruit often starts at the injured place, spreading from and enlarging the cavity, as shown in the figure, and soon rendering the fruit worthless, except for immediate use. Fruit thus punctured in the fall will not, as a rule, keep well in storage and should not, of course, be included in the best grades.

Although the curculio larva is able to develop on the trees in peaches, plums, and cherries, it does not appear to be able to do so in apples and pears. The larvæ, however, develop perfectly in apples which fall to the ground, and orchards are thus kept well stocked with the insect.

PERIOD OF OVIPOSITION AND NUMBER OF EGGS LAID.

The adult beetles are out and ovipositing on plums and other early fruit before apples, as a rule, are of sufficient size to be used. As soon as the apple is grown to the size of a small marble, however, it is attacked by the curculio for egg-laying purposes, and most of the eggs are deposited during the first six or eight weeks after egg laying begins. A large number of records of the number of eggs deposited by the curculio in plums, peaches, apples, etc., has been obtained in different localities, as well as other data on the life and habits of the insect.

It has been found that the greatest number of eggs deposited by any one female was 557, and the minimum 1, with an average of 144.85 eggs per beetle for all the individuals under observation. While there is much variation in the number of eggs deposited within a given time in the several localities, there is a general agreement in that the great majority of the eggs are placed by the end of eight weeks; approximately one-fourth of the total eggs are deposited during the first two weeks; one-half have been deposited by the close of the first month; three-fourths within six weeks, and about 88 per cent of the total within eight weeks after oviposition began. The value of these data will appear when it is remembered that the injury to the apple results from the egg and feeding punctures, which it is desired to prevent. To accomplish this best, sprays must be applied with timeliness and be in effect over a considerable period.

TIME REQUIRED FOR TRANSFORMATION FROM EGG TO ADULT.

Many observations have been made in different localities, which show the time spent in the fruit by the curculio larva, and also the time spent in the ground, before and during pupation, until the emergence of the beetle. Thus the average time spent in the fruit (egg and larval stages combined), for the several localities investigated, proved to be 19.48 days, and the average time spent in the ground (as larva, pupa, and adult) was found to be 30.89 days, giving an average life-cycle period for the insect of 50.27 days.

Complete observations of the life cycle have also been made on a total of 597 individuals from many parts of the country, which give a final average per individual of 50.71 days, differing only a fraction of a day from the time determined in an essentially different manner. Approximately 50 days would therefore appear to be the average life-cycle period for the plum curculio for the country as a whole. The variation for different individuals will be considerable, and as actually determined in the case of individual records was from 37 to 58.45 days.

For practical purposes there is only one generation of the beetles each year. The adults, developing from fruit during the summer, spend the remainder of the time, until hibernation begins, feeding upon the foliage and fruit. With the approach of cold weather the beetles seek shelter, apparently wherever they may be, under trash in orchards, along fences, and in similar places. They are always abundant in woods adjacent to orchards.

CAN THE CURCULIO BE CONTROLLED BY SPRAYS?

During the past few years much experimental work has been done in the use of arsenical sprays in the control of the curculio on apple, notably by Prof. Stedman in Missouri and Prof. Crandall in Illinois. Prof. Crandall's investigations extended over two years. In regard to the value of the work he states as follows:

> To sum up the matter of spraying for the curculio from the standpoint of results obtained during the two seasons of 1903 and 1904, it seems possible, under favorable conditions and with a reasonable number of applications, to control curculios to the extent of from 20 to 40 per cent of the possible injury. There is benefit to be derived from spraying, but not that degree of benefit which would warrant commendation of spraying as the one great panacea of injury done by the curculio.

Many experiments by the Bureau of Entomology emphasize in general the soundness of the conclusions of Prof. Crandall. In the following table are given results of spraying for the curculio on apple as carried out by the Bureau of Entomology in different parts of the country.

TABLE I.—*Results of spraying apples for the plum curculio—various localities.*

Locality.	Treatment.	Number of sound apples.	Number of apples punctured.	Total number of apples.	Average percentage of sound apples.	Number of applications.
Anderson, Mo., 1908	Bordeaux mixture (4-4-50) plus ¼ pound Paris green.	1,710	1,867	3,577	47.81	7
Do	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	3,844	2,846	6,690	57.45	7
Do	Untreated	193	3,312	3,505	5.51	None.
Westfield, N. Y., 1908	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	10,506	921	11,427	91.07	4
Do	Untreated	300	761	1,061	25.44	None.
North East, Pa., 1906	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	1,354	359	1,713	79.04	2
Do	Untreated	270	791	1,061	25.44	None.
Siloam Springs, Ark., 1909.	Bordeaux mixture (4-4-50) plus 1 pound arsenate of lead. Trees drenched.	37,304	5,899	43,203	86.34	1
Do	Bordeaux mixture (3-3-50) plus 2 pounds arsenate of lead.	26,897	5,554	32,451	82.88	5
Do	Untreated	2,234	22,212	24,446	9.14	None.
Crozet, Va., 1909	Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead. Trees drenched.	15,406	5,432	20,838	73.93	1
Do	Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead.	12,231	1,846	14,077	86.89	4
Do	Untreated	10,322	8,785	19,107	....	None.
Mount Jackson, Va., 1909.	Bordeaux mixture (2-2-50) plus 2 pounds arsenate of lead. Trees drenched.	11,335	8,240	19,575	57.90	1
Do	Bordeaux mixture (1-1-50) plus 2 pounds arsenate of lead.	6,651	9,642	16,293	40.82	3
Do	Untreated	6,984	18,657	25,641	27.23	None.
St. Joseph, Mo., 1909	Arsenate of lead, 2 pounds to 50 gallons of water. Trees drenched.	2,130	3,658	5,788	36.80	1
Do	Bordeaux mixture (4-4-50) plus 2 pounds arsenate of lead.	2,480	2,470	4,950	50.10	4
Do	Untreated	182	4,307	4,489	4.05	None.

It will be noted that the results of spraying vary widely. It is apparent that account must be taken of other conditions, such as the relative abundance of the insects as compared with the amount of fruit present on the trees. With a small fruit crop and an abundance of curculios the most thorough spraying will not serve to bring through a satisfactory amount of sound fruit, as will be noted in the results of experiments at St. Joseph, Mo. With a large crop of fruit and an abundance of insects, results will likewise be disappointing; note the results at Mount Jackson, Va. If the curculios for any cause are scarce, and there is a large fruit crop, injury is, of course, much less important. In other words, the degree of success in spraying varies with the abundance of the insects. While spraying is undoubtedly a most important adjunct, and if persisted in from year to year may answer reasonably for its control, yet it is clear that where the insect is abundant other measures should also be employed. In all cases which have come under our observations the insects have always been found most abundant in orchards which are in sod or are poorly cared for and allowed to grow up more or less in weeds and trash. Orchards adjacent to woods will also usually suffer severely, especially along the border. As opposed to this condition is the notably less injury in orchards kept free from weeds and trash. In such cases the sprayings usually given for other orchard insects, as the codling moth, serve to keep the curculio well under control. In fact, it may be said as a general statement that this insect will never become seriously troublesome in apple orchards given the usual routine attention in cultivation, spraying, pruning, etc., now considered essential in successful fruit growing.

THE LESSER APPLE WORM.

The larva of the lesser apple worm (*Enarmonia prunivora* Walsh) and its work have been quite generally confused with those of the codling moth. The caterpillar when full grown is about one-half the size of the full-grown codling-moth larva, and is fusiform in shape and usually pink or flesh colored. A codling-moth larva of this size is rarely, if ever, pinkish in color, but dirty white, and marked with black dots. The injuries of the two species are in a way quite similar. The first-brood larvæ of the lesser apple worm enter the fruit mostly at the calyx end. Cavities or holes from one-fourth to one-half inch deep are eaten into the flesh, more or less around the calyx lobes and core within. The larvæ, boring directly through the skin at the base of the calyx lobes, or, more commonly, entering the calyx cavity, excavate mines or short burrows down into the flesh. Frequently also the larvæ burrow out in the calyx basin just under the skin, producing winding or blotch mines (see fig. 7). Such mines occur on the sides of the apple, especially where two fruits are in contact. Young fruit thus injured usually falls or ripens prematurely. Later in the season the calyx-end injury is about as described, though the surface injury is more common, the larvæ eating out the flesh under the skin in large, irregular, more or less linear patches, which are quite conspicuous. Larvæ of this species apparently do

FIG. 7.—Injury by the lesser apple worm (*Enarmonia prunivora*) in calyx basin and end of a ripe apple.

not reach full development as early in the fall as those of the codling moth, and may find their way to barrels with the fruit, where they continue to feed, often doing considerable damage. Figure 8 illustrates apples thus injured, as found in barrels on the Washington market.

The lesser apple worm is probably a native insect, and it infests other fruits, wild and cultivated. It is recorded from apples, haws, plums, prunes, cherries, peaches, and species of Cratægus. It has also been reared from the black-knot of plum, and from galls on oak and elm.

Its life history and habits probably closely parallel those of the codling moth. It is known to be present quite generally in orchards from Canada south to Georgia and west to the Rocky Mountains. It

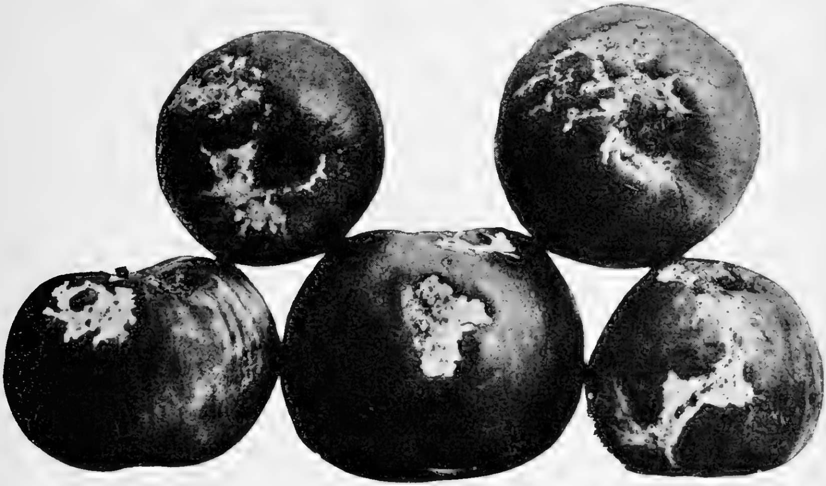

FIG. 8.—Injury by lesser apple worms to apples after barreling.

has been found abundantly in apples in the Puget Sound district in Washington, and is known also from British Columbia.

The schedule of treatments recommended for the codling moth will be effective in the control of this species.

CANKERWORMS.

Two species of cankerworms in the United States are often destructive pests in apple orchards, the larvæ making their appearance shortly after the leaves have put forth. The caterpillars (fig. 9) are rather small, slender, naked creatures with the habit of looping as they crawl, for which reason insects of this habit are commonly designated as "span worms" or "measuring worms." The fall cankerworm (*Alsophila pometaria* Harris) occurs more commonly in the northern United States, as from Rhode Island to Canada and westward to Lake Superior, and it is also common in California. The spring cankerworm (*Paleacrita vernata* Peck) is particularly abundant in the Mississippi Valley from Texas to Iowa, ranging eastward to Maine. It is common in the orchard section of northern Virginia, western Maryland, and West Virginia. The two species thus overlap in their distribution and both may be concerned in the defoliation of an orchard, especially in the northeastern part of the United States.

The fall cankerworm deposits its eggs in ringlike masses on the twigs during late fall or in warm periods during the winter. The spring cankerworm oviposits in early spring, before the buds start, in irregular masses under bark scales, along the trunk and limbs,

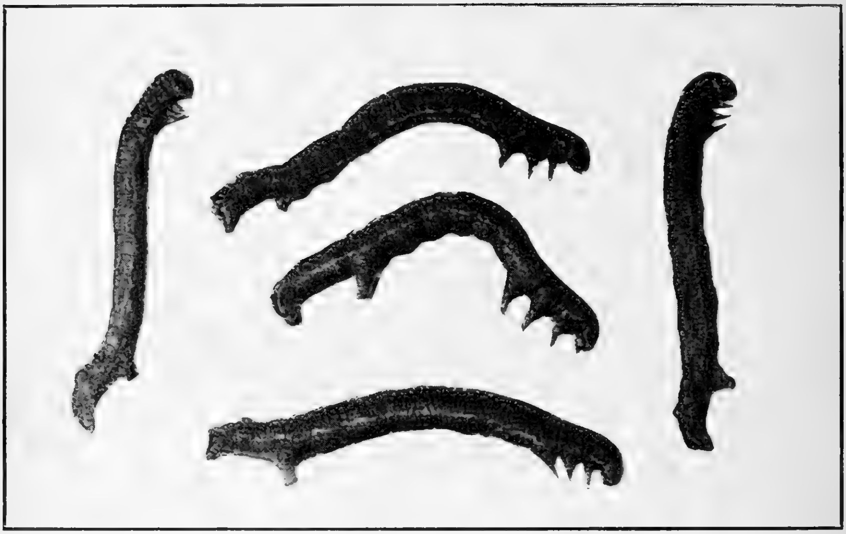

FIG. 9.—Spring cankerworms. Enlarged.

or more or less promiscuously. The young larvæ have hatched and are attacking the foliage by the time the young leaves are well free from the bud scales. They often occur in such enormous numbers that the trees are quickly defoliated, leaving only the midribs of the leaves (see fig. 10), the orchard from a distance appearing as if swept by fire. After the larvæ mature they go to the ground and pupate just below the surface, and are easily destroyed by plowing and cultivations during the late spring and early midsummer. There is only one generation of the insects each year, the adults of the fall species coming out in late fall and winter, and those of the spring species in early spring, as stated. The adult females of both species are wingless and must crawl up the trunks of the trees to oviposit.

TREATMENT.

Three methods of control are applicable against cankerworms, and where the insects have been quite injurious the use of all three methods in conjunction may be adopted.

The wingless moths, and also the caterpillars, may be prevented to a large extent from reaching the foliage by the use of bands of sticky substances around the trunks of trees, some 12 to 18 inches from the ground. Some excellent preparations for this purpose are on the market, or home-made adhesives may be used. A simple plan is first to scrape off the rough bark from the trunk of the tree in a band 8 to 10 inches high, and surround the tree at this place with a strip of stiff paper, tying tightly, so that no moth or larva can work up the trunk beneath it. The paper band should then be coated with a sticky adhesive, which should be replenished as often as necessary to keep it in good working condition. This method is especially suited to large trees in lawns around the home, or elsewhere, where plowing and spraying are considered impracticable.

FIG. 10.—Work of the spring cankerworm (*Paleacrita vernata*) on apple.

The larvæ are readily poisoned with arsenicals, as arsenate of lead and Paris green, used at usual strengths. The first treatment for apple scab, while a little late for cankerworms, will in most cases answer fairly well, and where the insect is troublesome an arsenical should be added, as for the bud moth.

Plowing orchards during late spring and early summer, with a few subsequent cultivations, will destroy most of the pupæ in the soil. Care should be taken to stir the soil beneath the spread of the limbs of the trees, as in this soil most of the pupæ are located.

Except during very unusual conditions of abundance, orchards properly sprayed and cultivated will not be troubled by these insects. Cankerworms thrive in neglected old orchards in sod, and may appear for several seasons in succession, and by devouring the leaves destroy the fruiting capacity of the trees.

THE BUD MOTH.

The larva of the bud moth (*Tmetocera ocellana* Schiff.) winters in a little hibernaculum or cocoon of silk covered with bits of dirt and bark attached to the limbs and twigs of trees. Early in the spring, as the buds of the apple are opening, the little dark-brown caterpillars, scarcely one-fourth of an inch long, leave their winter quarters and attack the tender developing leaves, often boring into the bud before the scales have spread apart. When abundant the larvæ are thus able to do a large amount of injury. Severe damage may result to nursery stock or young trees following attack on the terminal buds of twigs or shoots. In some cases the twig itself is penetrated, the larva boring down into the pith some 2 or 3 inches.

After their appearance in spring the larvæ continue to feed, mostly at night, for some six or seven weeks, attacking principally the leaf and fruit buds. When full grown they pupate in a tubular fold of a leaf, well lined and securely fastened with silken threads; or two or three partly devoured leaves may be drawn together and within these the cocoon is made. In New York State, and probably in the New England States, in which region this pest is frequently complained of, pupation takes place on dates varying from about June 1 to June 25. Moths begin to emerge as early as June 5, and emergence continues somewhat later than July 10. Eggs are deposited for the most part singly on the lower surface of leaves and hatch in from 7 to 10 days. The newly hatched larvæ construct a tube along the midrib or larger vein of a leaf, from which they emerge to feed on the adjacent tissues, spinning as they go a web of silk for their protection. Feeding continues during July and August, and a few are thus engaged in September, when, deserting the foliage, hibernacula are constructed, as described, in which the half-grown larvæ remain until the following spring, attacking the buds as stated. The principal injury results from the attack to the unfolding buds and to the twigs in the spring, although in neglected orchards considerable injury to foliage may result from the feeding of the young larvæ during midsummer. In more northern latitudes the bud moth is single-brooded, though in the central and more southern States it is thought that there may be two broods of larvæ each year.

TREATMENT.

The control of the bud moth rarely requires treatments other than those given in the course of spraying adopted by progressive orchardists. The first treatment for the apple scab coincides fairly well with the time when these larvæ are actively feeding in the spring, and where their injury has been noted or is suspected an arsenical should be added to the fungicide used. The spray application after the falling of the blossoms, constituting the first treatment for the codling moth, is effective in further reducing the bud moth, and the two treatments should, under ordinary conditions, be sufficient to keep it well reduced.

FIG. 11.—Nest and larvæ of the apple-tree tent caterpillar (*Malacosoma americana*).

THE APPLE-TREE TENT CATERPILLAR.

The conspicuous, unsightly nests or tents of the apple-tree tent caterpillar (*Malacosoma americana* Fab.) are not often seen in well-cared-for orchards, as this insect is kept well in check by the usual applications of arsenical sprays for the codling moth, curculio, etc. The nests, however, are often in evidence in neglected orchards and in trees along roadsides, and indicate a lack of interest on the part of the landowner in his orchard crops.

The insect winters in the egg stage, the eggs being placed on twigs in a ringlike mass. The young larvæ appear as the foliage is pushing out in the spring and at once start their nest in the crotch of some limb or branch, in which they retreat for protection when not feeding. As the caterpillars grow the nest increases in size, until by the time the insects are full grown, it is a conspicuous, unsightly object. (See Fig. 11.)

TREATMENT.

As stated, orchards well sprayed for other fruit pests will rarely be seriously troubled by the tent caterpillar. Nevertheless the insect during certain seasons may become unusually abundant and special treatments may be necessary for its control. The destruction of the nests themselves and the contained caterpillars is comparatively easy. Where the nests are low down on the tree it will be practical to destroy them by hand, or, if the nests are out of reach, they may be destroyed by means of some form of torch on a pole, the torch being made of asbestos or other absorbent material saturated with an inflammable oil, such as kerosene or crude petroleum.

FIG. 12.—Baldwin apple badly infested with the San Jose scale (*Aspidiotus perniciosus*).

THE SAN JOSE SCALE.

The use of dilute lime-sulphur sprays as fungicides on trees in foliage appears to have a distinctly retarding effect on the development of the San Jose scale. While all orchards infested with this insect should be given the usual dormant tree treatment, for one reason or another considerable numbers of the scale may escape destruction, especially on the terminal twigs, which are more difficult to coat thoroughly with the wash. The scales which thus escape are usually so few in number that no serious damage results during the season to the twigs and branches, but the young "lice" have a tendency to crawl out and settle on the fruit, thereby greatly disfiguring it. (See Fig. 12.) The presence of these scales is very objectionable on apples intended for export trade, as scale-infested fruit is excluded from entry by certain foreign governments, and is discriminated against by buyers generally. The following data (Table II) on the effect of sulphur sprays in lessening scale infestation of the fruit were obtained by Mr. E. W. Scott, of the Bureau of Entomology, in the course of some experimental work during 1911, at Fennville, Mich.:

TABLE II.—*Results of lime-sulphur sprays in preventing marking of fruit by the San Jose scale.*

Plat No.	Treatments.[1]	Variety.	Number of apples infested.	Number of apples not infested.	Total number of apples.	Percentage of uninfested apples.
1	Commercial lime sulphur, 1½ to 50; sprayed May 12, 25, June 14, July 25.	Rhode Island Greening.	137	1,606	1,743	92.13
2	.....do	Baldwin	80	778	858	90.67
3	Home boiled lime sulphur, May 12,25, June 14, July 25.	Greening	79	3,939	4,018	98.03
4	.....do	Baldwin	37	1,813	1,850	98.00
5	Commercial lime sulphur, 1½ to 50; May 12, 25, June 14, July 25.	.....do	13	298	311	95.81
6	Bordeaux mixture (3-4-50), May 12, 25, June 14, July 25.	Greening	843	1,055	1,898	55.58
7	.....do	Baldwin	525	500	1,025	48.78
8	Unsprayed	Greening	796	805	1,601	50.28
9	.....do	Baldwin	809	190	999	19.01

[1] All treatments had 2 pounds of arsenate of lead to each 50 gallons of spray, except in case of plat 5, which had the poison in the application of May 12 only.

The influence of the sulphur sprays in checking the settling of the young scales on the fruit is here very marked and furnishes an added reason for the use of sulphur sprays as fungicides.

APPLE SCAB.

ECONOMIC IMPORTANCE.

Apple scab is a fungous disease of the fruit and foliage of the apple and ranks as the most destructive disease to which this fruit is subject. In unsprayed orchards it often causes the loss of 50 to 75 per cent of the crop, and not infrequently the entire crop of certain varieties is rendered unfit for market by the deformed, cracked, and unsightly condition produced by the fungus. Affected fruit is usually small, unsightly, often cracked, and does not keep well. However, since the practice of spraying has become general among apple growers this condition has been largely relieved.

DISTRIBUTION.

Apple scab is common practically wherever the apple is grown—in America, Europe, Australia, New Zealand, and elsewhere. However, it is essentially, a cool-climate disease, and in the United States it is most destructive in New England, the Middle Atlantic States, the Great Lakes region, the Mississippi and Ohio Valleys, and portions of the Pacific Northwest. In the Southern States it is not a serious pest, except on the higher elevations, and then only on very susceptible varieties.

CHARACTER OF THE INJURY.

The fungus causing apple scab attacks the fruit, foliage, and to a much less extent the twig. The greatest damage is done to the fruit, on which it produces the scabby spots familiar to most apple growers. These spots are circular, though somewhat irregular, in outline, dark gray or olivaceous in color, becoming blackish with age, and they range in size from mere specks to spots one-fourth inch or sometimes one-half inch in diameter. (See fig. 13.) The fungus ruptures the epidermis of the apple, forming a gray, jagged ring at the border of the healthy tissues. Two or more spots may coalesce, forming a large scabby area, in some cases covering one side of the apple. The disease prevents the normal development of the fruit, the affected side becoming dwarfed, pitted, and otherwise deformed. It also causes the development of cracks, which may extend half

Fig. 13.—Apples affected with the scab fungus, the one on the left showing characteristic spots and the one on the right smaller spots with crack.

way around the apple and almost to the core. A large percentage of the affected fruit drops to the ground before maturing.

In a cool, wet spring the blossom buds and young fruits in blossom may be attacked and destroyed. Occasionally, though rarely, the entire crop of an important fruit section may be destroyed in this manner.

The disease occurs on both sides of the leaves, forming smoke-brown or olivaceous patches which become swollen and blisterlike. (See fig. 14.) The affected leaves often curl somewhat and may drop prematurely. The fungus is said to occur also on the twigs, forming blackish-olive patches, but this is apparently not common in the United States.

THE FUNGUS CAUSING THE DISEASE.

Apple scab is caused by a fungus known as *Venturia pomi* (Fr.) Wint., which lives over winter in the fallen apple leaves. In the spring, when the weather becomes warm enough to start apple trees into growth, the fungus becomes active, producing large numbers of spores, which are discharged into the air and carried to the young leaves, blossom buds, and later to the young fruit. If there is sufficient moisture present these spores germinate, producing infections that develop into the characteristic scab spots. Summer spores are soon produced on these spots, and through them the fungus may readily spread to other fruits and leaves.

The period of greatest infection is from the time the first apple leaves appear until about four weeks after blooming. The fungus thrives best in cool, moist weather, such as is likely to occur during this period. Hot weather is very unfavorable to it, and infections rarely take place after summer sets in. However, in the New England States a second infection period sometimes occurs during September, and from these late infections small scab spots may develop after the fruit is picked and stored.

Fig. 14.—The scab fungus on apple leaf.

TREATMENT.

Scab was one of the first apple diseases to receive attention by investigators, and its successful treatment was worked out as early as 1891. Until quite recently spraying with Bordeaux mixture constituted the remedy for it, but owing to the injurious effect on both fruit and foliage produced by this otherwise excellent fungicide, especially during wet seasons, dilute lime-sulphur solution is rapidly coming into use as a substitute for it. Lime-sulphur solution has about the same fungicidal value as Bordeaux mixture in the treatment of apple scab and produces decidedly less injury to fruit and foliage.

Lime-sulphur solution may be purchased from several manufacturers or it may be prepared at home. (See pp. 38–40.) Taking a solution that registers 32° on the Baumé hydrometer as a standard, the strength to use in spraying for scab is $1\frac{1}{4}$ or $1\frac{1}{2}$ gallons to each 50 gallons of water. On varieties seriously attacked by scab and in localities where the disease thrives the greater strength should be used, but in order to reduce the danger of injury to a minimum the weaker spray should be used where only slight outbreaks of scab are expected. Arsenate of lead at the rate of 2 pounds to each 50 gallons of solution should be added to control the codling moth, curculio, and other insects.

Spray the trees (1) when the cluster buds open, just before blooming; (2) as soon as the petals fall; and (3) two or three weeks later. Varieties only slightly affected by scab, especially in the South, do not require the first application of this series, the two sprayings after the petals fall being sufficient to prevent the disease. On the other hand, in New England an extra application about the middle of August may be required to prevent late scab infections on some very susceptible varieties.

BITTER ROT.

ECONOMIC IMPORTANCE.

In sections where it is prevalent bitter rot is the most dreaded of all the common apple diseases. After the fruit has been safely nursed through the attacks of scab and the codling moth and is about ready to be harvested an outbreak of bitter rot may destroy the entire crop of some varieties without much warning. It is rather spasmodic in its appearance, depending largely on weather conditions. Hot weather with plenty of moisture is essential to the rapid development of the disease, and it therefore does not occur to any serious extent in the more northern parts of the apple belt nor in the drier sections of the West. It is well distributed throughout the Southern States where apples are grown, extending into southern Illinois, and has in the past destroyed several million dollars worth of apples during a single season. However, in recent years, since its treatment has been better understood and more thoroughly put into practice, the annual losses have not been so great.

FIG. 15.—Apple affected with bitter rot.

CHARACTER OF THE INJURY.

The bitter-rot disease appears on the fruit as a circular brown spot with concentric rings of fruiting pustules. (See fig. 15.) The young spots are very small and often show purplish or reddish margins, but under favorable conditions they rapidly enlarge, involving the entire apple in decay. The disease extends inward toward the core at about the same rate as the spread on the surface, forming a cone-shaped area which can be easily crushed out with the fingers. Owing to the shrinking of the invaded tissues, the spots become somewhat sunken, and this distinguishes it from black rot and brown rot. Several spots, or, in severe cases, several hundred spots, may occur on the same apple, although one spot is sufficient to destroy the whole fruit.

CAUSE OF THE DISEASE.

Bitter rot is caused by the fungus *Glomerella rufomaculans* (Berk.) Spauld. and Shrenk, which invades the tissues of the apple, producing the familiar spots described above. It passes the winter in cankers on the limbs and in mummied fruits. Under favorable weather conditions spores from these sources and perhaps from unknown sources infect the fruit, starting an outbreak of bitter rot. When the germ tube, resulting from the germination of a spore, finds its way through the skin of the apple, it immediately begins to branch and grow rapidly, obtaining its food supply from the tissues and causing these to die and turn brown. After a time clusters or tufts of fruiting branches are formed and these burst through the skin in rings, producing pink masses of spores which serve to spread the disease to other apples. Millions of spores are produced from a single spot, so that under favorable conditions the entire crop of an orchard may become diseased from one center of infection.

In addition to the summer spores or conidia, there are produced on the mummied fruits and in limb cankers winter spores or ascospores, which constitute the perfect stage of the fungus. It is not definitely known that these ascospores play any important part in the life history of the fungus.

THE LIMITING FACTORS.

Barring preventive measures, the two limiting factors determining bitter-rot outbreaks are weather conditions and varietal resistance. Heat and moisture are essential to the vigorous growth of the fungus, and of these two heat is the more important. While hot, showery, or muggy weather is ideal for the development of the fungus, serious outbreaks of the disease may occur during comparatively dry weather, provided the temperature is high and the dews are heavy at night.

Infections may take place at any time during July, August, and September, but rarely earlier or later. High summer temperatures are required for the rapid growth of the fungus, and these are the months in which such temperatures usually occur. Infections may begin to take place during the latter part of June if the weather conditions are right, but since the fungus does not thrive on young, green fruits, no serious outbreak need be feared until July. Owing to climatic influence the bitter-rot disease is confined mainly to the southern tier of apple-growing States.

The second limiting factor, namely, varietal resistance, varies in different sections of the country. For example, the Yellow Newtown in Virginia is very susceptible to the disease, and under favorable conditions the entire crop may be destroyed, while the Ben Davis in the same orchard will become only slightly, or not at all, affected. On the other hand, the Ben Davis, in portions of the Middle West—southern Illinois, southern Missouri, and northwestern Arkansas—is one of the most susceptible varieties. This would indicate that there are two strains of the fungus, the Ben Davis being susceptible to the one occurring in the West and resistant to the one occurring in Virginia.

The most susceptible varieties grown in bitter-rot sections are Yellow Newtown, Willow, Huntsman, Smokehouse, Stark, Jonathan, Ben Davis, and many other less prominent varieties.

TREATMENT.

Although it has been abundantly demonstrated that bitter rot can be readily controlled, even under the most severe conditions, many apple growers look upon it as the most treacherous of all the diseases with which they have to contend. The chief reason for this is the irregularity with which the disease appears. One year an outbreak may occur in July, while the next year the disease may not appear until September. Varieties partly resistant to the disease may go through several seasons without becoming affected, but when there comes a season unusually favorable to the fungus, much of the fruit of these varieties may be destroyed by the disease. This erratic habit of the disease keeps the apple grower in doubt as to when to expect it and when to spray. He does not care to give his orchard three or four bitter-rot sprayings when there is no bitter rot to fight, and he is loath to begin the treatment in June if the disease does not occur until September, yet the only safe plan in bitter-rot districts is to expect the disease every year and to keep the fruit protected from the latter part of June until the end of September.

Bordeaux mixture is still the best fungicide to use for bitter rot, the lime-sulphur solution having proved only partially effective against this disease. Fortunately Bordeaux mixture has very little or no injurious effect on the apple after the young fruits have attained an age of 6 or 8 weeks, and may therefore be used for bitter rot with comparative safety.

As to strength, the mixture should be used as weak as is consistent with good results in order to avoid as much as possible leaving a stain on the ripe fruit. A mixture composed of 3 pounds of bluestone and 4 pounds of lime to each 50 gallons of water, if properly applied, is sufficient for ordinary bitter-rot treatment; but the very susceptible varieties in districts where the disease is common should be sprayed with a stronger mixture, composed of 4 pounds of bluestone and 4 pounds of lime to 50 gallons of water.

In order to protect the fruit throughout the possible bitter-rot infection period the trees should be sprayed four times at intervals of two to three weeks, beginning seven to eight weeks after the petals have been shed. In the bitter-rot belt the dates of the application would be about as follows, though varying somewhat with the season: (1) June 25–30, (2) July 10–15, (3) July 25–31, and (4) August 10–15. Such a course of treatment, properly carried out, will secure protection against outbreaks of bitter rot under the most adverse conditions. By observing the weather conditions and watching for the first infections the first application may be delayed a few days and the intervals lengthened so that three sprayings can be made to do the work. With very susceptible varieties this is risky, but with varieties only moderately susceptible three sprayings are sufficient.

The removal of cankered limbs and the destruction of bitter-rot mummies doubtless help to control the disease, and should be practiced, but these precautions can not take the place of spraying.

For the control of the second brood of the codling moth arsenate of lead at the rate of 2 pounds to each 50 gallons of Bordeaux mixture should be used in the second and third bitter-rot sprayings.

APPLE BLOTCH.

Apple blotch may be considered the scab disease of the South, its effect on the fruit being very similar to that of apple scab. It is well distributed over the southern half of the apple belt, beginning approximately where apple scab leaves off, although there is considerable overlapping of the two diseases at some points. At present the disease is most destructive in Kansas, Oklahoma, Arkansas, Missouri, Kentucky, and southern Illinois. The destruction of half the crop of certain varieties is not an infrequent occurrence in some of these badly affected districts. The disease occurs on the fruit, twigs, and leaves, but the principal damage is done to the fruit.

CHARACTER OF THE INJURY.

On the fruit.—Apple blotch appears on the fruit as a hard brown spot with a roughened surface and a somewhat jagged margin. The blotch or spot is at first very small and light brown in color, but it gradually enlarges, finally attaining a size of one-fourth or sometimes one-half inch in diameter. (See fig. 16.) The advancing margin usually has a fringed appearance, and the surface is dotted with minute, black, raised dots known as pycnidia.

The spots may become so numerous as practically to cover one side of the apple, causing it to ripen and drop prematurely. They are usually accompanied by a cracking of the fruit, thus opening the way for other fungi and insects as well. Some of these cracks are very small, while others are half an inch or more in length. The appearance of affected fruit is so marred as to render it practically unfit for market.

On the twigs.—The fungus causing apple blotch attacks the twigs, fruit spurs, and "water sprouts," producing small brown cankers with purplish margins. These cankers are usually only about one-fourth by one-half inch in size, but may become considerably larger and often girdle the affected twig. With age the bark over the diseased area becomes cracked and scales up, giving the canker a rough appearance. These cankers as a rule do no serious damage to the tree, but the fungus passes the winter in them and they thus become a dangerous source of infection for the new fruit crop.

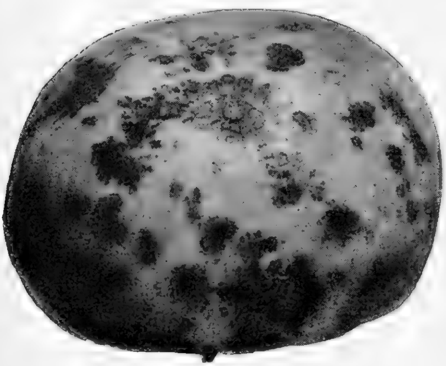

FIG. 16.—Maiden Blush apple affected with apple blotch.

On the leaves.—The leaves also become affected and here the disease manifests itself in the form of very small light-brown or yellowish spots. These spots are angular in outline and attain a size of only about one-sixteenth of an inch in diameter. The spots are usually very numerous on leaves of trees affected with the twig cankers, but they are so small that the injury produced is not often serious.

CAUSE OF THE DISEASE.

Apple blotch is caused by the fungus *Phyllosticta solitaria* E. & E. The fungus lives over winter in the twig cankers, where it is perennial, and in the spring produces spores which ooze out in great numbers from little black raised points or pycnidia. These spores are carried to the fruit by rains, wind, and perhaps insects. Upon germination in the presence of moisture they throw out one or two fungous threads, which penetrate the skin, become much branched, and grow slowly in a radial manner, finally producing the brown blotches.

On the young spots the fungus growing underneath produces small black receptacles in which spores are borne. These spores, when discharged, may infect other fruits, leaves, and twigs.

INFECTION PERIOD.

The fungus in the twig cankers becomes active about the time the apple trees bloom, and about four weeks later fresh spores are produced, ready to infect the fruit and leaves. If the weather conditions are favorable, infections, therefore, begin to take place from four to five weeks after the petals fall. Infections may continue to take place for several weeks, but as a rule the chief damage to the fruit crop results from the infections occurring within six weeks after the petals fall. Spraying for its control should, therefore, be done in time to protect the fruit from these early infections. The fungus is a slow grower and the spots may not show up until two or three weeks have elapsed after infections have taken place, so that to begin spraying when the first spots appear would be much too late to prevent the disease.

TREATMENT.

Unfortunately the lime-sulphur sprays have not proved entirely satisfactory for the control of apple blotch. In orchards where the disease is not very serious lime-sulphur solution may be used with good results, but for the present at least the chief reliance for the prevention of the disease should be placed on Bordeaux mixture. Lime-sulphur solution should be used with the first codling-moth spray as soon as the petals fall, thus avoiding a part of the danger of spray russet, and Bordeaux mixture should be used in the subsequent applications. The spraying schedule for bad cases of apple blotch should be about as follows: (1) Lime-sulphur solution as soon as the petals fall; (2) Bordeaux mixture three weeks later; (3) Bordeaux mixture six weeks after the petals fall; and (4) Bordeaux miture nine weeks after the petals fall. In a dry season the third treatment may be omitted, and in mild cases lime-sulphur solution may be used in all the applications. For the control of the codling moth and curculio, arsenate of lead should be added to the first, second, and fourth treatments.

CEDAR RUST.

Cedar rust, also known as orange rust, is a disease affecting both fruit and foliage of the apple, quince, and other pomaceous plants. It is common in practicaly all the apple-growing districts east of the Rocky Mountains, causing considerable damage to certain varieties of apples. In some sections the disease is troublesome nearly every year, but as a rule destructive outbreaks occur at rather wide intervals, depending upon weather and other conditions. Since the fungus causing the disease passes the winter on cedar trees and infection can take place only with spores from that source, the disease is confined to localities where the red cedar occurs.

CHARACTER OF THE INJURY.

On the leaves the cedar rust disease manifests itself at first as minute, pale-yellow spots, which slowly enlarge, finally attaining

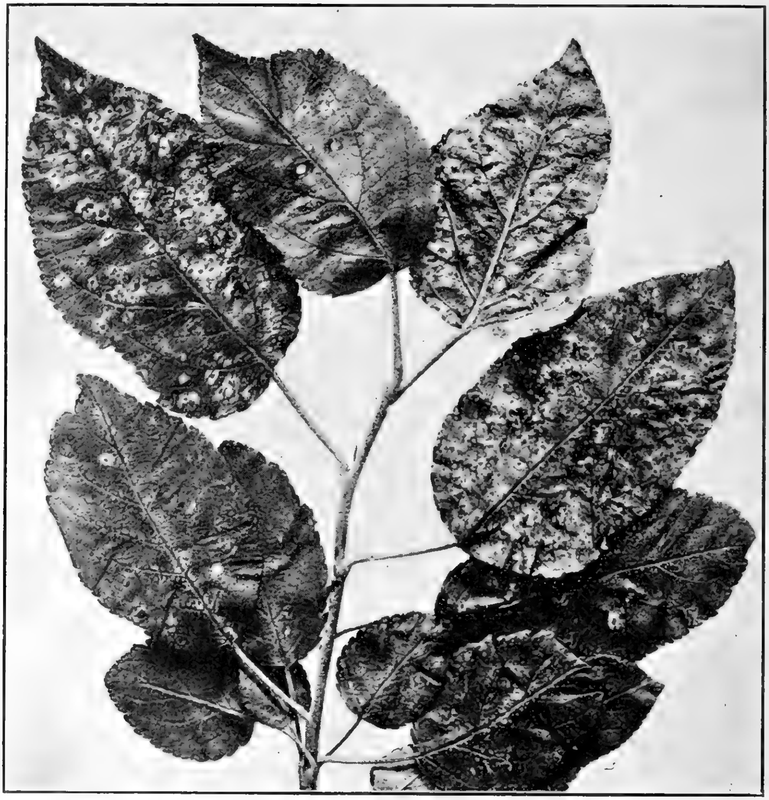

FIG. 17.—Foliage of York Imperial apple affected with cedar rust.

one-eighth to one-fourth inch in diameter and becoming orange-colored, with small black dots in the center. (See fig. 17.) Some time later, on the under side of the leaf beneath each spot the tissues become swollen, forming a blister or cushion on which cup-shaped spore receptacles are produced. These cluster cups are small tubular projections with fringed margins.

When only a small percentage of leaves is affected, as is frequently the case, no noticeable damage results, but susceptible varieties adjacent to cedar trees may become so badly affected that the trees appear yellowish, even from a distance. In such cases the function of the leaves is so interfered with that the fruit, the buds for the following year, and the tree itself are not properly nourished. This results in small, immature, poorly colored fruit, as well as weak buds and a weakened condition of the tree. Badly affected leaves usually drop prematurely.

Cedar rust appears on the fruit of the apple as bright yellow spots about one-half inch in diameter or sometimes larger. Both the black dots and the cluster cups occur on the spots, the latter usually forming one or more rings near the margin. (See fig. 18.) The spots may occur at any point on the fruit, but they are most frequently found near the blossom end. In severe cases the affected fruit may become deformed or atrophied, but as a rule there is no disfiguration other than the presence of the yellow spot. The market value of affected fruit is naturally reduced, much of it being discarded as culls. The disease on the fruit is not so important as that on the foliage, the greater damage being caused by the latter.

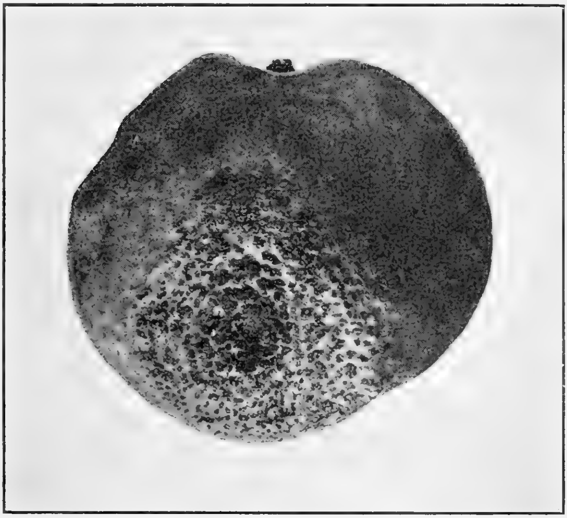

Fig. 18.—Cedar rust disease on the apple.

LIFE HISTORY OF THE CEDAR-RUST FUNGUS.

There are several different species of rust fungi which pass a part of their existence on the red cedar and are obliged to spend the remainder upon the apple or some other pomaceous plant. Perhaps the most common of these is the one known as *Gymnosporangium juniperi-virginianæ* Schw. The spores produced in cluster cups which occur on the diseased leaves and fruit of the apple are carried by the wind to the red cedar trees, infecting the twigs of the latter and thus producing the well-known "cedar apples." (See fig. 19.) These are reddish-brown, globular swellings ranging in size from one-fourth to 1 inch or more in diameter when mature. The fungus thus established on the cedar passes the winter and develops during the following summer, enlarging the gall, and finally during the second spring throws out long, yellowish, gelatinous projections in which spores are borne. These spores, while still in the gelatinous mass, germinate, producing a short fungus growth which bears a crop of smaller secondary spores. When the yellowish mass dries these secondary spores are carried like dust particles on the wind and when lodged on the fruit or foliage of the apple germinate, giving rise to a fungous thread, which enters the tissues and finally produces the characteristic yellow or orange-colored spots. Later the cluster cups are formed on the underside of the leaf and on the fruit spots. In these cups are produced another kind of spore, which is carried back to the cedar trees, as previously indicated. This takes place during July, August, and September. The spores produced on the apple can not reinfect this plant, but must find their way to the cedar or perish. Spores for the infection of the apple must come from the cedar.

FIG. 19.—Cedar rust disease on the cedar. (Cedar apple.)

INFECTION PERIOD.

Plenty of moisture is required, both for the production of spores on the cedar apples and for the germination of these spores on the leaves and fruit of the apple. It naturally follows, then, that a serious outbreak of the disease is likely to occur during a wet spring, while if dry weather prevails very few, if any, infections can take place. Beginning about the time apple trees are in bloom, infections may take place over a period of three to six weeks, depending upon weather conditions. In warm, wet weather during this period the cedar apples throw out the yellow gelatinous masses in which the spores are produced. These may dry out and swell up again several times with alternate dry and wet weather, more spores being liberated each time. Such weather conditions prolong the infection period and result in a serious outbreak of the disease on the apple.

TREATMENT.

Since the fungus causing the disease comes from the cedar trees and since the apple can not become infected from any other source, the natural and most effective remedy is to destroy all red cedars in orchard districts. The cedars in fields or woods adjacent to the orchards are the most dangerous, but since the spores are like particles of dust they may be carried on the wind for several miles. However, upon being carried so far they would be scattered over a wide area and the chances for serious infection of any one orchard would usually be slight, especially since moisture is necessary for the germination of the spores after they reach the apple. Orchards with no cedar trees within a mile may be considered fairly safe from infections. In cleaning up the cedars, the underbrush, fence rows, and hedges should be carefully searched for young cedars. Little cedar plants only a foot high often have cedar apples, and these are usually overlooked by the orchardist.

Spraying has not proved entirely satisfactory in the control of this disease, although much can be accomplished by this method. The usual treatment for scab and leaf-spot, namely, spraying (1) just before the blossoms open, (2) as soon as the petals fall, and (3) three weeks later, will largely prevent this disease during some seasons. In showery weather, however, an extra application should be made about 10 days after the petals fall. The sulphur sprays appear to be somewhat more satisfactory for this disease than the copper sprays.

FIG. 20.—Apple leaf-spot on leaf of Ben Davis apple.

APPLE LEAF-SPOT.

With the possible exception of cedar rust, leaf-spot, also known as frog-eye, is the most important fungous disease affecting the foliage of apple. It occurs in all sections east of the Rocky Mountains where the apple is grown and in unsprayed orchards causes considerable damage by defoliating the trees.

The spots are circular or somewhat irregular in outline, and reddish-brown in color, becoming grayish with age. (See fig. 20.) At first they appear as minute purple specks, which rapidly enlarge until a diameter of from one-eighth to one-half inch is reached. The mature spots are usually circular, but after midsummer may become irregular or lobed in outline, due apparently to a secondary extension of the disease from two or more points on the margin of the original spot.

The leaf-spot disease begins to appear early in the spring soon after the first leaves unfold and infections may continue to take place until midsummer or somewhat later. A large number of spots may occur on a single leaf and in bad cases the trees may become defoliated six weeks or two months before the ripening time of the fruit. As a result of this premature defoliation the fruit either drops off or remains small and is of poor quality, the fruit buds are so weakened as to decrease the chances for a crop the following year, and the trees are materially weakened.

CAUSE OF THE DISEASE.

The black-rot fungus known as *Sphæropsis malorum* Peck is the cause of apple leaf-spot, or at least it is the most common cause. Other fungi frequently occur on the diseased areas, but they are apparently secondary, and it has never been definitely proved that any of them are capable of producing the leaf-spot described above.

The black-rot fungus is perhaps the most common fungus that occurs in pome fruit orchards. In addition to the apple leaf-spot, it is the cause of the black-rot of apple, pear, and quince, and produces cankers on the trunks and branches of these fruit trees. It also grows and fruits on twigs killed by pear-blight and other parasites. Spores are produced in great abundance on these dead twigs and it is from this source that the leaves most commonly become affected. The fungus fruits on the leaves hanging on the trees only sparingly, but after the diseased leaves drop to the ground spores are produced abundantly.

TREATMENT.

Apple leaf-spot is easily controlled by spraying with lime-sulphur solution. The treatment for apple scab, as already outlined, will effectually prevent this disease, no special treatment being necessary where the usual orchard spraying is practiced. During the process of pruning affected twigs should be cut off and burned, so as to eliminate this important source of infection.

SOOTY FUNGUS AND FLYSPECK.

Toward the end of the growing season apples may become affected with large sooty blotches composed of dark olive-brown matted fungus threads. When numerous these blotches give the skin of the apple a clouded effect and many fruit growers have learned to call the disease "cloud." The fungus is superficial, growing on the surface of the apple, and it does not produce any noticeable diseased condition of the tissues. However, the sooty or clouded appearance which characterizes the disease injures the market value of the fruit, rendering it practically unsalable. (See fig. 21.)

With the sooty spots are usually associate groups of small, circular, dark-colored flecks. This is a fungous trouble known under the common name of flyspeck. (See fig. 21.) It also mars the appearance of the fruit, but not to such an extent as the sooty spots. According to Duggar [1] sooty blotch and flyspeck are stages of the same fungus (*Leptothyrium pomi* [Mont. & Fr.] Sacc.), although for years they have been considered as two distinct fungi.

The sooty fungus and flyspeck are common throughout the Eastern States and in unsprayed orchards often cause considerable damage. The fungus thrives best in moist, shaded places and is especially troublesome when cloudy, showery weather prevails during late summer or fall.

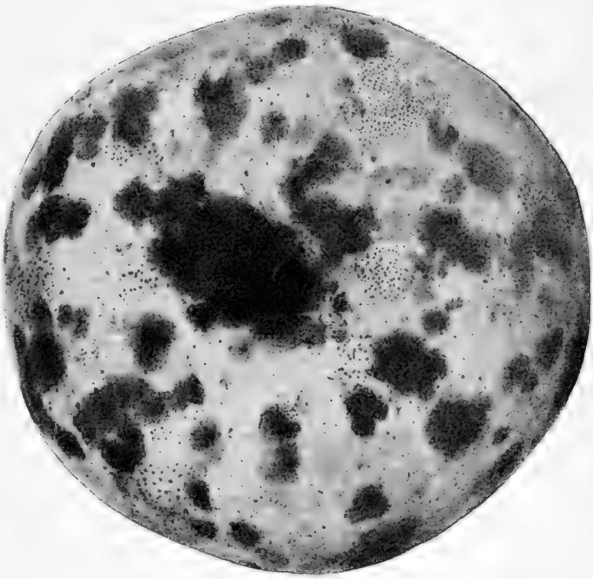

Fig. 21.—Sooty fungus and flyspeck on the Huntsman apple.

TREATMENT.

The sooty fungus and flyspeck are more easily prevented than any other disease affecting the apple, as would naturally be expected from their superficial habit of growth. When treatment for bitter-rot is practiced these troubles need no further consideration. Even the fungicide in the last spraying for apple scab will hold over long enough largely to prevent them unless the conditions during late summer are specially favorable, in which case an application of Bordeaux mixture or lime-sulphur solution should be made in July. In low, damp situations an application during the first week in July and another during the first week in August, using a weak Bordeaux mixture, will often be found desirable.

PREPARATION AND USE OF SPRAYS.

The several troubles herein considered are, for the most part, satisfactorily controlled by a thorough use of sprays. During the past

[1] Fungous Diseases of Plants, pp. 367–369.

few years there have been important improvements in the field of orchard spraying as regards the materials used and also in the character of machinery employed. At the present time orchardists, by careful attention to details, are able to obtain a much higher benefit from spraying operations than formerly, and while results vary, depending upon weather and other conditions, yet the successful orchardist now expects to harvest, as sound fruit, from 90 to 95 per cent of his crop. Below are given the spray materials recommended in the present bulletin, with directions for their preparation.

LIME-SULPHUR SOLUTION.

Uses.—Fruit growers have now become quite familiar with lime-sulphur sprays as a remedy for the San Jose scale, peach leaf-curl, and blister mite, and other troubles requiring dormant tree treatment. The lime-sulphur wash, as used on dormant trees, has gone through a good deal of evolution since the California formula was first employed in the East. Whereas a few years ago it was the practice to make the wash at home for immediate use, utilizing for this purpose in many cases very large cooking outfits, the tendency at the present time is toward the employment of the commercial lime-sulphur solution, a concentrate which is kept indefinitely and used as needed, or a similar homemade solution, both of which are prepared on a distinctly different formula from the wash as formerly used.

A distinct advance was made in the control of fungous diseases when it was found that these commercial and homemade lime-sulphur concentrates, properly diluted, could be used with satisfactory results as fungicides on trees in foliage, replacing Bordeaux mixtures, the use of which is attended with danger of russeting the fruit and injuring the foliage, depending upon weather conditions.

Home-boiled lime-sulphur solution.—Concentrated lime-sulphur solution, to be diluted and used for the summer spraying of orchards, may be prepared by boiling together for about 50 minutes, 100 pounds of sulphur, 50 pounds of lime, and water to make 50 gallons of concentrated solution. Any finely powdered sulphur of 98 to 99 per cent purity may be used. The commercial ground sulphur is the cheapest form and is as good as the flowers or flour for that purpose. The best grade of fresh stone lime is required for the best results, although a good grade of hydrated lime may be used, provided proper allowance be made for the high percentage of moisture it contains.

The boiling may be done in barrels or vats with steam or in kettles over a fire. An ordinary 75 to 100 gallon food cooker composed of a kettle with jacket and fire box is perhaps the most convenient and economical outfit for small and medium sized orchards.

Place about one-fourth of the required amount of water in the kettle, bring it to the boiling point, then put in the lime and immediately add the sulphur. Stir vigorously until the lime is slaked, then add sufficient water to finish with 50 gallons of the concentrated solution and boil for 50 minutes. The total time of actual boiling should not exceed 1 hour, and, as a rule, a boiling period of only 50 minutes gives better results. After the sulphur has gone into the solution, combining with the lime to form sulphids, further boiling brings about a chemical change which finally results in throwing some of the sulphur out of the solution to form a sediment. The sulphur should first be passed through a sieve to break up any lumps that it may contain, and there is perhaps some advantage in working it into a thick paste with water before adding it, or the sulphur may be placed in the kettle first and worked into a paste before adding the lime. In order to finish with 50 gallons of solution the kettle should be filled to about 58 gallons, on account of evaporation. If the water evaporates to below 50 gallons more water should be added to make up the loss. A measuring stick with a 50-gallon mark, and other marks as desired, will be found useful in determining the amount of liquid in the kettle. When steam is used the process is about the same as above described. Owing to the condensation of the steam a somewhat smaller amount of water is required. When the boiling is finished the solution should be poured through a strainer of about 20 meshes to the inch, so as to remove the coarse particles of sediment. It may be used immediately or stored in barrels or other containers and kept indefinitely, provided the air is excluded. In practice the fruit growers, as a rule, have not been able to prepare the lime-sulphur solution without obtaining a large amount of sediment and this has tended to make the commercial product more popular. This sediment is due largely to impurities in the lime and improper mixture and boiling. Straining will take out the coarser particles, and the remainder will not prove to be seriously objectionable.

After the sediment has been settled, the clear liquid should test 25° to 28° on the Baumé hydrometer. It takes about 2 gallons of the homemade preparation to equal in strength 1½ gallons of the commercial product, and these amounts, respectively, are the amounts required for each 50 gallons of spray. For the summer spraying of apple trees, lime-sulphur solution, whether home-made or commercial, should be so diluted as to contain 3½ to 4 pounds of sulphur in each 50 gallons of spray. Prepared according to the above directions, 1 gallon of the homemade product contains approximately 2 pounds of sulphur in solution, and therefore 2 gallons would give the requisite amount of sulphur for each 50 gallons of spray. For spraying trees during the dormant season it should be used much stronger, 12 to 15 pounds of sulphur to each 50 gallons of diluted spray being required. For dormant tree spraying about 7 gallons of the home-made solution in each 50 gallons of spray would therefore give the proper strength.

Commercial lime-sulphur solution.—For some years manufacturers of insecticides and fungicides have had on the market concentrated solutions of lime-sulphur, originally designed as treatment for the San Jose scale, which obviated the necessity of orchardists preparing the wash at home. These solutions have now come to have a much wider range of usefulness, forming a satisfactory substitute, in most cases, for Bordeaux mixture as a fungicide. These concentrated solutions, for the most part, are well made and are fairly uniform in strength, registering from 30° to 34° on the Baumé scale. Many orchardists prefer to use them rather than to prepare the spray at home. In the case of small orchards their use is doubtless advisable, but where the orchard interest is considerable the fruit grower might well afford to prepare the concentrate at home.

In the use of the commercial lime-sulphur solution, as in the home-made solution, the orchardist should know rather exactly the proper dilution to make which will insure the control of the troubles in view, and on the other hand not prove injurious to the foliage and fruit. Dilutions are based on the strength of the concentrate as shown by its specific gravity. Thus commercial lime-sulphur showing a density of 32° on the Baumé scale should not be used stronger than 1½ gallons for each 50 gallons of spray. According to the writers' observations a variation of 2° above or below the density indicated is immaterial as regards danger of foliage injury, so that the recommendations hold for practically all of the commercial concentrates on the market. Where the fungous troubles to be treated are not very serious, it is recommended that only 1¼ gallons of the concentrate should be used to each 50 gallons of spray in order to eliminate, in so far as possible, the danger of injury to fruit and foliage.

BORDEAUX MIXTURE.

Bordeaux mixture is composed of copper sulphate (bluestone) and quicklime, with a certain quantity of water. The amounts of copper sulphate and of lime to be used with a given quantity of water vary somewhat, according to the kind of plants or trees to be sprayed and the disease to be treated. When used on the apple the following formula is quite satisfactory for general orchard work:

Copper sulphate (bluestone)	pounds	3
Quicklime	do	4
Water to make	gallons	50

In bad cases of bitter rot or apple blotch it is often advisable to use 4 pounds of bluestone and 6 pounds of lime to 50 gallons of water instead of the above formula.

Directions for making.—To make a single barrel of Bordeaux mixture, dissolve the bluestone in 25 gallons of water and in a separate vessel slake the lime and dilute it to 25 gallons. Then pour the two solutions simultaneously through a strainer into the spray tank.

If large quantities are to be used, stock solutions of the bluestone and lime should always be prepared, thus saving the time necessary to dissolve the materials. A stock solution of the copper sulphate may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water, and place a sack (or box with perforations in the bottom and sides) containing 50 pounds of copper sulphate in the upper part of the barrel, suspending it by a string or copper wire. In from 12 to 24 hours the sulphate will have entirely dissolved, and the sack or box should be removed and enough water added to fill the barrel. After slight stirring the solution is ready for use. The stock lime may be prepared by slaking 50 pounds in a barrel or other vessel, and finally adding water to make 50 gallons. In slaking the lime sufficient water should be used to prevent burning, but not enough to "drown" it, and the mass should be continually stirred with a shovel or spading fork until a thin paste is formed.

In making Bordeaux mixture take the necessary quantities of the stock copper sulphate and the stock lime solutions to give the formula in the total amount of water to be used, and place each in separate elevated dilution tanks, which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons each dilution tank should hold 100 gallons, and, according to the above formula, 20 pounds of copper sulphate (20 gallons of the stock solution) and 20 pounds of lime (20 gallons of stock solution) would be required. To each dilution tank add water (one-half the total amount of spray) and after stirring allow the diluted ingredients to run through separate hose or troughs attached to faucets near the bottom of the tank into the strainer on the spray tank, where the two solutions come together, producing the Bordeaux mixture. Only the quantity which can be used during the day should be mixed, as the Bordeaux mixture deteriorates on standing.

In case the dilution tanks are not elevated to admit of filling the spray tank by gravity, the diluted solutions must be dipped and poured into the latter by hand, a bucketful of each simultaneously. This method is advisable in small operations, where a few barrels at most are needed.

It is important that Bordeaux mixture should be thoroughly strained in order to keep out any coarse particles that would clog the spray nozzles, and it is a good practice to strain the stock solution of lime while pouring it into the dilution tank. The best material for a strainer is brass wire netting of about 20 meshes to the inch.

ARSENATE OF LEAD AND OTHER ARSENICALS.

Arsenate of lead is the principal arsenical used in orchard spraying. It comes on the market in a puttylike paste and to a more limited extent in the form of a powder. Its present large use is due to certain advantages it has over other arsenicals, in that it contains very little water-soluble arsenic, and is therefore much less likely to injure the foliage. It also adheres better than other arsenicals, such as Paris green and arsenite of lime. All arsenicals used in spraying fruit trees may be used in Bordeaux mixture. However, not all of these can be used in lime-sulphur solutions without danger of foliage injury. Arsenate of lead when added to lime-sulphur solution undergoes considerable chemical alterations, as shown by the prompt change in color of the mixture. Chemical analyses show that a small percentage of the arsenate of lead is broken down, and lead sulphid and arsenate of lime formed. Abundant experience, however, has shown that this alteration of the chemical nature of the arsenical and of the lime-sulphur wash does not injuriously affect their efficiency as fungicides and insecticides, nor materially add to the danger of foliage or fruit injury. Arsenate of lead is used in Bordeaux mixture or lime-sulphur at the rate of 2 pounds to each 50 gallons of the spray. As there are numerous brands of arsenate of lead upon the market the grower should be careful to purchase from reliable firms. When the paste form of arsenate of lead is used it must be worked free in water before it is added to the spray. Powdered arsenate of lead is used at about one-half the strength of the paste form.

In large spraying operations it will be more convenient to prepare in advance a stock mixture of arsenate of lead as follows: Place 100 pounds of arsenate of lead in a barrel, with sufficient water to work into a thin paste, diluting finally with water to exactly 25 gallons. When thoroughly stirred each gallon of the stock solution will thus contain 4 pounds of arsenate of lead, the amount necessary for 100 gallons of spray. In smaller spraying operations the proper quantity of arsenate of lead may be weighed out as needed and thinned with water. In all cases the arsenate of lead should be strained before or as it is poured into the spray tank. The necessary care should be exercised to keep the poison out of the reach of domestic and other animals.

Arsenite of lime is recommended by Stewart[1] as an arsenical for use in lime-sulphur solution, but when so employed the Kedzie formula should be somewhat modified as follows:

White arsenic	pounds	2
Sal soda crystals[2]	do	2
Water	gallons	1½

Boil the above ingredients together in an iron vessel until entirely dissolved, which will require about 15 minutes. This solution is then used to slake 3 or 4 pounds of best stone lime. If the slaking is thoroughly done, the arsenic will be well combined with the lime and the product will retain its strength indefinitely. After slaking, add enough water to bring the total up to 2 gallons. This is a stock solution, which after having been labeled to indicate its poisonous nature, may be stored for use as needed. The stock solution, after thorough stirring, is used at the rate of 2 pints for each 50 gallons of lime-sulphur spray and contains the equivalent in arsenic of one-half pound of Paris green.

This preparation may be used equally well in Bordeaux mixture.

Paris green may be used in Bordeaux mixture at the rate of 5 or 6 ounces for each 50 gallons of spray. This poison, however, should not be used in lime-sulphur spray.

SCHEDULE OF SPRAY APPLICATIONS.

In connection with the several insects and diseases previously referred to, information has been given as to the treatment to be employed in their control. It rarely happens, however, that the orchardist has to consider only one or two of these troubles, there being present as a rule several important insect or fungus pests which must be considered. Fortunately for the orchardist, many of his most serious troubles permit of control by a few well-timed applications of a combined insecticide and fungicide, such as lime-sulphur wash and arsenate of lead. It is, therefore, possible to indicate a schedule of applications which has been found satisfactory to protect fruit and foliage from injury. An outline of this kind, however, must be very elastic to apply to the varied conditions obtaining in the various orchard sections of different parts of the country, as, for instance, in the New England States and in the Ozark region of Arkansas. The orchardist, therefore, must know what his troubles are in order to save himself the expense of unnecessary treatments, on the one hand, and of serious loss, on the other, on account of failure to spray where such work is desirable. The following schedule of applications is recommended, and if carefully followed out it

[1] Bul. 99, Pennsylvania Agricultural Experiment Station.

[2] If the anhydrous or water-free sal soda is used, one-half the quantity will be sufficient.

should insure protection against practically all of the troubles affecting the fruit and foliage of the apple:

First application.—Use lime-sulphur solution at the rate of 1½ gallons to 50 gallons of water plus 2 pounds of arsenate of lead paste or 1 pound of powdered arsenate of lead just before the blossoms open. This is for apple scab, the plum curculio, cankerworms, the bud moth, case-bearers, and the tent caterpillar.

Second application.—Use same spray as in first application, as soon as the blossoms have fallen. This is for the above-mentioned troubles as well as for the codling moth, leaf-spot, and cedar rust. It is the most important application for both apple scab and the codling moth. In spraying for the codling moth at this time the aim is to place in the calyx end of each little apple a quantity of the poison and, to accomplish this, painstaking work will be necessary. Failure to do thorough spraying at this time can not be remedied by subsequent treatments.

Third application.—Use the same spray as indicated above three to four weeks after the blossoms fall. This is the second treatment for the codling moth, cedar rust, and leaf-spot, and gives further protection against apple scab.

Fourth application.—Use Bordeaux mixture (3–4–50 formula) and an arsenical eight to nine weeks after the petals fall (about June 25 to 30). This is the first application for bitter rot, the arsenical being added for the second brood of the codling moth. It is also essential for the sooty blotch and flyspeck, especially in damp situations.

The applications given above, if carefully followed out, are, as a rule, sufficient to bring the fruit crop through to maturity in good condition, except where bitter rot occurs, for which further treatment will be necessary as indicated below.

Fifth application.—Use Bordeaux mixture from two to three weeks after the fourth application. This is the second application for bitter rot, and since it is very little extra expense to add an arsenical this may be profitably done as a further protection against late-appearing larvæ of the codling moth.

Sixth application.—Use Bordeaux mixture again two or three weeks after the fifth treatment has been applied. This is the third application for bitter rot and is ordinarily sufficient to carry the fruit through, but on specially susceptible varieties in bitter rot sections, a treatment to be made two weeks later may be found necessary.

Apple-blotch treatment.—The second, third, and fourth applications of the above schedule will control mild cases of apple blotch, but in bad cases an extra treatment, using Bordeaux mixture, applied six weeks after the petals have fallen (two or three weeks after the second application), will be found necessary for the best results.

Many orchards located in the Middle Atlantic States and southward do not require the first application of the above schedule. Only bad-scabbing varieties, like Winesap, need spraying at this time, unless cankerworms or the bud moth should prove serious enough to necessitate a special spraying. The York Imperial and Ben Davis varieties, which constitute a large proportion of the orchards throughout this region, rarely need spraying before the trees bloom.

EQUIPMENT FOR SPRAYING.

With other conditions favorable, the orchardist will not be able to secure satisfactory results in spraying unless he uses an efficient spraying outfit. While there has been a notable improvement in the character of spraying machinery used by orchardists during the last few years, there are yet many outfits in use which greatly handicap the work. At the present time there are on the market a large series of makes of spray pumps, many of which are quite efficient for the purpose for which they are designed, and the orchardist should not be satisfied with any but the best.

The barrel type of spray pump is serviceable in small to medium sized orchards and when properly fitted with hose of sufficient length, a good agitator, and good nozzle, very effective work may be done. The pump, according to design, may be fitted to the end or side of the ordinary 50-gallon kerosene or similar barrel and may be mounted on a sled or wheels, or preferably placed in a cart or wagon. One man is required to pump and one or two men to handle the nozzles, depending on whether one or two leads of hose are used. A good barrel pump should supply two leads of hose, each with double nozzles. Tank outfits are mostly used in the larger orchards, but are very desirable for the small orchardist as well. These outfits consist of rectangular or half-round tanks, flat on top, holding from 100 to 300 gallons of the spray mixture, fitted to the wagon in place of the wagon bed. Some growers use a 100 to 200 gallon tank placed on one end of the wagon. The barrel type of pump may be used on these tanks, but for this purpose it is better to use the larger tank pumps with suction hose. The hole in the top of the tank should be covered with a close-fitting lid to keep out leaves, twigs, and other trash, which would clog the pump and nozzles.

However, in large commercial orchards power sprayers are mostly used, such as gasoline, compressed air, etc. With such outfits a much higher pressure may be maintained than is possible with hand pumps, giving a fine spray, which may be driven to all parts of the tree. Sufficient power will be furnished to supply several leads of hose and the spraying may be done rapidly, which is very important, especially in regions where suitable days for spraying are not frequent. The usual defect in spraying outfits is that the hose is not of sufficient length. Each lead of hose should be from 25 to 35 feet long, and provided with an 8-foot to 12-foot bamboo extension rod. This length of hose will permit the complete spraying of a tree before leaving it, insuring more thorough work than if only one side is sprayed at a time, and the amount of driving necessary will be reduced by one-half.

The nozzle, of which there are many kinds on the market, is a very essential part of the spraying outfit. Whereas a few years ago the nozzles available were far from satisfactory for orchard spraying, there are now to be obtained good nozzles for the purpose. For general spraying the Vermorel or eddy chamber type of nozzle, of which there are various modifications, is best. These nozzles give a spray of different degrees of fineness, depending upon the size of the aperture of the cap used. In the spray application given immediately after the falling of the petals, especially to lodge poison in the calyx cups for the control of the codling moth, a cap with a large opening is used by many orchardists, and some fruit growers, especially in portions of the West, use at this time a still coarser spray, as that from the "Bordeaux" or similar nozzles. Information on this point as obtained by the Department of Agriculture under humid conditions indicates that there is no advantage in using so coarse a spray, such as is produced by Bordeaux nozzles, especially since a much larger amount of spray is required and greater injury may result.

In spraying high trees some form of elevated platform should be constructed on the wagon, on which one of the men holding the nozzles may stand to spray the higher parts of the tree, the other men spraying from the ground as high as may be reached and overlapping the work of the men on the tower.

In many commercial orchards more time is consumed in driving to and from the water supply than in actually applying the spray. This can be remedied by the use of a supply tank which will hold 200 to 300 gallons. One hand should be able to prepare the mixtures and deliver them to the sprayers in the orchard, thus keeping the outfit constantly in operation. The mixture may be quickly transferred from the supply tank by means of a rotary pump attached to the engines or by other tank-filling devices.

APPLYING THE SPRAY.

Sprays are preventive and not curative, and must therefore be applied before the injury becomes apparent. After a fungus has gained entrance to the foliage or fruit it can not be reached and the diseased parts made sound again; but the infection may be prevented by coating the parts with a fungicide, such as lime-sulphur solution, which prevents the germination of the spores. Similarly, the codling moth may not be poisoned after it has burrowed into the fruit, but if the poison has been put into the calyx cavities before the calyx lobes have closed, and has been sprayed on the foliage and fruit before the latter is entered by the larvæ, the destruction of the latter in large numbers is insured. Successful spraying, therefore, must be based on a knowledge of the diseases and insects to be controlled. With all of the affections here considered the work should be done in advance of their expected appearance in the orchard.

There are two principal reasons why spraying in the hands of some is unsatisfactory, namely, failure to make the applications at the proper time and failure thoroughly to coat the trees and fruit with the mixture. In order to overcome the former difficulty the orchardist must be informed as to the nature of the malady or insect to be treated, and the latter may be overcome by maintaining proper equipment and by giving the necessary attention to thoroughness in spraying.

In the operation of spraying the liquid should be broken into a very fine mist. The nozzles should be so manipulated that every part of the foliage and fruit shall be uniformly covered with fine dots of the spray. It is not necessary that the foliage and fruit should be actually coated with the spray, but every portion should be thickly peppered with it. The higher and inner portions of the tree are commonly insufficiently sprayed, and while the liquid may actually be dripping from the lower branches the upper parts of the tree may show little of the spray.

The desired mistlike spray can ordinarily be secured only with high pressure at the pump. This pressure should be not less than 100 pounds, though this is not ordinarily obtained except with gasoline or other power outfits, which should supply a pressure of 125 to 150 pounds. When hand pumps are used the pressure should be maintained as high as practicable, and never less than 75 pounds, in which case good nozzles become more essential for perfect work. To maintain this pressure will require constant hard work, and the tendency will be to allow the pressure to lighten. Except in spraying the tops of trees the nozzle men should never ride in the wagon, even while spraying the smallest trees. In order to reach the inner branches and the underside of the fruit and foliage the operator must spray from the ground, where he is free to walk around and under the trees. Many failures result from attempts to spray trees from the wagon as the outfit is being driven by.

The question is frequently asked, especially by persons not much experienced in spraying, as to the proper quantity of spray required per tree. This information is not only an index to the thoroughness of the spraying that is being done, but is especially useful in arriving at an estimate of the amount of spray chemicals to be purchased.

The quantity of liquid to be used on trees and foliage naturally varies with the size of the tree. For orchards just coming into bearing and with average-sized trees 8 to 10 years old, a proper manipulation of the nozzle should insure thorough spraying with 3 or 4 gallons per tree. For average-sized trees 12 to 15 years old the amount of spray required per tree would be from 5 to 7 gallons, and for older trees a larger quantity will be required, all varying with the size of the opening in the nozzle used and the rapidity with which the work is done. Very old trees of considerable height and spread of limbs often require from 10 to 15 gallons per tree to insure a thorough treatment.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

Issued May 25, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 500.

THE CONTROL OF THE BOLL WEEVIL.

BY

W. D. HUNTER,

In Charge of Southern Field-Crop Insect Investigations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 4, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript prepared by Mr. W. D. Hunter, of this bureau, entitled "The Control of the Boll Weevil."

The matter contained in this manuscript is extracted largely from Bulletin 114, of this bureau. That publication is a comprehensive treatment of all phases of the boll-weevil problem. The object in reprinting a portion of it is to place the matter relating to practical control in form for more economical distribution among the planters.

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

Hon. James Wilson,
Secretary of Agriculture.

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THE CONTROL OF THE BOLL WEEVIL.

INTRODUCTION.

The matter contained in this bulletin is extracted largely from Bulletin No. 114 of this bureau.[1] That publication contains a rather exhaustive account of the history of the boll weevil in the United States and in other countries, its life history and habits, and numerous methods of control that have been suggested from time to time. The reader is referred to the larger publication for much fuller information regarding many of the points discussed in this circular.

The work on the boll weevil is being continued, and there are definite indications of a successful outcome from experiments in control that will add still further to the planters' ability to combat the pest. This bulletin, however, contains a brief outline of the methods which have been tested under various conditions and sums up the present available knowledge concerning the subject of control.

The difficulties in the way of controlling the boll weevil lie both in its habits and manner of work and in the peculiar industrial conditions involved in the production of the staple, cotton, in the Southern States. In all stages except the imago the weevil lives within the fruit of the plant, well protected from any poisons that might be applied. The adult takes food normally only by inserting its snout within the substance of the plant. It frequently requires but 12 days for development from egg to adult. The progeny of a single pair in a season may exceed 12,000,000 individuals. It adapts itself to climatic conditions to the extent that the egg stage alone in November may occupy as much time as all the immature stages together in July or August. All of these factors combine to make it one of the most difficult insects to control.

BASIS FOR MEANS OF REPRESSION.

In spite of the many difficulties involved in the control of the boll weevil certain generally satisfactory means of repression are at hand, and others may be found as the result of future work. They consist of both direct and indirect means. Those of an indirect nature are designed to increase the advantage gained by the direct

[1] Bul. 114, Bureau of Entomology, U. S. Dept. Agriculture, "The Mexican Cotton Boll Weevil," by W. D. Hunter and W. D. Pierce. Also issued as Senate Doc. No. 305, 62d Cong., 2d sess.

measures and to increase the effectiveness of the several natural factors which serve to reduce the number of weevils. Thus the control measures constitute a combination of expedients, the parts of which interact in many ways. Naturally, the best results are obtained when the planter can put into practice all of the essential parts of the combination.

It is obvious that any method of controlling the boll weevil must depend upon full knowledge regarding its life history and the natural forces which tend to prevent its multiplication. Certain practices which upon superficial observation might be considered important in the control of the insect, upon investigation may be found to be of no avail whatever. In fact, in some cases what appear to be feasible means of control are worse than useless, because they tend to nullify the effects of natural forces which act against the weevil. This is notably the case with the practice of attaching a bar to a cultivator to jar the infested squares from the plants. As will be explained later, this practice is of advantage under only very restricted conditions. Throughout the greater part of the infested territory it is an assistance rather than a hindrance to the boll weevil.

There are seven features of the life history of the weevil that are of cardinal importance in control. These are indicated below.

(1) The weevil has no food plant but cotton.

(2) The mortality of the weevil during the winter is very high.

(3) The emergence from hibernating quarters during the spring is slow and prolonged until well into the summer.

(4) Early in the season, on account of comparatively low temperatures, the development of the weevil is much slower than during the summer months.

(5) The drying of the infested squares soon destroys the immature stages of the weevil contained therein.

(6) The weevil is attacked by many different species of insect enemies, the effectiveness of which is increased by certain practices.

(7) The weevil has but little ability to emerge when buried under wet soil.

Exactly how each of these features of the life history of the weevil affects plans for practical control will be explained in the following paragraphs:

In the case of many of the important injurious insects the problem of control is greatly complicated by the fact that the pests can subsist upon more than one food plant. In some cases a single species attacks several cultivated crops. In other cases the pests can subsist upon native plants practically as well as upon the cultivated species. All these difficulties are absent in the case of the boll-weevil problem. The insect is absolutely restricted to the cotton plant for food and for opportunities for breeding. The problem, therefore, is much more simple than it would be if the weevil could subsist upon any other plant in the absence of cotton. This peculiarity of the weevil (i. e., no food plant but cotton) was the basis of the recommendation made in 1894 that the pest be exterminated absolutely in the United States by the abandonment of cotton culture in a very restricted region. At that time only a few counties in Texas were affected. The procedure would have involved but small expense. Even now the weevil could be exterminated in a single season by preventing both the planting of cotton and the growth of volunteer plants throughout the infested territory. This proposal has been made at various times, notably at the National Boll-Weevil Convention held in Shreveport, La., in 1906. Various difficulties, however, appear to render the plan entirely impracticable. In the first place, there would be strong opposition in large regions in Texas where the planters have learned to combat the weevil successfully. Moreover, the expense would be enormous. A large army of inspectors would be required. The work would not end with the prevention of the planting of cotton, but would necessarily extend to the destruction of volunteer plants which would be found along roads and railroads, about gins and oil mills, and on plantations throughout the infested region. The loss to mills, railroads, merchants, banks, and others dependent upon the cotton trade would complicate matters further. Unless a plan of reimbursement were followed, there would be strenuous opposition from these quarters, and any scheme of payment for damages would add very materially to the cost. From a theoretical standpoint, all the expenses involved would be justified. The saving in a few years would more than offset the cost. Nevertheless, the practical difficulties undoubtedly will always prevent the execution of the plan. All interests now favor the necessary adjustment of conditions to the boll weevil and the practice of the known measures of control rather than total eradication, which was once practicable, but now little more than visionary.

In Bulletin No. 114 it was shown that during the several years in which careful experiments have been performed the average rate of winter survival was 7.6 per cent. It is noteworthy that frequently the survival is much smaller. In the experiments to which reference has been made it ranged from 0.5 per cent to 20 per cent. The most important means of controlling the boll weevil that are available are designed to increase this tremendous mortality caused by natural conditions during the winter. The destruction of any certain number of weevils during the winter is much more important than the destruction of much larger numbers at any other season. The best means at the command of the farmer for increasing the winter mortality is through the uprooting and burning or burial of the stalks at an early date in the fall. Numerous experiments have shown the increased mortality due to depriving the weevils of their food at early dates in the autumn. In fact, the experiments showed a practically uniform increase in the number of weevils surviving as the dates of the destruction of the plants became later. For instance, in all of the experiments performed in Texas it was found that September destruction resulted in a survival of only 0.2 per cent; destruction two weeks later showed a survival of 2.3 per cent; destruction during the last half of October, 5.6 per cent; and during the first half of November, 15.4 per cent. The results of the Louisiana experiments were similar. Destruction in September showed a survival of 0.3 per cent; destruction in the first half of October, 2 per cent; in the last half of October, 8 per cent.

In addition to the experiments in which the weevils have been placed in cages at different times in the fall the Bureau of Entomology has conducted considerable field work to show the benefits of fall destruction. The most striking experiment was performed in Calhoun County, Tex., in 1906. In this experiment an isolated area of over 400 acres of cotton was utilized. There was no other cotton within a distance of 15 miles. By contracts entered into by the department, the farmers uprooted and burned all of the stalks during the first 10 days in October, 1906, and provision was made to prevent the growing of sprout cotton. As a check against this area, cotton lands about 30 miles away were used. Here the stalks were not destroyed in the fall, and the interpretation of the results of the experiment was based upon a comparison of the number of weevils present during the following season in the two localities. In May, 1907, following the destruction of the plants, careful search revealed only one weevil in the experimental area. In the check, however, the weevils were so numerous at this time that practically all of the squares had been destroyed. Examinations made later showed similar advantage in regard to freedom from the boll weevil of the area where the stalks had been destroyed the preceding October. The last examination was made on August 20, 1907. At this time there were 10 sound bolls per plant on the experimental area and only 3 per plant in the check area. The difference in yield between the two areas was about 600 pounds of seed cotton per acre. The work, therefore, resulted in an advantage amounting to about $18 per acre.

Newell and Dougherty [1] have described a very satisfactory device for cutting the cotton stalks in the fall. It consists of a triangular, V-shaped, wooden framework designed to pass between the rows and cut two at the same time. In the process of cutting the machine windrows the stalks from two rows in the middle near where

[1] Circular 30, Louisiana Crop Pest Commission.

they were standing. The runners are provided with knives made of sharpened metal. Old saws have been found well adapted to the purpose. It is important to provide a metal runner at the rear end of the machine to prevent sliding. This runner is designed to run an inch or more beneath the surface of the ground. The device can be made by any blacksmith at a cost of about $4. It will cut and windrow from 10 to 15 acres of stalks in a day.

There is a disadvantage in cutting the stalks at or near the surface of the ground; this is that if warm weather follows, many of the roots give rise to sprouts that will furnish food for the weevils. On this account the process is less effective than uprooting the plants. Wherever the stalk cutter is used it should be followed by plows to remove the roots from the ground.

There is another important means by which the winter mortality of the weevil may be increased. This is by removing the hibernating quarters or destroying them after the weevil has gone into hibernation. Many of the insects are to be found in the winter in trash and débris in and about cotton fields. The more shelter provided in the form of weeds growing about the fields, the more favorable the conditions will be for the insect. By the burning of such hibernating shelter as is found in the cotton fields and in their immediate vicinity a farmer can cut off a very large proportion of the weevils that would otherwise emerge to damage the crop.

The prolonged period of emergence from hibernation gives the planter another important advantage over the weevil. The period of emergence from hibernation extends, in normal seasons, to practically the 1st of July. In fact, except in one of the experiments performed, the last weevils did not appear until after the 20th of June. In Texas it was found that 75 per cent of the emerging weevils appeared after April 8, and in Louisiana 64 per cent. In Texas, after May 1, in all the experiments, from 4 to 18 per cent of the surviving weevils appeared. In Louisiana, after May 1 from 30 to 40 per cent emerged.

It is obvious that the fact that many weevils do not appear until long after cotton can be planted and brought to a fruiting stage is a very great advantage to the planter. A portion of a crop, at least, can be set before the weevils have become active. Usually it is possible to plant a crop sufficiently early to have it set some fruit before much more than 50 per cent of the surviving weevils have emerged.

Attention was directed to the fact that the development of the weevil is much slower in the early portion of the season than later. For instance, at Vicksburg, Miss., the average period of development in April is 30 days, and in May 19 days. In June the period is shortened to 15 days. Consequently, the planter has an opportunity to force the development of fruit on the plants when the weevils are being held in check by the temperatures of the spring months. The ability of the cotton plant to grow during April and May is much greater than that of the weevils. This gives a margin of which the planter can take advantage.

It has been proposed at various times that late planting would be of advantage in the fight against the weevil, but exhaustive tests made by the Bureau of Entomology and the Louisiana Crop-Pest Commission have demonstrated the fallacy of this proposal.

In the section dealing with natural control it was shown that climatic checks are the most important that the boll weevil experiences. The principal manner in which climatic factors affect the weevil is through the drying of the fruit. Naturally, the more heat and light there is to reach the fallen squares the greater will be the effectiveness of the most important natural means of control. This is the basis for the recommendation that the plants should be given considerable space not only between the rows, but in the drill. Of course, it would be possible to place the plants entirely too far apart, and thus reduce the yield. There is a happy medium, however, at which planters must arrive from experience on their individual places. At the same time varieties should be cultivated which have a minimum tendency toward the formation of leafage.

The work of the insect enemies of the boll weevil is increasing from year to year. This work should be encouraged so far as possible. It happens that several of the recommendations made for other reasons will result in facilitating the work of the enemies of the weevil. This is the case with early planting, wide spacing, and the use of varieties with sparse rather than dense leafage. Even the fall destruction of the stalks is not a disadvantage, because it forces the parasites at the end of the active season to native hosts that carry them through the winter. Wherever possible varieties should be planted which retain a large proportion of the infested squares, because the hanging squares are more favorable for parasite attack than those which fall.

Whenever the squares are picked by hand they should, if practicable, be placed in screened cages, rather than burned or buried. In this way the weevils will be destroyed while the parasites may escape. The screen used on such cages should have meshes at the rate of about 14 to the inch.

Numerous experiments have shown that a large proportion of the weevils buried under 2 inches of moist soil can not reach the surface. Unfortunately, it is not possible to plow the infested squares under 2 inches of soil during the growing season. The operation would result in injury to the root system and cause great shedding.

Nevertheless, it is possible for the planter to follow this practice after maximum infestation has been reached and after the plants have been uprooted. Therefore, every means should be taken at the time of maximum infestation to plow under the infested squares as deeply as possible. This method is of little use in dry regions, but, fortunately, is of great importance in humid regions where other means of control are comparatively lacking in efficiency. Its importance is increased by the occurrence of large areas of so-called stiff soils in the humid area.

In 1909 the Louisiana Crop-Pest Commission published a circular dealing with the results of experiments with powdered arsenate of lead as a practical remedy for the boll weevil. This circular dealt with carefully planned field experiments which showed that the use of this arsenical was attended with great profit during that season. The Bureau of Entomology has investigated this subject for two subsequent seasons. The results have been to a certain extent contradictory, although there is an indication that a definite field of usefulness for the powdered arsenate of lead will be found. The results of this work will be published in due time. The striking results obtained by the Louisiana Crop-Pest Commission in 1909 seem to have been due to peculiar conditions, including a great abundance of insects, which prevailed during that season. The work of the Bureau of Entomology also shows that the greatest benefits will occur when the weevils are most abundant.

SUMMARY OF CONTROL MEASURES.

(1) *The destruction of the weevils in the fall by uprooting and burning or burying the plants.*—This is by far the most important step in control. It is so important that unless it is followed all other means will avail little to the planter.

The burning of the cotton plants is not, of course, a good agricultural practice. It should not be followed except in emergencies. In all other cases the plants should be uprooted as soon as the cotton can be picked, cut by means of stalk choppers, and plowed under immediately. The ground should afterwards be harrowed or dragged to make it still more difficult for the insects to emerge.

In many cases it will be found inadvisable to wait for the uprooting of the plants until all of the cotton is picked. When only a small portion remains for the pickers it is entirely feasible to uproot the plants by means of a turning plow and leave them in the field so that the cotton can be picked. This will hasten the opening of the green bolls and frequently result in a considerable saving to the planter.

(2) *The destruction of the weevils during the winter.*—This is accomplished by the destruction of the places in which the insects hiber-

nate. Many such places are found in the cotton fields or in their immediate vicinity. A certain number of the weevils will, of course, make their way into the heavy woods and other situations beyond the reach of the planter, but many remain where they can be reached.

(3) *Obtaining an early crop.*—The importance of obtaining an early crop has been shown to depend upon the small number of weevils which hibernate successfully, their late emergence from hibernating quarters, and their comparatively slow development during the early part of the season. The obtaining of an early crop is brought about by early preparation of the soil, by early planting, the use of early maturing varieties,[1] a system of upbuilding and fertilization which will stimulate the growth of the plants, and by continuous shallow cultivation during the season.

By early planting we do not mean that the planter should run great risk of loss of stand by frost. Planting at too early a date is as bad as late planting. By early planting we mean the earliest planting that the farmer's experience shows is reasonably safe.

(4) *Increasing the effects of climatic control.*—As has been shown, practically 50 per cent of all the weevil stages throughout the infested territory are destroyed by climatic influences. This means that the power of reproduction of the weevils is reduced by one-half. A planter can increase the advantage in his favor by providing a suitable distance between the plants and between the rows. It is also important to use varieties, where possible, which have a comparatively small leaf area.

(5) *Encouraging the insect enemies of the weevil.*—This is accomplished in part by procedures already recommended and, further, by the use of varieties which have a well-developed tendency to retain the fruit, and which also have a comparatively open structure and small leafage.

(6) *Hand picking of weevils and squares.*—This is a practice of varying importance. Under some conditions it may be highly advisable, under others entirely impracticable; everything depending upon the cheapness with which the work can be done. * * * It is therefore a matter that must be taken into consideration by each individual planter. This subject is now under investigation by this bureau, and the experiments under way will show under what conditions the practice of picking the squares or weevils can be recommended.

Wherever square picking is practiced the best results are likely to follow where the picked-up squares are placed in cages so that the

[1] Some of the best varieties for the humid region (Louisiana, Mississippi, and Alabama) are Cleveland's Big Boll, Cook's Improved, Toole's, and King. In Texas, Mebanes Triumph, Rowden, Lone Star, and other varieties will be found best adapted to boll-weevil conditions. For further information the planter should communicate with the Bureau of Plant Industry or the State Experiment Station.

parasites may escape and continue their work. As a matter of fact, under most conditions it is likely that the encouragement that can be given the parasites by this means is of much more importance than any direct checking of the weevil by the process of hand picking. Wherever squares are burned these enemies of the weevil are destroyed, thus stopping their beneficial work. It is of the utmost importance, however, that the cages in which the squares are held be free from cracks or openings such as result from the shrinkage or warping of the wood in barrels and boxes that are left exposed to the weather, through which the weevils could escape, and that the screen used on them have meshes at the rate of about 14 to the inch.

(7) *Control at gins.*—The use of modern cleaner feeders will eliminate practically all of the weevils from cottonseed. Such devices should be used at least in the case of all seed that is intended for shipment into any infested localities, and especially along the outer border of the infested territory, where wagons may carry infested cottonseed some distance into territory that has not been reached by the weevil. It is important in connection with the cleaner feeders to provide some means for the destruction of the insects that are captured. In some cases where the cleaner feeders are in operation the discharge is allowed to accumulate in an open barrel or box. From such receptacles weevils readily make their way into the seed cotton in storage. It is a simple matter to provide compression rollers through which the discharge from the cleaner feeder is passed. If for any reason the use of compression rollers is impracticable the trash should be fumigated at frequent intervals by means of carbon bisulphid or collected in a closed chamber and burned before the weevils have an opportunity to escape.

(8) *Fumigation of seed.*—This is a means of repression that will be of avail only in the case of shipments of seed into uninfested territory. It has been found that carbon bisulphid is the most satisfactory agent to use. Great care should be taken to insure thoroughness of application.

In addition to the specific means of control enumerated we may mention the prevention of the invasion of new territory by means of quarantines directed against farm commodities that are likely to carry the weevil. It is not necessary to have a quarantine applied to an extended list of articles. Only a few forms of cotton and of cotton by-products need to be considered. The most important is seed cotton. Next in importance are cottonseed and cottonseed hulls. There is no danger in cottonseed meal and scarcely any appreciabie danger in baled cotton.

Cottonseed can easily be rendered entirely safe by fumigation with carbon bisulphid.

The use of a crossbar attached to the cultivator to jar the infested squares from the plants has frequently been recommended. Under some conditions this practice should be followed, but under others it is worse than futile. It has been found that in the humid region, including Arkansas, Louisiana, and the eastern portion of Texas, the mortality in hanging squares is greater than in fallen squares. For this reason it is better for the squares to remain on the plants. There is another reason why they should be allowed to remain on the plants, which applies especially to the moist region in which the boll weevil is now doing great damage. This is that the hanging squares are much preferred by the boll-weevil parasites. The records have invariably shown a higher rate of parasitism in hanging squares than in fallen squares. In this way the hanging squares furnish a means for the breeding of parasites and their establishment in the field.

It will be noted that the means of repression of the boll weevil may be divided into two classes, namely, direct and indirect.

The direct means of control are the destruction of the weevils in the fall by destroying the plants and burning or burying the immature stages, hand picking of weevils and squares under some conditions, poisoning with powdered arsenate of lead, the burial of the infested forms at the time of maximum infestation, and the burning of the hibernating weevils in their winter quarters.[1]

The indirect means of control are early planting, the use of early varieties and of fertilizers that will accelerate growth, the improvement of the soil by the incorporation of humus, the selection of fields where the soil is suitable to rapid development, frequent shallow cultivation, the encouragement of the parasites of the weevil by placing the infested squares that may be picked by hand in cages instead of burning them, and the use of machinery which facilitates the various operations in preparing the land and cultivating the crop. These have the effect of increasing the acreage that a hand may cultivate. In view of the fact that the boll weevil forces a reduction in the acreage per hand, this is a consideration of some moment.

[1] Poisoning the adults with powdered arsenate of lead, judging by experiments now under way, will also serve as a direct check. Definite advice can not be given until the field experiments are completed.

Issued August 23, 1912.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 503.

COMB HONEY.

BY

GEO. S. DEMUTH,
Apicultural Assistant, Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 16, 1912.

Sir: I have the honor to transmit herewith a manuscript entitled "Comb Honey," by Geo. S. Demuth, apicultural assistant in this bureau.

In view of the increasing demand for the finest grades of comb honey and of a decrease in the amount of comb honey produced, it seems timely to present to professional beekeepers an analysis of the best practice as well as to point out some essentials to the production of maximum crops of the best grades. I recommend the publication of this paper as a Farmers' Bulletin.

Respectfully,

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

Hon. James Wilson,
Secretary of Agriculture.

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COMB HONEY.

INTRODUCTION.

The present tendency in beekeeping is decidedly toward the production of extracted honey rather than of comb honey. The recent activity among beekeepers toward specialization, which necessitates the establishing of out-apiaries, and the rapidly increasing demand for extracted honey are among the factors bringing about this condition. Enormous quantities of honey are now used for manufacturing purposes, and this demand is, of course, solely for extracted honey.

If the general public finally becomes convinced of the purity and wholesomeness of extracted honey, this will become a staple article of food. Comb honey to command the higher price—proportionate to the greater cost of production—must justify the extra cost to the consumer by its finer appearance. The consumer of extracted honey is not concerned as to the straightness or finish of the combs in which it was originally stored, but by virtue of its appearance there will probably always be a good demand for the finest grade of comb honey where appearance is the chief consideration. Present tendencies therefore emphasize the desirability of producing comb honey of the most attractive appearance possible.

Well-filled sections of comb honey with delicate white comb and perfect cappings are obtainable only during a rapid honey flow of sufficient duration to insure their completion. The production of comb honey, the appearance of which is sufficient to justify its extra cost, requires a combination of conditions that are peculiar to rather limited areas, outside of which the beekeeper will find it decidedly advantageous to produce extracted honey.

Comb-honey production should not be attempted in localities where the honey flow is very slow or intermittent, where the character of the honey is such that it granulates quickly in the comb while it is on the market, where the honey is dark or "off color," or where honeys from various sources are mixed if these different sources produce honey of different colors and flavors. Local market conditions may of course in some instances be such as to make it seem advisable to produce comb honey in limited quantities in a locality that is not well suited to comb-honey production, but the beekeeper who produces comb honey for the general market should first be sure that his is a comb-honey locality. Even in the best localities during an occasional season conditions are such that it is not possible to produce comb honey of fine appearance. Some comb-honey specialists find it profitable to provide an equipment for extracted honey for such an emergency. In some cases comb honey is produced only during the height of the season, when conditions are most favorable, extracting supers being used both at the beginning and close of the honey flow.

While the professional beekeeper is thus curtailing the production of indifferent grades of comb honey, bee diseases are rapidly eliminating the careless producers. From the present indications, therefore, it would seem certain that there must be a gradual elimination from the markets of all inferior and indifferent comb honey—grades that must compete directly with extracted honey. This should mark a new era in the production of the best grades of comb honey in the localities that are peculiarly adapted to comb-honey production. The beekeeper who is thus favorably located will do well to consider the possibilities of future market conditions for a fancy grade of comb honey.

The following discussion is necessarily but a brief outline of modern apparatus and methods and of course can not in any sense take the place of the broad experience necessary in profitable comb-honey production. It is assumed that the reader is more or less familiar with the more general phases of beekeeping. (See Farmers' Bulletin No. 447. This bulletin also contains a complete list of publications of the Department of Agriculture on beekeeping.)

APPARATUS FOR COMB-HONEY PRODUCTION.

Shop and Honey House.

A building containing storage space for apparatus, a well-lighted and ventilated workshop as well as a honey room, is a necessity in comb-honey production. The arrangement and location of the shop and honey house will depend upon local conditions and circumstances. The usual mistake is in constructing these too small. In the North the shop and honey house is usually built over the wintering repository or cellar. Since rats or mice would do great damage to the contents of such a storehouse, the construction should be such as to exclude them. If a concrete foundation is used and the sills are embedded in a layer of "green" mortar, no trouble of this kind should be experienced. If a series of out-apiaries are operated for comb honey, the supers, extra hives, etc., are usually kept in one building located near the home of the beekeeper. This serves as a central station and storehouse, the supplies being hauled to and from the apiaries as needed. This building may be supplemented by a very small building at each apiary, though in comb-honey production this is not really necessary.

The honey room should be so located that it will receive the heat from the sun, preferably an upstairs room immediately under the roof. When so located a small hand elevator should be installed for taking the honey up and down. The room should be papered or ceiled inside to keep out insects and to permit fumigation if necessary and should contain facilities for artificially heating in case continued damp or freezing weather should occur before the honey is marketed. The honey room should be provided with ample floor support for the great weight that may be placed upon it.

Hives.

A beehive must serve the dual purpose of being a home for a colony of bees and at the same time a tool for the beekeeper. Its main requirements are along the line of its adaptation to the various manipulations of the apiary in so far as these do not materially interfere with the protection and comfort it affords the colony of bees. Since rapid manipulation is greatly facilitated by simple and uniform apparatus, one of the fundamental requirements of the equipment in hives is that they be of the same style and size, with all parts exactly alike and interchangeable throughout the apiary. While the hives and equipment should be as simple and inexpensive as possible, consistent with their various functions, a cheap and poorly constructed beehive is, all things considered, an expensive piece of apparatus.

In this country the Langstroth (or L) frame ($9\frac{1}{8}$ by $17\frac{5}{8}$ inches) (fig. 1) is the standard frame and throughout this paper frames of brood will be discussed in terms of this size of frame. The advantages of standard frames and hives are so great that the beekeeper can not afford to ignore them for the sake of some slight advantage of another size.

There is, however, a wide difference of opinion as to the number of frames that should be used in a single hive body. The wide variation in the building up of colonies previous to the honey flow in different localities and seasons, the race of bees, and the skill of the beekeeper are all factors entering into this problem, which make it improbable that beekeepers will ever fully agree on this point. The races that build up more rapidly in the spring are, of course, other things being equal, able to use to advantage a larger brood chamber than the races that are more conservative in brood rearing. It is also noticeable that within certain limits as the beekeeper's skill in building up his colonies for the flow increases, so the size of the brood chamber best adapted to his purpose increases. In other words, while the careful and skillful beekeeper may succeed in having large brood chambers well filled with brood at the beginning of the honey flow, the less skillful beekeeper under similar conditions may be doing well to approximate this condition with a much smaller brood chamber.

For comb-honey production the brood chamber should be of such a size that by proper management it may be well filled with brood at the beginning of the honey flow, so that the brood and surplus apartments may be definitely separated. A brood chamber may be considered too large if by proper management it is not on an average fairly well filled with brood at the beginning of the honey flow, and too small if it provides an average of less room than the colony is able to occupy with brood previous to the honey flow. Unless the beekeeper practices feeding, a brood chamber that does not contain sufficient room for both winter stores and brood rearing during late summer and autumn may also be considered too small. It may be well to note that by this standard if the brood chamber seems to be too large the fault may lie in the management during the previous autumn, winter, or spring. Of course the brood chamber that is barely large enough for one colony will be too large for another in the same apiary or the character of the season may be such that all brood chambers may be too large for best results one season and too small the next, so an average must be sought. While by manipulation good results may be secured by the use of any of the sizes in common use, any great departure in either direction from the size best suited to conditions of a given locality necessitates an excessive increase in labor to give best results. There is at the present time

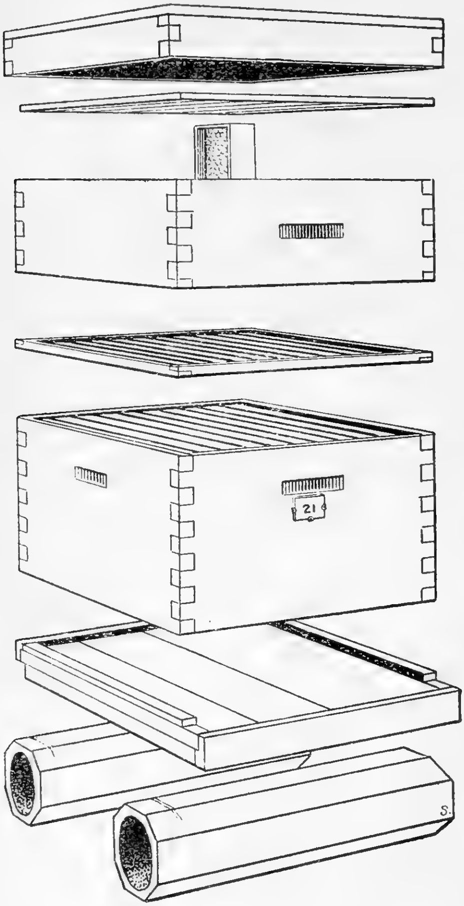

FIG. 1.—A 10-frame hive with comb-honey super and perforated zinc queen excluder. (From Phillips.)

a strong tendency toward the use of the 10-frame hive body as a medium-sized brood chamber which may be used as a unit of a larger elastic brood chamber when necessary.

The comb-honey producer is more exacting as to certain details of construction of hives than is the producer of extracted honey since it is more necessary for him to handle individual brood frames during the honey flow. The spaces [1] above and between the top bars of the brood frames must be accurate or they will be bridged with burr and brace combs and these filled with honey. Burr and brace combs make the removal and readjustment of the super and the manipulation of frames a slow and disagreeable task, to say nothing of the waste of material, which should have been placed in the sections in the beginning. The use of the slatted honey board (fig. 2), while preventing brace combs between itself and the super, does not prevent the building of burr and brace combs between and above the top bars of the frames. This trouble is largely eliminated by proper spacing. Most hive manufacturers are at present making the top bars of the brood frames of such a width that the spaces between them is from one-fourth to five-sixteenths inch with the same spacing above them. The difficulty, however, is in maintaining this spacing with any great degree of accuracy. Self-spacing frames [2] are a partial solution of this difficulty. In some localities, however, the ordinary self-spacing frames are so badly propolized as to render their removal from the brood chamber difficult as well as materially to interfere with the proper spacing. The advantages of such frames are then nullified, while their disadvantages are retained or even intensified. In such localities metal spacers having but small surfaces of contact are sometimes used. Some beekeepers prefer omitting the spacers entirely. However, some of the difficulties arising from the use of self-spacing frames are the result of carelessness on the part of the operator in

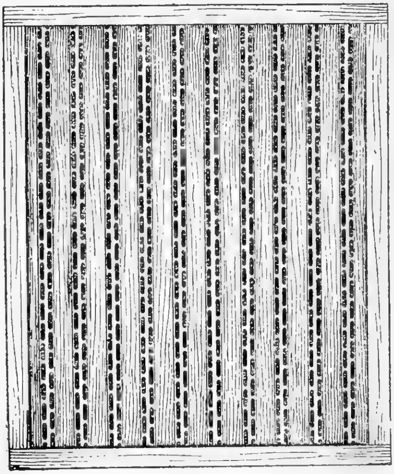

FIG. 2.—Perforated zinc queen excluder. (From Phillips.)

[1] A bee space, or that space in which bees are least inclined to put comb or propolis, is perhaps a scant one-fourth inch. In hive construction one-fourth or five-sixteenths inch is usually used.

[2] These are so constructed that the end bars are one-fourth or five-sixteenths inch wider than the top bars throughout a portion of their length or furnished with projections of metal fitted to the edges of the frame. In either case the adjustment is such that when the frames are crowded together in the hive the spaces between the top bars will be correct.

not crowding the frames together properly when closing the hive after having handled the frames.

SECTIONAL HIVES.

The sectional hive in which the brood chamber is composed of two or more shallow hive bodies, making it horizontally divisible, offers some advantages, especially to the comb-honey specialist. Most of the ordinary manipulations can be performed readily with such hives without removing the frames. One of their greatest advantages in comb-honey production is the rapidity with which the apiarist can examine the colonies for queen cells if natural swarming is to be controlled by manipulation. They are also very elastic, the units or sections usually being of 5-L frame capacity, permitting a brood-chamber capacity of 5 or any multiple of 5-L frames. Among the disadvantages of these hives are the extra cost owing to the greater number of parts necessary in their construction and the difficulty in maintaining proper spacing without the use of top bars on the frames heavier than would seem advisable in the middle of the brood nest.

Sections and Supers.

There is a wide variation in the style of sections and the supers designed to contain them. This, while to some extent brought about by different local conditions, is largely due merely to the notions of individual beekeepers. Comb-honey apparatus could probably be standardized without sacrificing any really vital features.

BEEWAY *v.* PLAIN SECTIONS.

There are two general styles of sections in common use differing in the method of spacing—the beeway section in which the spacer is a part of the section itself (fig. 5), and the plain in which the spacer

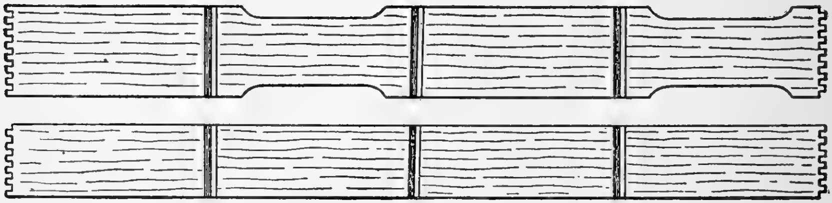

FIG. 3.—Beeway and plain sections, unfolded. (Original.)

is a permanent part of the separator (fig. 4). Each style has its advocates and each offers some advantages.

Some of the advantages of the plain (fig. 3) over the beeway sections are: (1) They are simpler in construction, therefore costing less. (2) The edges being plain with no insets, the plain sections are more easily cleaned of propolis when being prepared for market and are especially adapted to cleaning by machinery. (3) By leaving the spacers in the super, sections of the same honey content occupy less space in the shipping case, thus reducing the cost of packages. (4) The plain section is adapted to an arrangement permitting freer communication lengthwise of the row of sections, especially at the corners (p. 15).

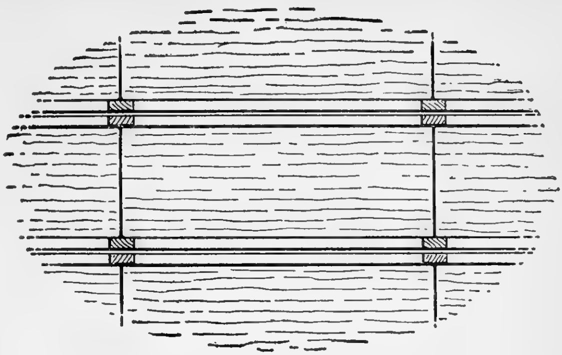

FIG. 4.—Plain section in super, showing method of spacing. (Original.)

Some of the advantages of the beeway sections (fig. 3) are: (1) The honey is somewhat less liable to injury by handling. (2) Being wider at the corners where folded, they are stronger. (3) Some markets, being accustomed to the larger cases necessary to contain a given number of beeway sections, object to the smaller package containing the same number of plain sections, simply because it is smaller.

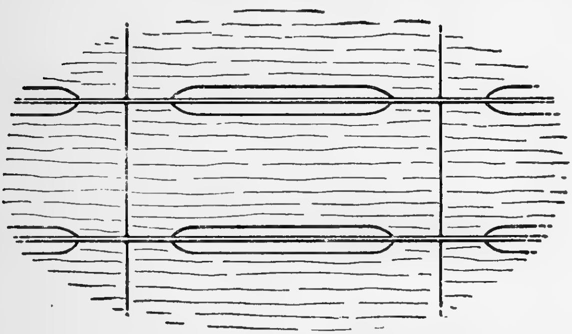

FIG. 5.—Beeway section in super, showing method of spacing. (Original.)

DIMENSIONS OF SECTIONS.

Sections of various dimensions are in use by beekeepers, but the sizes in general use are the $4\frac{1}{4}$ inches square and the 4 by 5 inches. Some producers prefer the 4 by 5 sections because of the more pleasing appearance of the oblong package (fig. 6). The standard widths of the $4\frac{1}{4}$ by $4\frac{1}{4}$ inches section are $1\frac{7}{8}$ inches in the beeway style and $1\frac{1}{2}$ inches in the plain section. The extra width in the beeway style is for the purpose of spacing and does not add to the thickness of the comb. The 4 by 5 is $1\frac{3}{8}$ or $1\frac{1}{2}$ inches wide in the plain style and not much used in the beeway style. The $1\frac{3}{8}$ width of the 4 by 5 section contains practically the same amount of honey when filled as the

$4\frac{1}{4}$ by $4\frac{1}{4}$ by $1\frac{1}{2}$ plain or the $4\frac{1}{4}$ by $4\frac{1}{4}$ by $1\frac{7}{8}$ beeway, assuming of course that all are used with separators and filled under like conditions. Since there are well-defined limits as to the thickness of the combs most profitable to produce, the area of one comb surface in a section weighing about a pound is usually from 16 to 20 square inches, the exact size and shape being an adaptation to given space in the super. The thinner combs, showing more comb surface, have the appearance of being larger and a greater number can be accommodated on a given hive. Honey in such combs may also be ripened sooner and possibly better than in thicker combs. They, however, require more foundation for each pound of honey produced and a slightly greater amount of wax, in proportion to the honey, to complete them. Also

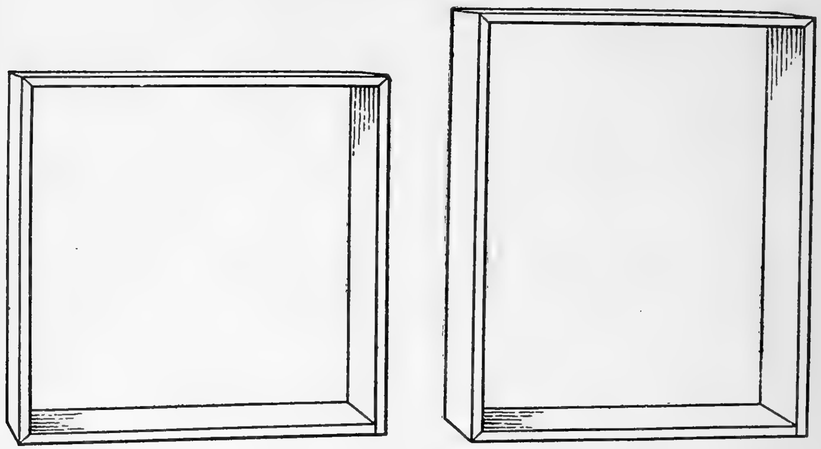

FIG. 6.—Square and oblong sections. (Original.)

the thinner the comb, the greater the difficulty with the sheets of foundation swinging to one side on account of uneven work on the two sides or because the hives do not stand level.

SUPERS.

The main points of difference between the various types of comb-honey supers are in (1) the method of supporting the sections, (2) the amount of protection afforded to the outside of the section, and (3) the degree of free communication from section to section within the super.

The Method of Support.

Sections are supported either by means of cross supports under the ends of the sections or by a slat of proper width supporting each row of sections. The T super (fig. 7), so called from the shape of a cross section of the strip of tin used to support the sections, is illustrative of the first, while the supporting slats, section holders (figs. 8, 9 and 10), and wide frames (fig. 11) are illustrative of the second type of support.

Protection.

The T super and others of this type offer no protection against propolizing to either the top or bottom of the sections, the section

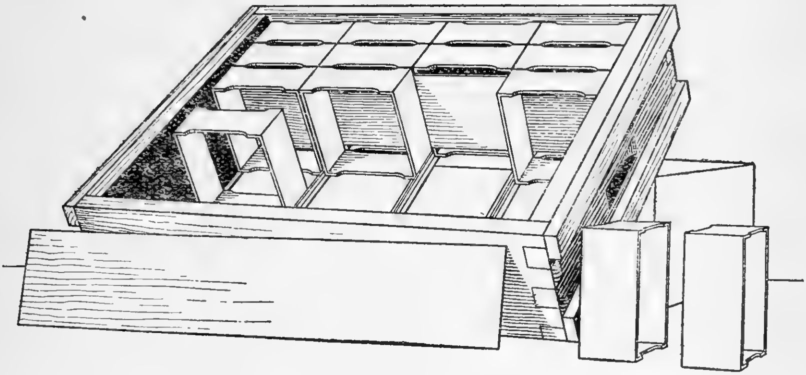

Fig. 7.—The T super. (Original.)

holder or slat (figs. 8, 9, and 10) protects the bottom, while in the wide frame (fig. 11) the entire outer surface of the sections is protected except at the edges. The greater the protection afforded the

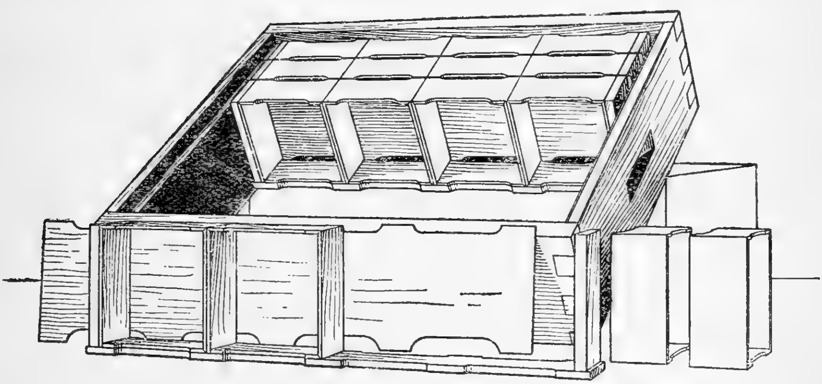

Fig. 8.—Super with section holder for beeway sections. (Original.)

section, the more complicated and expensive the super, and the more complicated supers require more labor in cleaning of propolis and filling with sections. On the other hand, sections of honey produced in properly constructed wide-frame supers are much more easily cleaned of propolis, and ordinarily present a neater appearance when packed for market.

Free Communication Within the Super.

The use of closed-top sections (1-beeway) and solid separators, making each section a separate compartment with openings for the bees at the bottom only, illustrates one extreme; while the sections with openings on all four sides (4-beeway) used without separators

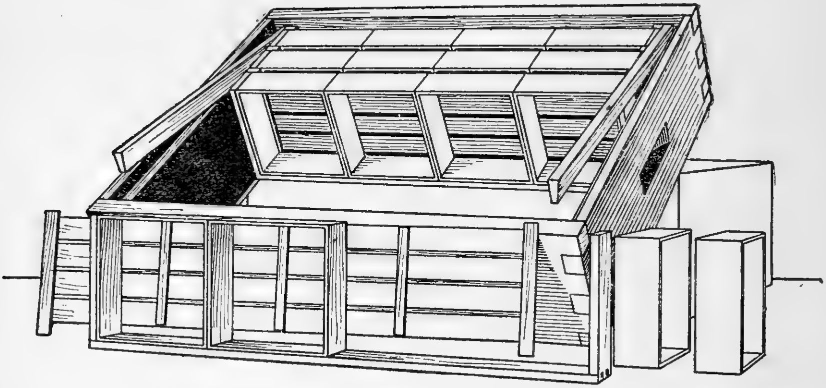

FIG. 9.—Super with section holder for square plain sections. (Original.)

illustrate the other extreme as to free communication; and between these extremes are various intermediate types.

It would be desirable so to adjust the sections that when filled with honey a row of them would, so far as the bees are concerned,

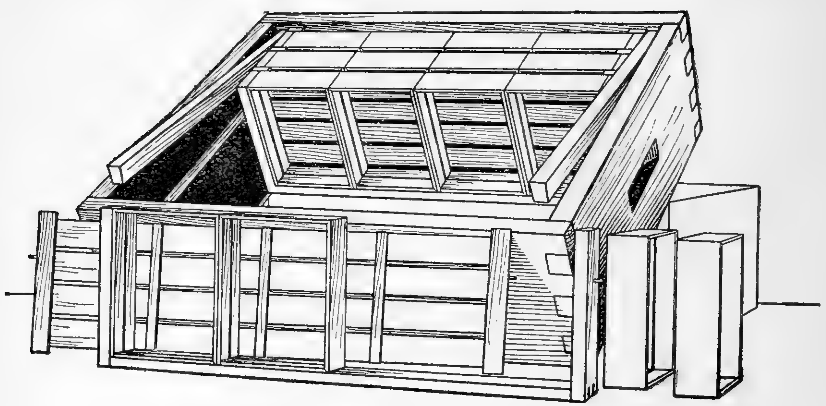

FIG. 10.—Super with section holder for oblong plain sections. (Original.)

be equivalent to a single comb, that the bees might have the same free access to the outside row of cells from all sides as they do the other cells and might pass up or down from any section and the full length of the row, as well as around the ends. While, under the same conditions, such free access to the outside row of cells from all sides would result in the sections being slightly better filled than with the ordinary adjustments, such an arrangement presents some mechanical difficulties and would add considerable to the first cost of the supers. If separators were not necessary, such an adjustment of sections could be readily accomplished. In Europe a type of separator having transverse openings corresponding to the upright edges of the sections is used to give free communication lengthwise of the row of sections. In this country some such separators are used as well as a separator made of wire cloth so spaced between the rows of sections as to give free communication along the rows, as well as from one row to another. These, however, are not widely used in the United States.

The plain section, when used in connection with the "fence" separator (fig. 4), having the upright posts considerably shorter than the height of the section, offers a fair compromise as to free

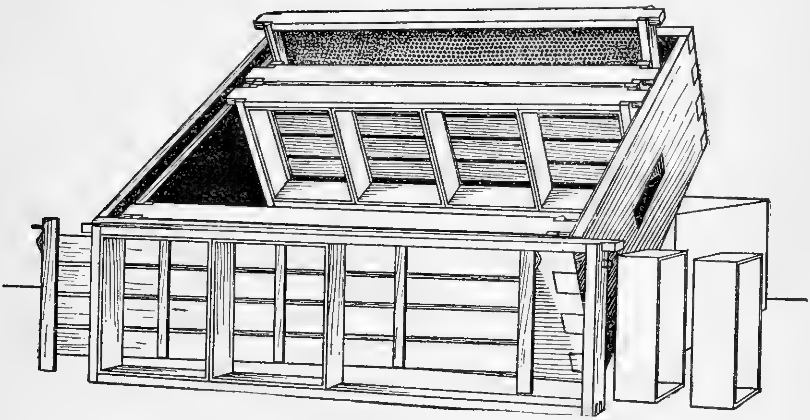

FIG. 11.—Combination super with wide frames for oblong plain sections. (Original.)

communication within the super. Most of the comb honey produced in this country, however, is produced in sections which offer no communication from section to section lengthwise of the super, being produced in the regular 2-beeway section, having openings at the top and bottom only (figs. 7 and 8).

THE USE OF SEPARATORS.

Separators are made of strips of tin or wood and are used between the rows of sections to compel the bees to build the combs straight and all within the section. The thicker the combs the greater becomes the necessity for separators. While an expert can produce very uniform comb honey without separators during a heavy honey flow by using very narrow sections, it is usually not advisable to do so on account of the resulting large percentage of imperfect combs, especially during poor and indifferent seasons and at the close of any season. The use of separators results in a much more uniform product.

SHALLOW EXTRACTING SUPERS.

Some comb-honey producers add to their equipment one shallow extracting super for each colony. These are a great convenience in a comb-honey apiary and may be used for the following purposes: (1) To keep the brood chamber free of honey before the beginning of the main honey flow; (2) to use at the beginning of the honey flow to induce the bees to begin work promptly in the supers; (3) to use at the close of the honey flow instead of the last comb-honey super; (4) to use during any flow of inferior honey or honeydew; (5) to use during very poor seasons when first-class comb honey can not be produced.

COMBINATION SUPERS.

Other comb-honey producers provide each comb-honey super with two shallow extracting combs. These are placed one on each side of the super with the sections between them (fig. 11). The purpose of this arrangement is to induce the bees to begin work in the super promptly without the use of "bait sections" (sections containing comb previously drawn) or an extracting super and also to do away with the usual poorly finished sections in the corners and outside rows. One great advantage of this system over the use of an extracting super to start early super work is that the combs are not removed. When shallow extracting supers are used for this purpose, they are removed as soon as the bees have started well in them and a comb-honey super substituted. This brings back much the same conditions existing before giving the extracting super, and while some colonies will begin work in the sections promptly when the change is made, many colonies hesitate about beginning the new work almost as though the extracting super had not been used. Such colonies are thus thrown out of "condition" (p. 19) and may begin preparations to swarm. The use of these combs in supers that are added subsequently allows the apiarist to place the empty super over the one already on the hive until the bees begin work therein without seriously crowding the super room, because each super thus added contains room in the form of empty comb into which the new nectar may be stored at once (see p. 42).

Other Apparatus.

Among the other apparatus needed in commercial comb-honey production are a honey extractor, wax press, bee escapes, and escape boards (fig. 12), queen-excluding honey boards (fig. 2), feeders, tools, etc. It is not necessary to provide queen-excluding honey boards for each colony unless some special system is followed, yet a few excluders are very desirable for various special manipulations. Good feeders may be had by using tin pans in connection with an empty super. A handful of grass should be placed on the sirup to prevent the bees from drowning. In addition to these appliances in the northern States, if the hives are single walled, some means of protection is necessary if the colonies are wintered out of doors.

Preparing Supers.

FOLDING SECTIONS.

Section presses and foundation fasteners are sometimes combined in one machine by which the section is pressed together square and the foundation is fastened by a single operation. Usually, however, they are separate machines requiring that each section be handled twice before it is ready to be placed into the super. Ordinarily the one-piece sections must be dampened before folding, as otherwise the breakage is considerable and the sections are greatly weakened by folding. A crate of sections as it comes from the factory may be dampened by removing one side so as to expose the V-shaped grooves, then directing a small stream of hot water into these grooves. Care should be taken that only the thin portion where the section is folded be dampened. Another very satisfactory method of dampening sections is to wrap the crates containing them in a wet blanket the day before they are to be folded.

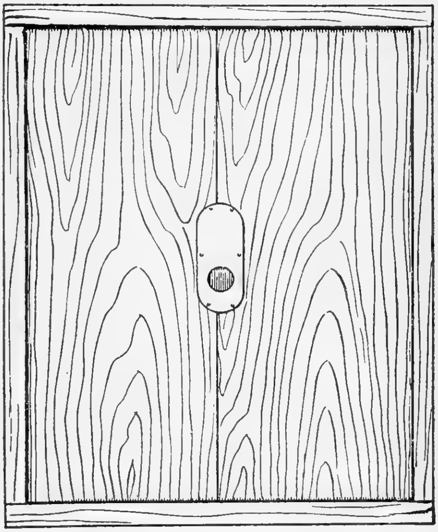

FIG. 12.—Bee escape board for removing bees from supers. (From Phillips.)

FASTENING FOUNDATION IN SECTIONS.

The use of comb foundation in full sheets filling each section as nearly as possible is considered a necessity in the production of fancy comb honey. This foundation should be as thin as can be used without being gnawed or torn down by the bees. The sheet of foundation is usually fastened centrally at the top of the section, leaving only enough space at the sides to allow it to swing freely without binding and about three-sixteenths to one-fourth inch at the bottom to allow for stretching while being drawn out. To secure better attachment of the comb to the bottom of the section, a bottom starter about five-eighths inch wide may be used. In this case the top starter should reach to within three-sixteenths to one-fourth inch of the bottom starter. In some localities the character of the flow is such that but little is gained by the use of the bottom starter, while in other localities it is difficult to produce honey that will stand shipment well without it.

The various types of apparatus usually used for fastening foundation in the sections make use of a heated metal plate which, after melting the edge of the sheet of foundation, is withdrawn, allowing the melted edge to be brought quickly in contact with the section. This fastens one edge of the sheet of foundation firmly to the wood. Foundation fasteners employing this principle may be simply a hand apparatus consisting of a metal plate of proper size provided with a handle, the operator transferring the tool from the source of heat to the edge of the foundation. Or the principle may be incorporated in a more or less complex machine which provides for the maintenance of the proper temperature of the heated plate, its movement to melt the edge of the foundation and a proper support for the section and foundation during the process. For the purpose of securing better filled sections of honey various methods of attaching the sheet of foundation to the sides as well as the top of the section have been devised, but are not extensively used by producers. Among these methods are fitting the sheet of foundation in place, then directing a fine stream of melted wax along its edges, or the use of split sections in which a sheet of foundation is continuous through a row of sections, extending through their sides and top.

Some super construction is such that the sections may be placed directly into the super by the operator who puts in the foundation. This work is usually done during the winter months when the bees require no special attention. Enough supers should be provided to take care of the largest possible crop, even though it is not often that all are used the same season. The beekeeper who is operating several apiaries can not afford to take time to prepare supers for the bees during a good honey flow. Supers of sections thus prepared in advance should be kept clean by storing them in piles and keeping the piles covered from dust.

MANIPULATION OF THE BEES.

It is important to note that there are four essential factors entering into the securing of a crop of honey: (1) A sufficient amount of bloom of healthy and well-nourished nectar-secreting plants growing in soil to which they are adapted and within range of the apiary.

(2) Weather conditions favorable to nectar secretion and bee flight. (3) A large number of workers in excess of those needed for the routine work of the colony. (4) Conditions of the colony making the storing instinct dominant. If any one of these factors is absent, the effect of the other three is immediately nullified, and the amount of honey secured will vary as these factors are present at the same time in greater or less degree or as the time during which they are all present is longer or shorter. It is therefore possible to have each of these factors present at some time during the season without securing a crop of honey and the period of time during which they are all present at the same time is usually quite short.

Grouping the first and second factors we have a combination usually spoken of as the locality and season. These factors are largely beyond the control of the beekeeper except as he may choose a location in which both are usually present at some time or times during the season, may take advantage of the plants of several locations by practising migratory beekeeping, or may improve a given locality by directly or indirectly increasing the amount of nectar-secreting plants, such as buckwheat, alsike clover, sweet clover, or alfalfa.

Grouping the third and fourth factors we have conditions capable of being brought about by manipulation and for which the beekeeper is more directly responsible. The beekeeper's skill therefore lies in supplying and maintaining these factors throughout the short period during which the bees may store more than they consume. He should know which plants may be expected to furnish the nectar for his crop of honey, that his various manipulations may be properly timed. It should be noted that the shorter the duration of the honey flow, the greater becomes the necessity of having the colonies in proper condition at its beginning and keeping them so until its close. However lavish nature may be with the secretion of nectar and fine weather, it is of little avail if the beekeeper fails to secure a large force of workers to gather and store his crop or, even having provided workers, if he fails to keep his forces together and contented, bending all their energy in the one direction of gathering and storing honey. It is a common occurrence among inexperienced beekeepers to have the colonies become strong enough to work in the supers only after the flowers have ceased blooming or to see strong colonies during a good honey flow doing nothing in the supers simply because conditions are not such as to make the storing instinct dominant.

So far as the skill of the beekeeper is concerned in the production of the crop of honey in a given location, every manipulation of the season should be directed (1) toward securing the greatest possible number of vigorous workers at the proper time, and (2) keeping the entire working force of each colony together and contentedly at work throughout the given honey flow.

Securing Workers for the Honey Flow.

Of course, the shorter the period for brood rearing previous to the honey flow, the more serious the problem of getting the colonies strong enough. Adverse weather conditions greatly retard brood rearing and thus have the effect of shortening this period. On the other hand, in some localities the main honey flow comes so late in the season that the colonies may even be divided and both divisions built up.

In most comb-honey localities the season is short and there is usually during the season only one honey flow that furnishes any considerable surplus suitable for comb honey, with perhaps other honey flows either very meager or furnishing honey unsuitable in color. The early minor flows are in such localities utilized in brood rearing in preparation for the main flow, and those occurring after the main flow may be utilized for winter stores, or if sufficient in quantity some surplus may be secured. In localities where the season is made up of a series of honey flows of almost equal importance and with sometimes a long interval between, the problem of securing workers for the harvest is rendered more complex, since the process must be repeated for each crop or the colonies kept very strong throughout the season. As a rule such localities are not the best for comb-honey production.

The workers that gather and store the crop of honey are those that emerge during the few weeks preceding and during the first part of the honey flow. Unless it is of unusual duration, the eggs that produce these workers are all laid before the honey flow begins, since those which develop from eggs laid later are not ready for work until after the close of the flow. On the other hand, the workers that emerge six weeks or more before the honey flow will have died of old age or be too old to be of much value during the flow. Their services, however, are of great value provided they expend their energy to the best possible advantage in rearing brood. If brood rearing ceases or is greatly restricted during this period, a colony that has been strong earlier in the season is rendered almost worthless as gatherers, since it begins the harvest with old and worn-out workers. This is exactly what often happens unless the beekeeper is alert and provides conditions such that brood rearing is not restricted during this period. In the clover belt, for example, it frequently happens that there is a scarcity of nectar during the period when the workers for the harvest should be reared and, unless the colonies are abundantly supplied with stores, brood rearing is greatly restricted. This may to some extent justify the saying among beekeepers that if the early flowers yield well the season will be good. The progressive beekeeper, however, provides conditions favorable to brood rearing even though the early flowers fail to yield nectar. It is therefore highly important (1) that each colony be in a normal condition at a period six or eight weeks previous to the honey flow, and (2) that brood rearing be at its maximum for the entire period of six or eight weeks during which the brood is reared to produce workers available for the honey flow.

BUILDING UP THE COLONY IN THE EARLY SPRING.

The condition of the colonies in the early spring depends upon many factors not all of which are under the control of the beekeeper. In the white-clover belt for instance, where the honey flow comes early, a large percentage of strong colonies in early spring means of course that they have wintered well, which in turn is largely dependent upon proper conditions the previous late summer and autumn. The manipulations having for their purpose the rapid upbuilding of the colony may therefore have their beginning at or even before the close of the honey flow of the previous year, including late summer and fall management and wintering. Good queens, preferably young, with enough room for breeding purposes and a supply of stores during the previous late summer and autumn are among the factors favoring good wintering. During the winter the central idea is the conservation of the energy of the bees, the complex details of which can not be presented in this paper.

The rapidity with which the colonies build up in early spring depends upon a number of conditions, some of which are: (1) The number and vitality of the workers; (2) the age and fecundity of the queen; (3) the supply and location of stores within the hive; (4) weather conditions; (5) the supply of new pollen, nectar, and water; (6) the conservation of heat within the brood nest; (7) the race of bees; (8) the character of the brood combs, etc. Most of these conditions are to a great extent within the control of the beekeeper. By supplying each colony with a young queen the previous autumn, or at least supplanting all undesirable ones, a greater number of young and vigorous workers are reared late in the season, which usually means greater vitality and numbers the next spring. Young queens reared the previous summer or autumn should be in prime condition the next spring. If to this combination is added an abundance of stores within the hives, brood rearing should progress rapidly, even in spite of adverse weather conditions. It is now the general practice among beekeepers to supply enough stores the previous autumn not only for winter stores but for brood-rearing purposes the next spring. Since the amount consumed during the winter varies considerably with different colonies, an early examination to determine the amount of stores may be necessary. Under some conditions it may be found profitable to stimulate brood rearing early in the spring by slowly feeding diluted sugar sirup to each colony, by spreading brood, or by doing both, but any very early stimulation of this kind should be used with caution. Among extensive beekeepers the tendency is decidedly toward letting the bees alone until the weather is more settled, simply making sure that they have sufficient stores. The apiary should, if possible, be so located that the bees may have access to water without the necessity of exposure of a long flight during bad weather. In localities that do not furnish natural pollen, it may be necessary to feed an artificial substitute, such as rye meal. A good hive that will conserve the heat of the cluster is also a great help in early brood rearing. Some beekeepers who winter their colonies in the cellar in single-walled hives find it profitable to give them some additional protection after they have been removed from the cellar. In the northern States double-walled hives are especially advantageous during the spring. A protected location for the apiary in some instances makes a great difference in early brood rearing. Some races breed up more rapidly in the spring than others. The Italians are somewhat conservative in this respect, but have so many excellent traits that they are generally used in this country. In localities having intermittent honey flows Italian bees may not give the best results because of their tendency to restrict brood rearing during the honey flow by crowding the queen and to curtail the production of brood during a scarcity of nectar. Drone comb within the brood nest in early spring is a decided barrier to rapid brood rearing. Many brood combs considered by the average beekeeper to be perfect contain, especially in the upper portion, a large percentage of cells which can not be used for rearing worker brood because of imperfections in shape and size due to the stretching of this portion of the combs during hot weather. This suggests the advisability of the use of a heavier grade of foundation or some method of using vertical wires or wooden splints in the upper half of the sheet of foundation.

THE PRODUCTION OF GATHERING BEES.

During the six or eight weeks just preceding the honey flow every colony should be encouraged to rear the greatest possible amount of brood. Brood rearing during this period is often restricted by insufficient stores or by insufficient room. It is therefore of great importance that both stores and available brood-rearing space be supplied in abundance. If stimulative feeding or spreading the brood is practiced, this is the time it should be done.

Providing Sufficient Stores.

If feeding is not practiced during this critical period, the beekeeper should see that each colony is at all times supplied with a reserve of stores, for surprisingly large quantities are consumed when brood rearing is going on rapidly. If any colonies should run short, brood rearing will be carried on sparingly and the colony so severely crippled that it may not recover its strength until after the honey flow is over.

Whether stimulative feeding or supplying each colony with an abundance of reserve stores is the more profitable depends upon circumstances and must be decided by each beekeeper for his own conditions. Stimulative feeding, if properly done, will undoubtedly result in the rearing of more bees for the harvest. When the beekeeper is operating several apiaries and must travel some distance to reach them the labor involved is considerable, and the question to be decided is whether this labor would yield greater returns if expended in stimulative feeding or in operating a larger number of colonies. If the brood chamber is large and well provisioned or if the flowers furnish some nectar in early spring the colonies may have sufficient stores for this period of heavy brood rearing. Some beekeepers save combs of honey of the previous year to supply food for this period. This is one of the most convenient and satisfactory methods of feeding.

Providing Available Blood-Rearing Space.

There should be no restriction whatever in the room for brood rearing up to the time of putting on the supers, just previous to the honey flow, for a crowded brood nest at this time tends to diminish the number of workers available for the honey flow as well as to encourage swarming.

If the space for brood rearing should be restricted by too much early honey in the brood chamber some of the heaviest combs should be removed and empty ones given instead, or an extra brood chamber containing empty combs may be given. In localities where considerable early honey is gathered the brood chamber may be kept almost free of honey by placing an extracting super over each colony at the beginning of such a flow. This super should not be removed until the comb-honey supers are given, for the honey may be needed later in brood rearing.

Should the brood nest be restricted by a small brood chamber the colonies may be equalized by removing some frames of brood from the stronger colonies, exchanging them for empty combs taken from weaker colonies, or another brood chamber filled with empty combs may be given, thus building the colonies up individually.

The former method has the following advantages: (1) After being built up to approximately the same strength, most of the colonies will be ready for a given manipulation at the same time, thus facilitating the work. (2) It requires a smaller stock of extra brood chambers and combs, at least previous to the honey flow. (3) The brood is in a more compact form, which is a very desirable condition in comb-honey production. (4) When properly done, the total number of young bees reared in a given time is probably considerably greater, owing to the fact that none of the colonies is strong beyond the capacity of the queen, the workers of the entire apiary being so distributed that all the queens are utilized to the best possible advantage. (5) When the honey flow begins the colonies are ready for the supers without additional manipulation, such as removing extra brood chambers, sorting combs of brood, etc. In equalizing colonies combs of hatching brood with the adhering workers, *without the queen*, are usually drawn from the strongest colonies and given to colonies less strong, but *never to very weak colonies.* The weakest colonies are left until the last, then built up quickly, provided there is time enough to have all the hives well filled with brood. If this is not possible the very weak colonies can more profitably be used for purposes other than comb-honey production. Another plan of equalizing is that of shaking bees from combs taken from strong colonies at the entrance of colonies less strong. The older bees at once take wing and return to their hives, while the younger bees enter the weaker colony. The operator must, of course, be sure that the queen is not on the comb thus shaken.

Some of the advantages of building up the colonies as individuals are: (1) The labor required is considerably less, fewer visits being required, so that this method is particularly adapted to out-apiary conditions. (2) It is possible to determine with much greater accuracy which colonies show the most desirable traits for breeding purposes. (3) It can be more safely practiced if brood diseases are imminent.

SUMMARY.

(1) The workers that take part in storing a crop of honey from any given honey flow are usually those reared within the period of six or eight weeks just preceding the honey flow. The workers reared previous to this period are too old to be of much value as gatherers, while those reared after this period mature after the flow has ceased.

(2) It is necessary that the beekeeper know what plants are likely to furnish the surplus honey and their approximate period of bloom, so that he can determine the limits of the heavy brood-rearing period in order to secure the largest possible working force for the honey flow.

(3) Colonies should be in a normal condition at the beginning of this period. (*a*) If the surplus is from an early flow, this normal condition can be obtained only by proper management the previous late summer and autumn, together with good wintering. Good queens, preferably young, together with sufficient room for brood rearing and winter stores, are important conditions during late summer and autumn. (*b*) Stores and protection are important factors in early brood rearing. (*c*) The character of the brood combs and the race of bees each have some influence upon brood rearing.

(4) During the time that workers for the harvest should be reared brood rearing should be constantly accelerated.

(5) Brood rearing is often restricted during this period (*a*) because of limited stores and (*b*) because of limited room in the brood chamber.

Using Available Workers to Best Advantage During the Honey Flow.

Brood rearing, which is of primary importance during the preceding period, becomes of secondary consideration at about the beginning of the honey flow, because this is nearing the limit beyond which time the resulting bees develop too late to take part in gathering and storing the crop of honey. At this time, therefore, there is a radical change in purpose of the manipulations. Instead of continuing the expansion of the brood chamber, the policy of the beekeeper should now be rather a concentration of the workers and brood. There is perhaps a limit to the number of workers that can be profitably kept in a single hive and set of supers, but this limit is seldom reached, the usual mistake being in having too few. Each colony should have its brood chamber well filled with brood in a compact form and be so crowded with young and vigorous workers that they will immediately occupy the supers when the honey flow actually begins. The brood chamber of colonies occupying more than one hive body should at this time be reduced to one, any extra brood being used in colonies having less than one brood chamber full of brood. After this operation, should there still be some colonies left with the brood chamber but partly filled with brood, they should be filled with combs of brood and adhering bees (without the queen) drawn from some colony or colonies too weak to work well in comb-honey supers.

It may be advisable to unite the weaker colonies in order to secure the proper strength for the best work. This massing of the workers in strong colonies, so essential to the production of a fancy grade of comb honey, renders necessary extremely careful and skillful management, since the efforts of the beekeeper may still be nullified in either of two ways: (1) The bees may divide their forces by swarming into two or more parts, neither of which would be ready to work in the supers until the season is much advanced or perhaps closed entirely, or (2) being balked in their desire to swarm or from lack of convenient storage space, etc., they may do very poor work even during a good honey flow simply because the conditions of the colony are such that the storing instinct is not dominant. *To bring about the best results in comb honey, the entire working force of each colony must be kept undivided and the means employed in doing so must be such that the storing instinct remains dominant throughout any given honey flow.* Any increase made before or during the flow [1] is made at the expense of the surplus honey unless it be made with brood that would emerge too late for the young bees to be of use during the honey flow (p. 31). In general, however, increase may be made at much less expense by setting aside some of the colonies for that purpose. To keep the forces together and satisfied, with the storing instinct dominant during a good flow, is the most difficult problem with which the producer of comb honey must deal.

Swarming.

All colonies do not behave alike as to swarming. (1) There are certain colonies that go through the season with apparently no thought of swarming. Such colonies do the very best work in the supers, and their number can be increased by skillful management. (2) Other colonies start queen cells preparatory to swarming, but can be persuaded to give it up by such mild measures as destroying the queen cells and perhaps removing a few frames of brood. (3) Certain colonies are determined to swarm and, unless the flow ceases, nothing short of swarming or some radical manipulation will satisfy them. (4) A certain percentage of queens fail during the honey flow and swarming may occur in connection with the supersedure. Such colonies usually do very poor work in comb-honey supers.

The beekeeper can do much (1) toward increasing the percentage in the first group and discouraging those of the second—*preventive measures*, and (2) toward making the most of the colonies under the third and fourth groups—*control measures.*

PREVENTIVE MEASURES.

Some effort has been made toward the final elimination of swarming by breeding from colonies showing the least disposition to swarm. Although after years of selection bees continue to swarm when conditions are favorable, many practical beekeepers testify to having greatly reduced the percentage of swarming colonies by years of careful selection and breeding. It would certainly seem advisable to

[1] In localities where the main honey flow is so late that colonies may be divided long enough before the flow so that both colonies may be built up to proper strength in time to take advantage of it, of course increase previous to the flow would be advisable. This condition is rare in comb-honey localities.

replace the queens of all colonies which persist in swarming with young queens reared from colonies less inclined to swarm. The swarming problem has also been attacked from the standpoint of the hive and mechanical attachments, finally resulting in the invention of a "nonswarming" hive. More attention has, however, been paid to the prevention and control of swarming by manipulation than along either of the other lines, probably because proper manipulation gives immediate results and is now available as a means of preventing the losses due to swarming. The success in swarm control attained by the best beekeepers is a result of some effort along all three of the above lines at the same time.

Among the manipulations that tend to discourage swarming are (1) the introduction of young queens (preferably reared from selected stock); (2) an abundance of empty comb in the brood chamber at all times previous to the honey flow; (3) prompt work in the supers at the beginning of the flow induced by using "bait sections" or extracting combs in the first super given, thus tiding the colony over one of the critical periods; (4) a judicious manipulation of the supers during the honey flow (p. 41); (5) the use of more nearly perfect worker combs in the brood chamber, since drone comb and imperfect cells (p. 22) have the effect of contracting the brood chamber, thus bringing about a crowded condition; (6) an abundance of ventilation during the honey flow, obtained by means of a large entrance or by raising the hive above the bottom board by means of small blocks; (7) protection of the hive from direct rays of the sun during the hottest portion of the day by some such means as a double cover or shade board; (8) the removal of one or two frames of brood and the substitution therefor of empty combs or sheets of foundation; (9) the destruction of all queen cells provided they contain only eggs or very small larvæ.

If queen cells are well advanced, their destruction usually has little or no effect as a swarm preventive measure. While destroying queen cells in their early stages can not be relied upon as a preventive of swarming, beekeepers who practice examining the brood chambers once a week for queen cells during the swarming season are usually surprised at the number of colonies that can be induced to give up swarming and turn their attention to storing in this way. Such a result at least partly compensates for the large amount of labor required for these weekly examinations.

CONTROL MEASURES.

After having taken all precautions as to preventive measures there will still be some colonies that will attempt to swarm when producing comb honey. During poor seasons of course the percentage may be quite low, but during good seasons the conditions are sometimes such that a majority of the colonies may make an effort to swarm. Swarming colonies, however, may be controlled in such a manner that practically as much surplus honey is secured as if the colony made no attempt to swarm. If but a single apiary is being operated and the beekeeper is present during the swarming season, the bees may be permitted to swarm naturally without loss to the beekeeper; but if several apiaries are being operated, it is more economical to employ some method by which swarming may be controlled by visiting each apiary at given intervals during the swarming season, rather than to have an attendant at each.

Control of Natural Swarms.

Natural swarms may be managed (1) by allowing them to cluster naturally, then hiving them in the ordinary manner; (2) by the clipped queen method; (3) by the use of queen traps (fig. 13; see Farmers' Bulletin No. 447, pp. 29–30); or (4) by use of the swarm catcher.[1]

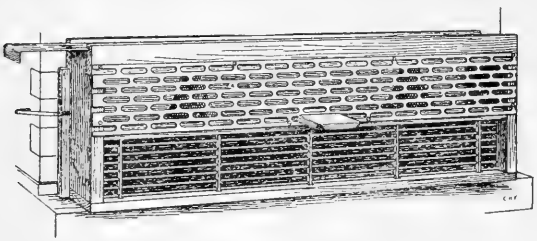

FIG. 13.—Drone and queen trap on hive entrance. (From Phillips.)

To keep the forces together (1) the swarm without the queen may be returned to its hive, the queen cells destroyed a week later, and the colony afterwards requeened (p. 36); or (2) the brood may be removed from the hive while the swarm is out, after which the swarm with the queen is returned. The former method is useful under some conditions (p. 37), but the latter is the one usually preferred.

When the swarm is hived back without the brood on its old location in this manner, the colony does not lose any of its flying bees and is back at work with renewed energy in the same set of supers it was but a few minutes before so eagerly deserting. Instead of removing the combs from the brood chamber the usual practice is the removal of the entire brood chamber and the substitution of another whose external appearance is the same. This method of swarm management keeps the bees, queen, and supers together and is one of the most satisfactory known. It is not, however, adapted to out-apiaries or any apiaries not having an attendant, and requires considerable time in watching for and hiving swarms.

[1] This is simply a wire-cloth cage large enough to be set over the hive or be fitted over the entrance. If the attendant is provided with a number of these catchers he can avoid the usual confusion ordinarily occurring when several swarms issue at about the same time. After being caught in this manner the swarms may be hived at the convenience of the beekeeper.

USING THE REMOVED BROOD TO BEST ADVANTAGE.

The disposition of the brood that is left when a swarm issues should be such that (1) no "after-swarms" (swarms resulting from the emergence of a plurality of virgin queens) are permitted to issue and (2) that the emerging workers may be used to the best advantage.

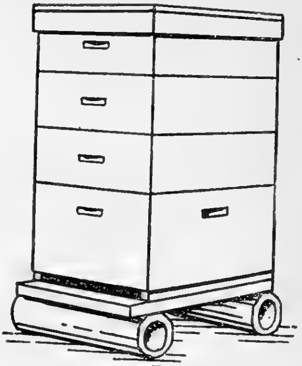

FIG. 14.—Colony before swarming; supers in place. (Original.)

"After-swarming" may be prevented by (1) breaking up the parent colony before any of the young queens emerge, using the unhatched brood elsewhere, (2) by destroying all queen cells but one before any young queens emerge, or (3) by greatly reducing the population of the parent colony[1] just before the young queens emerge.

If swarming occurs at a time when the resulting young bees can take part in gathering and storing the crop of honey, the usual practice is to allow the brood to emerge in a separate hive and later to add these young bees to the colony from which it was taken. Under such circumstances this reenforcement of the swarm is especially desirable, since otherwise its forces are constantly diminishing during the 21 days (the time required for worker brood to develop) immediately following the removal of all its brood. The brood, however, may be used anywhere in the apiary and should be placed where the resulting bees will be most needed. The plans given below make use of at least a part of the emerging bees in reenforcing the swarm from which the brood was taken.

FIG. 15.—Brood placed in hive turned 90 degrees from old entrance. (Original.)

When hiving natural swarms on the old location as suggested above, the old brood chamber is provided with a bottom and cover and set aside, usually with its entrance turned away about 90° from its former position (figs. 14, 15). This

[1] The term "parent colony" applies to the one in the hive from which the swarm issues and is in common use, though the correctness of the term is questionable.

is to prevent any field bees returning to the parent colony. A day or so later it is turned about 45° toward its former position (fig. 16) and as soon as the bees have this location of the entrance well marked the hive is placed parallel to the hive on the old stand (fig. 17). So far as the bees returning from the field are concerned, these two colonies are now on the same stand.

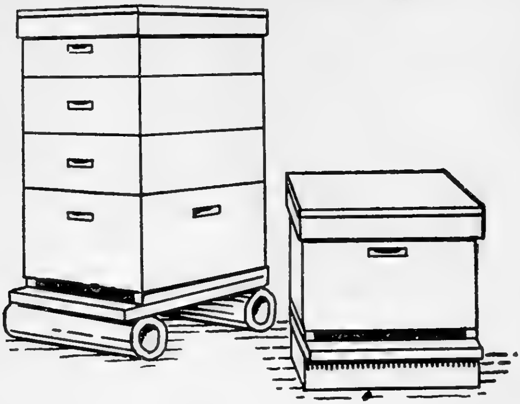

FIG. 16.—Hive with brood turned back to 45 degrees from old entrance. (Original.)

The further disposition of the remnant of the brood and young bees may be by any one of the following methods: (1) One week after the swarm issues, or just before the parent colony would cast a second or "after-swarm," it may, when the bees are well at work in the fields, be removed and given a new location. This throws the entire flying force into the colony having the supers, where they are of greatest service, and so depletes the other colony of its flying bees just when the young queens are emerging that "after-swarming" is usually prevented. (2) Before moving it away the parent colony may be more thoroughly depleted of its young bees by shaking most of them from their combs, adding them of course to the colony with the supers. The comb containing the finest queen cells should not be shaken, since to do so will probably injure the immature queens. Two or three frames should be left with their adhering bees in order that the parent colony will still contain enough workers to care for the remaining unemerged brood. (3) Instead of moving the parent colony away as in (1) above, the bees may all be added to the swarm by shaking them from their combs, and the combs then distributed among nuclei previously prepared. By successive additions of frames of brood these nuclei are finally built up into full colonies and "after-swarming"

FIG. 17.—Hive with brood turned parallel to old entrance. (Original.)

is prevented. (4) Instead of giving the parent colony a new location, as in (1) above, it may be shifted to the opposite side of the swarm on the old stand (fig. 18) and by thus shifting it from one side to the other at intervals of several days the young bees as they hatch and learn to fly will finally all be added to the colony with the supers. Few beekeepers, however, go to this extreme, as the season usually closes before the latest emerging young bees are thus transferred to the colony with the supers and these later-emerging bees may be used for increase at little if any expense in surplus honey. (5) If increase is not desired, the bees may be added to the swarm on the old stand as before, and after 10 or 15 days the combs of the parent colony still containing some unhatched brood may be used on which to hive another swarm. Before being used for this purpose the bees are of course shaken from these combs and added as before to the swarm on the old stand. (6) If the honey flow is of long duration or conditions otherwise such that the storing colony may prepare to swarm again, the brood chamber of the parent colony may be left by the side of the swarm (fig. 18) until the young queen begins to lay, then restored to its original position on the old stand and the supers transferred to it. The brood chamber containing the old queen is moved to one side, its flying bees thus induced to enter the hive containing the young queen. The two colonies may afterwards be united or the one containing the old queen may finally be moved to a new location for increase. If, when using this plan, a virgin queen or a ripe queen cell is given the parent colony just after the swarm issues, this colony is ready to be restored to its original position on the old stand about a week earlier than if left to requeen itself.

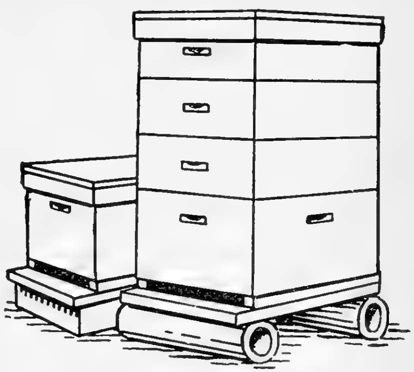

FIG. 18.—Hive with brood placed on other side of old entrance. (Original.)

In case the emerging bees are not to be added to the storing colony the brood and young bees may be used in one of the following ways: (1) They may be used immediately after the swarm issues to build up such colonies as are not strong enough to work in the supers or to build up previously prepared nuclei, as in (3) above. Before being used in these ways the adhering bees are usually added to the swarm. (2) The parent colony may be placed at once on a new stand and given a laying or virgin queen. To allow such a colony to requeen itself usually results in its casting an "after swarm," since it becomes quite populous again before the young queens emerge. This plan does not make immediate use of the emerging bees but may be useful under some conditions. (3) If the honey flow is of long duration or is followed closely by a second, two parent colonies, as in (2) above, may be placed upon the same stand, one of which is given a queen but with the queen cells destroyed in the other. After two or three weeks the bees may be shaken from the queenless colony in with the queen-right one. Such colonies are in excellent condition for rapid work in the supers.

WHAT TO USE IN THE BROOD CHAMBER WHEN HIVING SWARMS.

(1) The use of narrow strips of foundation 1 inch or less in width in the brood chamber offers some advantages. (*a*) When the brood chamber contains only these narrow "starters" and supers of partly filled sections are transferred from the parent colony to the new swarm at the time of hiving, there being no cells below in which to store the honey, it is taken to the supers. Under these conditions work in the brood chamber goes on slowly, the work of the colony being largely in the supers. (*b*) Colonies that are thus required to construct a set of new combs in the brood chamber and that are supplied with sufficent storage room seldom attempt to swarm again during the same season, even though the flow be of long duration. (*c*) The treatment of brood diseases may be combined with swarm control. (See Farmers' Bulletin No. 442, p. 14.) The greatest objection to their use is in the excessive amount of drone comb usually built when anything less than full sheets of foundation are used, especially if the queen is old or the brood chamber large in proportion to the size of the swarm.

(2) The use of full sheets of foundation in the brood frames has the decided advantage of resulting in straight combs having the maximum number of cells of the worker size, but is more expensive than the narrow strips and allows a more rapid building of comb in the brood chamber, which under some conditions is considered a disadvantage.

(3) The exclusive use of either narrow strips or full sheets of foundation in the brood chamber when hiving swarms necessitates the use for a short time of a queen excluder (fig. 2) if the supers are transferred from the parent colony to the swarm at the time of hiving, since otherwise the queen would probably enter the sections and a brood nest be established there. To avoid the use of queen excluders for this purpose, one or more empty combs may be used in each brood chamber, the remaining frames containing full sheets of foundation. This empty comb also serves as a storage place for pollen that may be gathered before the other combs of the brood chamber are constructed. Otherwise this pollen may be stored in

the sections (p. 46). It is also probable that fewer colonies will "swarm out" or desert their hives if hived in a brood chamber containing one or more empty combs than if foundation only is used. A disadvantage of this plan is that the cells near the top bar of the comb may be so elongated as to interfere with the complete drawing out of the foundation in the adjacent frame. Empty combs can not well be used in connection with narrow strips of foundation, since their use favors the construction of drone comb.

(4) Empty combs are sometimes used with the idea of saving the bees the work of constructing a new set of combs. Under same conditions this is false economy and gives poorer results than starters or foundation. With very strong colonies, or with the brood chamber contracted to five or six frames, empty combs in the brood chamber may give good results. Medium colonies on a full set of empty combs are inclined to store the honey in the brood chamber and neglect the supers.

(5) Combs of honey are sometimes used on which to hive swarms. In some instances the beekeeper uses frames of foundation or empty combs above the brood chamber previous to and during the first few days of the honey flow for the purpose of discouraging swarming and afterwards uses these partly filled combs on which to hive swarms. In order to make room for the queen, this honey is rapidly carried above, and stored in the sections.

(6) Combs of sealed brood in which no eggs have been laid during the previous 10 days or 2 weeks may be used. Such combs are usually available toward the close of the swarming season from colonies that have swarmed 10 days or 2 weeks before. This plan is especially desirable when the beekeeper runs short of hives during the swarming season. In some localities, however, the character of the flow is such that the colonies may later again prepare to swarm when hived on either empty combs or combs of sealed brood.

EXTREME CONTRACTION OF THE BROOD CHAMBER WHEN HIVING SWARMS.

Some beekeepers contract the brood chamber, when hiving swarms, to five or six frames, the remaining space being filled by means of division boards or "dummies." This reduction in the capacity of the brood chamber results in practically all the honey being stored in the supers and also restricts brood rearing at a time when the resulting bees develop too late to become gatherers. This is especially adaptable to locations furnishing an early flow of white honey followed by a later flow of darker honey. The white or more marketable honey is stored in the supers and later the brood chamber is expanded and provisioned for winter with the less desirable honey.

Some beekeepers accomplish a somewhat similar result by hiving two swarms together in a single hive body.

When practicing contraction it is best to give the full amount of room at the time of hiving the swarm and to reduce the space three or four days later, as otherwise the bees are apt to "swarm out" because of their cramped quarters. Since contraction of the brood chamber is but a temporary expedient, it should not be continued beyond the time that its use is of advantage. If there should be a later honey flow, the brood chamber should be expanded in time to rear the bees for it. In any event, contraction should not continue so long as to interfere with securing the proper conditions of the colonies for winter (p. 21). Frames of foundation, empty combs, frames of brood or honey may be used to complete the set of combs when expanding the brood chamber, and these are usually given just before or at the close of the honey flow. Contraction of the brood chamber to less than one hive body, except in hiving swarms, is not usually advisable.

Swarm Control by Manipulation.

Swarm control by manipulation enables the beekeeper to operate a series of apiaries by visiting each at certain intervals, thus eliminating the necessity of an attendant in each apiary during the swarming season. The fact that bees usually, by the construction of queen cells, indicate about a week in advance their intention to swarm, enables the beekeeper to control swarming by examining each colony once a week during the swarming period and forestalling the colonies that are making preparations to swarm. It is also possible to manipulate all the colonies before any swarming occurs so that most of them go through the honey flow without swarming, thus eliminating the weekly examinations.

Any manipulation for swarm control, whether applied after the colony has acquired the "swarming fever" or applied to all colonies alike previous to the swarming season, is based upon the single principle—*a temporary disturbance in the continuity of the daily emergence of brood.* This disturbance should occur just previous to or during the swarming season. In natural swarming the brood and the swarm are separated, the swarm being without hatching brood during a period of three weeks. The brood from which the swarm came may be allowed to emerge in a separate hive and the resulting bees may then be returned to the swarm (p. 29). In this way the swarming instinct is satisfied, at least temporarily, without materially decreasing the population of the colony. The beekeeper may anticipate swarming by removing the brood from the hive, allowing it to emerge in a separate hive and finally returning these young bees to the colony in the same manner as is done with the natural swarm. Under the same conditions the subsequent behavior of a colony treated in this way is similar to that of a natural swarm. In either case there has been a break in the continuity of the emergence of young bees in the hive during a period of three weeks.

Instead of hiving a natural swarm upon empty combs or frames of foundation, combs of emerging brood (without queen cells) taken from a colony that has been queenless during a period of 10 to 15 days may be used (p. 33) and a similar condition may be had without swarming by removing all of the brood and substituting such combs of emerging brood, thus at least temporarily avoiding swarming. In these cases there is a break of 10 to 15 days in the continuity of the daily emergence of bees.

A similar interruption of brood rearing may be accomplished by removing the queen from the hive or caging her within the hive during a period of 10 days or 2 weeks, then returning her to the combs. In this case no queen cells must of course be allowed to mature. A condition similar to this may be obtained without removing the queen by dividing the brood chamber into two parts with queen-excluding metal, for a period of 10 to 15 days. The brood from the division containing the queen is then removed and the bees, together with the queen, shaken into the other (queenless) division, the queen cells if any being first destroyed. The brood thus removed may later be returned to the colony in the form of young bees in the usual manner (p. 29). Even the destruction of the sealed brood by uncapping it has been advised as a means of swarm control. This gives a period of about 12 days during which few or no young bees emerge.

These methods are illustrative of the principle employed in the various methods of control by manipulation, which may be classified under three general headings: (1) Taking the queen from the hive. (2) Taking the brood from the hive. (3) Separating the queen and brood within the hive.

The following methods of swarm control are given for the purpose of illustrating the various types of control by manipulation. It is not to be understood that all the methods given are equally adaptable to any locality or season, but it is hoped that, presented in this way, the beekeeper may more readily see the principle underlying each plan as well as the basic principle underlying all the plans and thereby be better enabled to elaborate a system of control to meet his particular requirements.

TAKING THE QUEEN FROM THE HIVE.

The temporary removal of the queen from the colony for the required time (p. 36) and the return of the same queen is a method which has been used in swarm control. Of course, no queen cells should be permitted to develop in the meantime. Such colonies may prepare to swarm again, especially if the period of queenlessness is not more than 10 days. The method is a valuable one, however, and may be used at any time during the season on colonies making preparations to swarm.

Dequeening in connection with requeening.—Requeening each colony with a young queen early in the season may greatly reduce the percentage of colonies that attempt to swarm but can not be relied upon as a method of complete control since during a good and prolonged honey flow quite a number of such colonies prepare to swarm. If each colony is requeened with a young queen at the beginning of the honey flow, *after having been queenless for 10 or 15 days,* there will probably be very little if any swarming during an ordinary season. This method is not in general use among beekeepers, largely because of the difficulty in so timing the operation that there will be no loss. The following are illustrative of the various adaptations of requeening in connection with a period of no brood rearing.

(1) Just previous to the honey flow and at about the time that heavy brood rearing is no longer desirable, remove the queen from each colony. (*a*) Eight or ten days later destroy all queen cells but one and allow the colony to requeen itself, or (*b*) destroy *all* queen cells 8 or 10 days after removing the queen, then after 3 to 6 days supply each colony with a "ripe" queen cell (one in which the queen is ready to emerge), a virgin queen, or a young laying queen. It is usually desirable that the interval of queenlessness be as short as possible without defeating its purpose. Some beekeepers give a young laying queen 10 days after removing the old one, or a virgin or ripe cell considerably earlier, sometimes even at the time the old queen is removed, while others prefer a period of at least 14 days before giving either a laying or a virgin queen. However, colonies with virgin queens sometimes swarm even though no other queen cells or larvæ from which to rear a queen are present. Another objection to the use of queen cells or virgin queens for this purpose is that some of the queens fail to emerge and some virgin queens fail to mate, thus leaving the colony hopelessly queenless. For these reasons, some prefer to have the young queens mate and begin to lay in "nuclei" (very small colonies) before introducing[1] them in the strong colonies. This method may be used for the entire apiary at the beginning of the honey flow or it may be applied only to those colonies making preparations to swarm.

(2) Use two hive bodies as a brood chamber before the honey flow, uniting if necessary to secure strong colonies. At the beginning of the honey flow divide each colony, leaving the field bees and most of

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[1] These young laying queens may be introduced into the colony by the ordinary indirect or caging method (Farmers' Bulletin No. 447, p. 44) or together with a comb of brood and adhering bees from the nucleus from which she was mated.

the brood on the old stand in one hive body, placing the queen, remaining brood, and enough bees to care for it in the other hive body which is set beside the first. The supers are of course given to the queenless colony on the old stand, which after the proper interval of queenlessness is allowed to requeen itself or is requeened by the beekeeper as in (1) above. The colony containing the old queen may be used to strengthen the storing colony by shifting its position from one side of it to the other (p. 31), or used for increase.

(3) Ten days before the honey flow is expected to begin, put most of the brood into a single hive body, on this a queen excluder, and over this a second hive body with a frame of brood and the queen, the other combs of this set being empty except perhaps a little brood and honey. Nine or ten days later remove the upper story, supply it with a bottom board, and place it close beside the original hive. Destroy queen cells if any are present in the queenless portion which remains on the old stand, give a ripe queen cell, virgin queen, or a young laying queen, and put on the supers. The brood chamber containing the old queen may be used to make increase or its flying bees may be united with the storing colony (p. 31).

By any of these methods there is a break of 10 to 15 days in the continuity of brood emergence in the brood chamber left on the old stand and the colonies are requeened with young queens—each a strong factor in swarm control and when combined should with rare exceptions result in no swarming.

REMOVING THE BROOD FROM THE HIVE.

Since removing the brood brings about conditions quite similar to that of natural swarming (p. 28), such a management of the colonies is practically identical with that of natural swarming. The use of the brood that is removed (p. 29), the question of what should be used in the brood chamber instead of the removed brood (p. 32), the contraction of the brood chamber (p. 33), etc., have been discussed under natural swarming and need not be repeated here. While some of the plans using this principle may be applied to all the colonies in the apiary before swarming actually begins, the usual practice is to apply them only to such colonies as are making preparations to swarm. It should not be used on weak colonies, on colonies having a small percentage of sealed and emerging brood and few young bees, on colonies in which the queen is failing, or on any colonies during a very poor season. Under any of these conditions it is usually better to discourage swarming by destroying queen cells (p. 27), by removing one or two frames of brood, or, if some control measure is finally necessary, by requeening such colonies after an interval of queenlessness. On the other hand, for strong colonies having a high percentage of sealed and emerging brood and a good queen the method usually gives excellent results, since by its use the workers, queen, and supers are kept together during the flow. The following are some of the various plans employing this principle of swarm control:

(1) Find the queen and put the comb on which she is found to one side, then shake the bees from most of the other combs into or in front of their hive. As the combs of brood are removed put frames containing either narrow strips or full sheets of foundation or combs into the hive and replace the supers. When most of the shaken bees are in the hive, place the queen among them. Put all the brood and the few bees remaining thereon into another hive close beside the shaken colony (fig. 17). Enough bees should be left on the combs of brood to care for it; usually two combs are not shaken at all, but placed in the other hive with all the adhering bees. For further disposition of the brood see page 29.

(2) In order to avoid the trouble of finding the queen, the above plan may be varied by shaking and brushing *all* the bees from the combs so as to be sure that the queen is among them. In this case the brood may be utilized by one of the following plans: (*a*) Use it to build up weaker colonies (p. 31) or (*b*) place it in a hive body over a queen excluder on top of the forced swarm or some colony not being used for comb-honey production that can spare enough bees to care for it. In a short time bees will pass through the excluder and cover the brood, after which the hive body containing it is removed, supplied with a cover and bottom board, and placed at one side of the forced swarm so that the emerging bees may later be added to the swarm. Or (*c*) after the shaking is complete, remove the forced swarm and put the hive body containing the brood temporarily back on the original stand to induce field bees to enter it. Then in the evening set it aside and restore the swarm to its position on the old stand. These field bees will be able to prevent the brood being chilled during the night but in returning from the fields the next day will enter the hive on the old stand. In the meantime enough young bees will have emerged to care for the brood.

(3) Removing all the brood and substituting frames containing narrow strips or full sheets of foundation sometimes results in the colony swarming out the next day. This may be avoided by removing the brood in two installments with an interval of a few days between the two operations. When the brood is not all removed, full sheets of foundation or empty combs should be used or an excessive amount of drone comb will be built.

With sectional hives, stand the brood chamber on end, smoke the bees out of the lower section, and remove it. Destroy queen cells in the upper hive section. These will almost universally be found projecting into the space between the two sections of the brood chamber.

Substitute a new hive section containing empty combs or foundation for the removed section. After a few days remove the supers, smoke the bees out of the upper section, remove it, and add it to the section that was removed before, which at the time of its removal was given the usual position beside the colony (fig. 17).

(4) Use two hive bodies as a brood chamber throughout the year except during the honey flow. Have both as well filled with brood as possible previous to the flow. About 10 days before the honey flow is expected to begin, insert a queen-excluding honey board (fig. 2) between the two hive bodies. The queen is now confined to a single one of the hive bodies. After 10 days transfer the queen[1] to the other hive body placed on the old stand and put on the supers. Remove the hive body in which the queen has been confined to one side of the colony on the old stand and supply it with a ripe queen cell (in a protector) or a virgin queen. When the young queen begins to lay, exchange places with the two hive bodies so that the one containing the young queen now becomes the storing colony, giving it the supers and field bees. Shift the hive containing the old queen from one side to the other of the colony on the old stand about once a week, so that the entire flying force of both are at work in the hive with the supers (p. 31). At the close of the honey flow the old queen may be killed unless she is especially valuable and the two divisions may be reunited. The period of 10 days during which no eggs are laid in the hive body used by the storing colony at the beginning of the honey flow should delay swarming at least until the young queen begins to lay. When the other hive body with the young queen is substituted, it has had a similar period of no egg laying in addition to having a young laying queen, making a desirable combination.

Mechanical devices.—A number of mechanical devices have been described for shifting bees from one brood chamber to another. These permit the bees to leave the hive when going to the fields and are so arranged that the returning bees are led to enter the new brood chamber. This is accomplished by means of switches in the bottom board or by a chute or tube so attached that the entrance to the old brood chamber is closed, allowing exit only through the tube which opens near the entrance of the new brood chamber. In either case the hives are so arranged that the bees returning from the field readily enter the new brood chamber. The queen is found and together with a comb of brood and adhering bees is put into the new brood chamber, and the supers are transferred from the old to

[1] It is not necessary to find the queen, since the presence of unsealed brood indicates in which hive body she is confined. She may be transferred to the other hive body by shaking all the bees from the combs she is known to occupy in with the bees of the other hive body. In this case some bees are returned to the shaken combs (p. 38) before this brood is set aside, to prevent its being chilled.

the new brood chamber. The young bees as they learn to fly are added to the swarm by the same device. Otherwise the manipulation is the same as the other methods described.

SEPARATING THE QUEEN AND BROOD WITHIN THE HIVE.

In some swarm-control methods neither the queen nor the brood is removed from the hive, but these are temporarily separated within the hive. These methods are ordinarily used only on colonies making preparations to swarm and are practically equivalent to the dequeening plan. The following methods make use of this principle of swarm control:

(1) The queen may be placed in a wire-cloth cage within the hive or may be confined to a small comb surface within the brood chamber by means of queen-excluding zinc. No queen cells are permitted to mature, and the queen is liberated after 10 to 15 days.

(2) The queen together with a comb containing a small amount of brood is placed in a lower hive body containing no other frames or combs. After destroying all queen cells the brood is placed in a second hive body, the two hive bodies being separated by a queen-excluding honey board and the supers adjusted above the brood as before. The queen, being separated from the brood by means of the excluder, lays few eggs in the comb on which she is confined during this period of separation. After a week or 10 days the queen cells are again destroyed, and the brood and queen are put back into a single hive body as before. This method gives results quite similar to the dequeening method (p. 35).

If every season were alike in a given locality the beekeeper could work out a manipulation to be applied to each colony just before or at the beginning of the honey flow, which would result in practically no swarming. The wide variation in the seasons, however, renders it next to impossible to adopt a swarm-control measure that will prove most profitable every year. The means of control adopted must be such as to favor the domination of the storing instinct. Probably the plan of making weekly visits is the most widely used system of swarm control by manipulation. When a colony is found preparing to swarm, the brood is removed if conditions are such as to justify doing so (p. 37). Otherwise the removal of the queen is resorted to.

With any of these methods of control the colony may rapidly restore former conditions, and even though it has been diverted from swarming may later again prepare to swarm and require a second manipulation. Generally speaking, when the honey flow is short, less radical measures are required. Colonies that have been supplied with young queens after a period of queenlessness have one factor (the queen) changed with at least some degree of permanency. Colonies that have been compelled to construct a new set of brood combs from narrow strips of foundation have the most radical change of conditions as to brood rearing. Either of these changes alone is usually sufficient to insure no further preparations to swarm.

Manipulation of the Supers.

Proper manipulation of the comb-honey supers is not only a strong factor in the prevention of swarming but is also a stimulus to storing. The amount of room the colonies should have in the surplus apartment varies so much that the ordinary standard super is simply a unit in a large and flexible surplus apartment. If enough surplus room is given at the beginning of the season for the storage of the entire crop of honey, the space so given is too great for best results at the beginning of the honey flow, and little of it is needed at all if the season is poor. If, on the other hand, a single super is given and no other added until the first is completed, the room in the surplus apartment decreases from the time the super is given until the combs are completely drawn out, when there is little space left between the combs, the bees being practically crowded out. Thus while the population of the colony is increasing their room is being diminished—a condition highly conducive to swarming and less energetic work. After the super is filled, it is some time before the honey is ripened and sealed, ready to be removed. During this interval, if no other supers are given, there is no place for storage of the incoming nectar, and the comb builders must remain idle or waste their wax in building burr and brace combs. To avoid loss in this way, empty supers are added as they are needed, and the comb builders move from one super to another as their work in each is completed. The surplus apartment, whether consisting of a single super or several supers, should at all times contain some space for the comb builders.

If the honey flow is heavy and promises to continue, it is desirable to furnish not only sufficient room but to induce the bees to begin work in as many sections as possible, giving large comb surface for the storage and evaporation of the thin nectar, thus in a measure approximating extracted honey conditions.

There is a danger, however, that if the bees are induced to extend their work through too many supers, the sections when completed will be less well filled and therefore lighter in weight. Also, if the honey flow should not continue as expected a rapid expansion of the surplus apartment results in a large number of unfinished sections.

The rapidity of the expansion of work in the supers may to some extent be regulated by the position of each newly added super. If a rapid expansion is desirable, the empty super is placed below the supers already on the hive, while if it seems best to crowd the bees somewhat the empty super is placed above those already on the hive. When the empty super is placed above the partly finished ones, the bees do not begin work therein unless they need the room. This practice is always desirable during a slow honey flow or toward the close of any honey flow, but when nectar is coming in rapidly does not result in a rapid expansion of comb building sufficient to avoid a more or less crowded condition, which in turn causes a loss of honey and increases the probability of swarming. If each super is supplied with one or two extracting combs (p. 16), this disadvantage of the practice of placing the empty super on top largely disappears, since the extracting combs are immediately available for the storage of nectar.

When the empty supers are placed under the partly filled ones, work in them is commenced promptly, but this may be at the expense of the nearly completed sections, which by this plan are moved farther from the brood chamber as each empty super is added. In

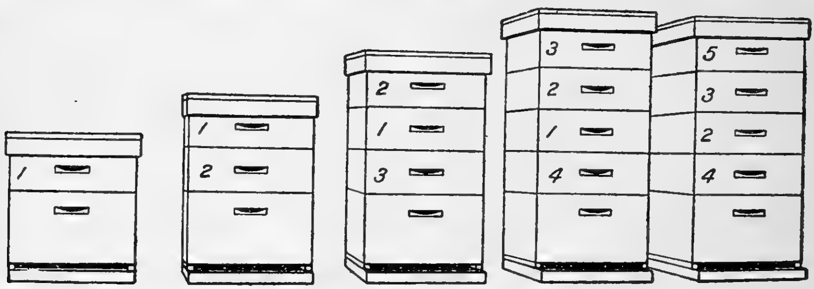

FIG. 19.—Arrangement of supers. (Original.)

the case of the super in which the honey is being sealed this distance is an advantage in so far as the whiteness of the cappings is concerned, but it may retard the completion of the work. An arrangement of the supers that to some extent avoids this difficulty is as follows: Except toward the close of the season, place each newly added super next to the brood chamber and keep the one nearest completion just above it with all others arranged above these two, the one in which least progress has been made being on top (fig. 19). Thus super No. 1 is raised up and No. 2 placed beneath it. When No. 3 is given, it is placed next to the brood chamber, while above it is No. 1 with No. 2 on top. If No. 4 is given, it is placed next to the brood chamber with Nos. 1, 2, and 3 in order above it. By this arrangement, if conditions justify doing so, strong colonies may be induced to expand their surplus apartment with great rapidity, since as soon as the foundation is well drawn in each newly added super it may be transposed to the top and an empty one put in its place. Such rapid expansion of work in the supers should not be attempted, however, except during a heavy honey flow.

If early in the honey flow the bees are storing rapidly, strong colonies should be given a second super as soon as work has been fairly begun in the first. Colonies of medium strength may of course be allowed to do considerable work in the first super before the second is given, while a weak colony may have sufficient room for comb building until the first super is almost completed. The first super should contain some empty comb when given to the colony, and each succeeding super should be given in advance of the time when the bees would be in any way crowded without it. At no time should all the sections be removed and new supers containing only foundation be given, but the surplus apartment should contain sections in all the various stages of development. In this way there is no break in the work in the supers, and the critical periods, so far as the super room bears upon the problems of swarming and energetic work, are largely eliminated.

During the latter part of the honey flow the reasons for further expansion of the surplus apartment in excess of the immediate needs of the colonies (p. 41) no longer exist. At the beginning of a good honey flow the maximum of new work consistent with well-filled sections is desirable, while toward the close of the flow the beekeeper desires the minimum of new work consistent with sufficient room. The precise period when further expansion of the surplus apartment is no longer desirable and a concentration of the work already begun should take place is sometimes difficult to determine, and to do so requires a thorough knowledge of the locality and good judgment on the part of the beekeeper.

It is usually desirable to remove the honey as soon after it is finished as can well be done. If it is left on the hives too long after it is finished, it is likely to become discolored or "travel stained," while if it is taken off too soon some of the sections are not completed. It is desirable that the honey be removed by entire supers instead of by individual sections, therefore conditions should be made as favorable as possible for the completion of all the sections in a super without the more advanced ones becoming "travel stained." The bees are more inclined to stain the white surface of the combs toward the close of the honey flow or during very slow flows. Trouble from this source is at such time intensified because of the uneven progress of work in the different sections, the more advanced sections therefore being sealed some time before the super is sufficiently advanced to justify its removal. Another form of discoloration is brought about by the honey being sealed in close proximity to old and dark brood combs, in which case some of the darker wax from the old combs is sometimes apparently used for capping the honey.

During a good honey flow all except the last supers may be left upon the hives until all or nearly all of the sections of honey are sealed, since (1) there is little trouble from "travel stain" when work is progressing rapidly, (2) all the sections in the super are ready to be sealed at about the same time, and (3) when there are several supers on each hive the one in which the honey is being sealed is at least one super removed from the brood combs.

Toward the close of the honey flow all supers having most of their sections finished should be removed and the sections sorted. The unfinished sections should be graded according to the degree of completion, the various grades placed in supers and given to such colonies as are most likely to finish them. Every effort should be made at this time to contract the surplus apartment, concentrating the work upon the sections nearest completion. All supers in which work has not yet been started should be removed and as soon as possible the surplus apartment of each colony should be reduced to one super. Though little room is necessary during the close of the honey flow, there should always be some room for the storage of new nectar until it is ripened. For such conditions extracting combs are valuable, since, instead of giving the last comb-honey super in which little work would be done, a set of extracting combs may be placed over the sections to afford room for the incoming nectar and comb surface for its ripening.

CARING FOR THE CROP.

Removing the Honey from the Hives.

If the honey flow is of considerable duration the major portion of the crop is removed before the flow ceases. At this time the removal of the finished supers is comparatively easy because the bees can readily be driven from them and also because the operator is not hindered in his work by robbing bees. At the close of the honey flow all the supers remaining upon the hives should be removed promptly, since to leave them on would result not only in some of the honey being carried down into the brood chamber but also in badly propolized sections. After the honey flow has ceased, great care should be exercised to keep bees from robbing. The use of bee-escapes (fig. 12) greatly facilitates the removal of the honey at any time, but their use is especially desirable in removing the honey remaining on the hives at the close of the honey flow. By their use the honey may be removed and stored in the honey house with little disturbance or excitement among the bees. The supers of honey should of course be taken directly to the honey house or kept well covered[1] from robbers.

Before finally storing the supers of honey in the honey room those that are but partly filled may have their sections removed and sorted. The unfinished sections that can not be disposed of at a profit locally are usually put back into supers and the honey they contain is fed to the bees. This feeding is done by simply exposing the supers where the flying bees can have access to them. If there are few supers compared with the number of colonies they should be placed in piles and only a small entrance allowed, since if free access were given to a large number of bees they would tear the combs to pieces. When the bees have finished removing the honey from these unfinished sections the latter may be stored for future use as "bait" sections.

Care of Comb Honey.

In the honey room the supers of honey should be placed in piles in such a manner as to allow a free circulation of air between them. This may be done by "sticking them up" as lumber is piled to dry or by placing alternate supers crosswise. The air in the honey room should be kept as dry as possible. This is usually accomplished by means of a high temperature, the honey room being located on the sunny side of the building or directly under the roof. The windows should be opened only during dry weather. Ventilation of the honey room is of no value except when the air that is admitted contains less moisture than that already present. Otherwise ventilation may be a positive detriment. If a protracted period of rainy or damp weather should occur while the honey is in this storage it may be necessary to use artificial heat to dry the air in the honey room. Any great variation in temperature should be avoided, since it may cause a condensation of moisture on the surface of the cappings which will be absorbed by the honey.

Some beekeepers find it necessary to fumigate comb honey to prevent damage by the larvæ of the wax moth. For this purpose sulphur fumes or bisulphid of carbon may be used. If bisulphid of carbon is used, great care should be taken not to bring it near a flame, as it is highly inflammable.

Scraping Propolis from Sections.

Before being packed for market the sections of honey should be removed from the supers and the wood scraped free of propolis. A

[1] Honey from out-apiaries should be loaded for transportation in such a manner that the bees can not get at it, then before the horse is hitched to the wagon the load of honey should be drawn by hand some distance from the apiary if the slope of the ground will permit doing so. If this is not possible the horse may be attached by means of a long rope and the load drawn to a safe distance before the horse is hitched to the wagon.

convenient bench should be provided for this work, with a large shallow box or tray to catch the propolis as it is scraped from the sections. This work is usually done by hand, though a few producers have designed and are using machines for this purpose.

Grading Comb Honey.

The importance of properly grading and packing comb honey does not seem to be well understood by the average beekeeper. Some extensive buyers of comb honey find it profitable to regrade and repack practically all the comb honey they receive before sending it out to their trade. The producer of this honey of course bears this extra expense by receiving a lower price for his honey. The lack of uniformity of grading is to some extent a result of differences of opinion as to what should be the standard for the various grades. Grading rules have been of material aid toward greater uniformity, but various producers may use the same set of grading rules with very different results. It would be well if a single set of rules were in use, since honey from various localities may be sent to the same market. The grading rules in most common use are given in Farmers' Bulletin 447, page 39.

After scraping the propolis from the wood, each section of honey may be placed in a pile with others of its grade. Some put the sections directly into the shipping cases as fast as they are scraped, but better grading can be done if each grade is put in a separate pile and the final grading all done by one person. By thus having a large number of sections in each grade from which to select there is greater opportunity for making the sections of honey in each case more nearly uniform as to weight and the various shades of finish. Such uniformity is especially desirable from the standpoint of the retailer. Sections containing only a few cells of pollen should be placed in a lower grade or sold as culls, while those containing a considerable amount of pollen should not be marketed in the form of comb honey. An excessive amount of pollen in the sections is usually caused by the use of very shallow brood combs, extreme contraction of the brood chamber, or hiving swarms on narrow strips of foundation in the brood frames with partly drawn comb in the sections (p. 32).

Packages for Comb Honey.

Comb honey is usually packed in cases holding 24 sections (fig. 20). Other sizes are sometimes used to meet special market requirements. The markets have become accustomed to cases with glass fronts, by means of which the contents are displayed to advantage. However, in keeping with present practice in other package goods, considerable comb honey is now placed on the market having each section inclosed in a carton. This practice, while losing the advantage of displaying the honey, has a decided advantage in insuring security from dust and insects while in the markets as well as greater safety to the fragile comb when the package is finally delivered to the consumer.

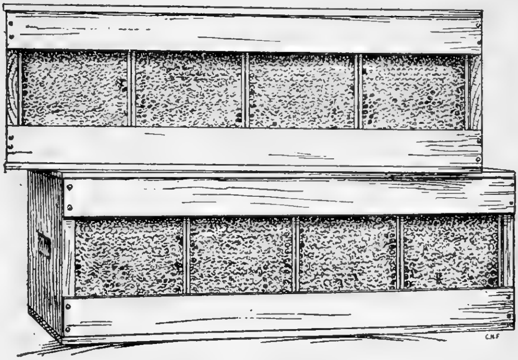

FIG. 20.—Shipping cases for comb honey. (From Phillips.)

Marketing.

Many beekeepers are able to dispose of their entire output of honey in their local markets, sometimes creating quite a demand for their product by advertising and demonstrating. Comb honey that is to be sent to a distant market should be shipped before cold weather, since the combs become extremely fragile when cold. Small lots should be crated in "carriers" holding several cases to prevent breakage by rough handling of individual cases, while in larger shipments the cases are simply packed in the car in such a manner that the individual cases can not be thrown about by the movement of the car.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 512.

THE BOLL WEEVIL PROBLEM,

WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

BY

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1912

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., June 29, 1912.

SIR: I have the honor to transmit herewith the manuscript of a paper by Mr. W. D. Hunter, in charge of southern field crop insect investigations in this bureau, dealing with the boll weevil, especially with reference to means of reducing its damage. This manuscript is a revision of Farmers' Bulletin 344, issued January 23, 1909, and is intended to supersede that publication. The data have been revised, certain new matter has been added, and the paper now includes results of investigations carried on since the original date of publication of Farmers' Bulletin 344. I recommend that this manuscript be published as a Farmers' Bulletin.

Respectfully,

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

HON. JAMES WILSON,
Secretary of Agriculture.

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THE BOLL WEEVIL PROBLEM, WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

INTRODUCTORY.

This bulletin, dealing with work done under the direction of Dr. L. O. Howard, Chief of the Bureau of Entomology, is intended to cover in a general way the whole field of the control of the boll weevil. As this control is inseparably connected with the life history and habits of the insect and, in fact, must be based thereon, attention is given to the principal features of the insect's economy. In addition, information is given relating to the amount of damage done, the extent of the infested territory, and such other matters as are of special interest at this time.

Like many of the most important injurious insects in this country, the cotton boll weevil is not a native of the United States. Its original home was undoubtedly in the plateau region of Mexico or Central America, and it may originally have fed upon some plant other than cotton. This is not necessarily the case, however, since there is evidence that the same region is the original home of the cotton plant itself. Previous to 1892 the insect had spread through Mexico, but little is known regarding the extent or rapidity of this dispersion. The records indicate, however, that it had probably 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 a half dozen counties in southern Texas and was brought to the attention of the Bureau of Entomology. A preliminary examination, made under the direction of Dr. L. O. Howard by Mr. C. H. T. Townsend, showed the enormous capacity for damage of the pest. Subsequent events have verified in every way the predictions that were made at that time, when the insect had not attracted any considerable amount of attention in the South. Since 1894 the boll weevil has extended its range annually from 40 to 70 miles, although in two instances the winter conditions have been such as to cause a decrease in the infested area. During the first 10 years after its advent into this country the annual rate of spread was 5,640 square miles. Since 1901 the annual increase in the infested territory has averaged 26,880 square miles, but in one exceptional season, namely, 1904, 51,500 square miles became infested. 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 was found to occur at the end of the year 1911 is shown in figure 1. This territory included the southeastern half of the cotton section of Texas, the southeastern corner of Oklahoma, the southern three-fourths of Arkansas, all of Louisiana, the southern three-fourths of Mississippi, the southwestern corner of Alabama, and the extreme western portion of Florida. Outside of the United States the boll weevil is known throughout the larger portion of Mexico and southward to Guatemala and Costa Rica. It is also known to occur in about one-half of Cuba.

DAMAGE.

The damage done by the boll weevil varies greatly from year to year and also in different parts of the infested area. As the rainfall increases the damage becomes greater. In prairie regions, where the insect obtains but little protection through the winter, it never becomes so numerous as in other quarters where favorable conditions for hibernation are found. These facts, together with variations due to winter conditions, make it rather difficult to estimate the exact damage that has been done. Some years ago the writer stated, from the statistics then available, that the weevil caused a reduction of at least 50 per cent of the cotton crop in regions invaded by it, but that after the first few years the farmers generally resorted to proper means greatly to reduce this loss. In many individual cases the means of control perfected by the Bureau of Entomology have been applied so successfully that the crop has been fully as large as before the coming of the weevil. This was not accomplished, however, without somewhat increasing the cost of production. The estimate of an initial falling off in production of 50 per cent was verified by Prof. E. D. Sanderson, formerly State entomologist of Texas, who arrived at his figures in an entirely different way.

The average yield per acre in Texas from 1893 to 1901 (when the weevil had not done damage sufficient to affect the general production) was 0.40 bale. The average since that time, 1902 to 1911, was 0.34 bale. By comparing these periods we have a reasonably accurate basis for estimating the damage the insect has done. The difference

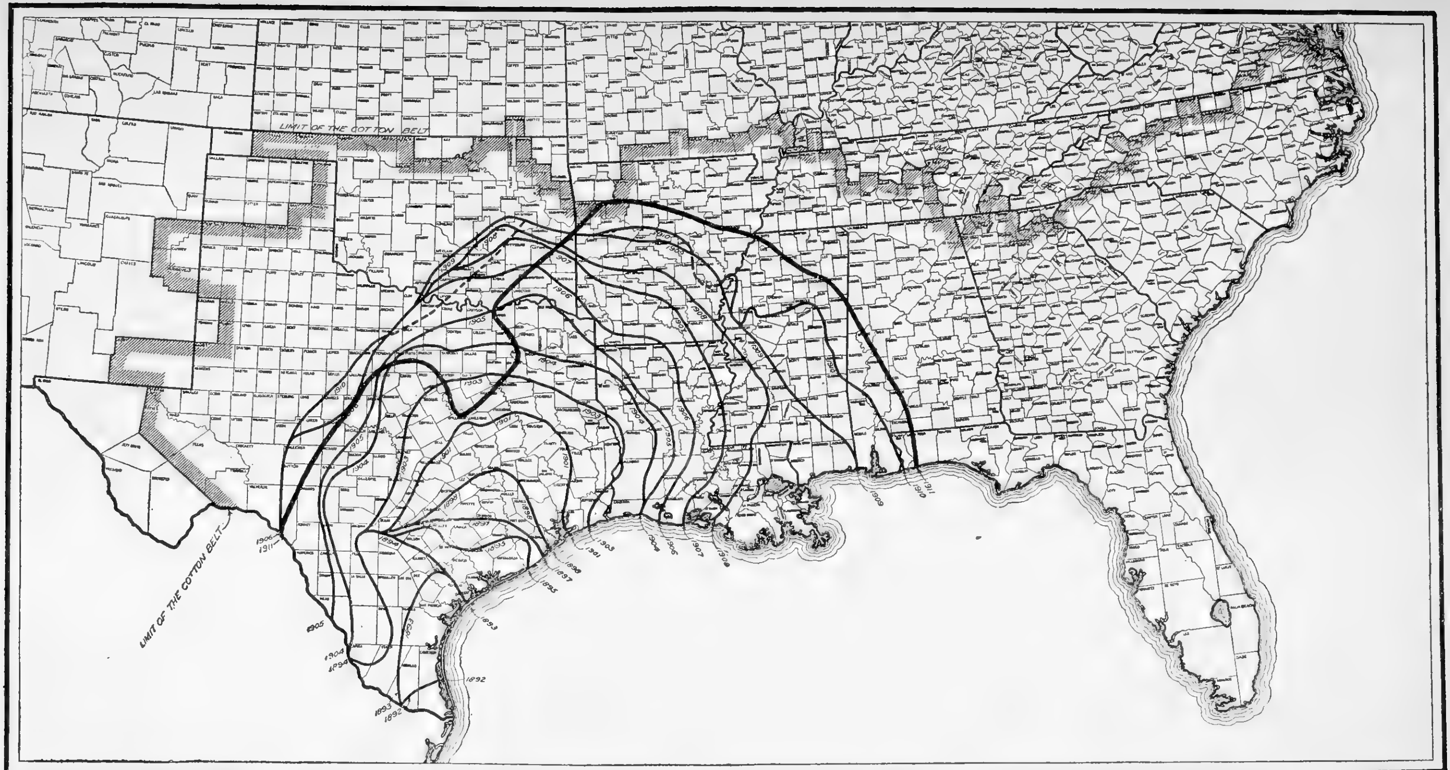

FIG. 1.—Map showing area infested by the boll weevil in 1911 and during various preceding years. The line for 1911 includes all territory in which any infestation was found during the season. Toward the outer part of the infested area very few weevils are to be found. This applies to a belt from 5 to 25 miles wide bordering the line for 1911 on the inside.

is 0.06 bale, or 30 pounds of lint per acre each year. At prices current through the period this means an annual loss, without considering the value of the seed, of at least $2.70 per acre which has been sustained by the cotton planters of Texas. Assuming that the area planted in cotton in Texas has averaged 10,000,000 acres, the annual loss for the State for the period from 1902 to 1911 has been $27,000,000.

Another tangible indication of the manner in which the weevil has affected cotton production is revealed by a comparison of statistics from Louisiana and Texas. From 1899 to 1904 the acreage in Texas and Louisiana increased at about the same proportion, but the crop in Texas decreased at the same time that the crop of Louisiana was increasing. There is an exception to this statement in the years 1900 and 1904, in which the production in Texas did not decrease, but these years were exceptionally unfavorable for the weevil and at the same time very favorable for the general growth of the cotton. In 1907 the yield per acre in Texas (0.24 bale) was the smallest in her history. This followed a winter so mild that more than the usual number of weevils overwintered.

Undoubtedly for several years the boll weevil has caused a loss of about 400,000 bales of cotton annually. Although farmers in older regions, in many cases, are increasing their production, there is loss in the newly infested regions which offsets that gain. A conservative estimate shows that since the weevil has invaded this country it has caused a loss of 2,550,000 bales of cotton, at a value of about $125,000,000.

PROSPECTS.

Reference has been made to the greater damage inflicted in moist regions and where the shelter for hibernation is best. The records of the Weather Bureau show that the annual precipitation increases very rapidly from the West to the East in the cotton belt. This is especially the case during the early growing season of cotton, namely, April, May, and June. The precipitation in the greater part of the cotton-producing area in Texas is normally about 40 inches. In Louisiana, Mississippi, and the eastern States of the cotton belt it is more than 50 inches, and sometimes exceeds 60 inches. The records that have been kept in Texas show that the damage has always been greater in wet seasons and that the insect has affected land values most where the general conditions approach those of the eastern part of the cotton belt. Without the assistance that is furnished by climatic conditions, especially dry weather during the spring, the farmers of Texas would not have been by any means so successful in producing cotton during the last few years as they have. The system of control outlined in this bulletin increases greatly in effectiveness when assisted by weather conditions. Fortunately in Texas this assistance is given under normal conditions. When this assistance is above the normal, as in 1904 and 1906, the crops will be exceedingly large.

On the other hand, it is clear that the problem of the control of the boll weevil will be more difficult as the pest continues its invasion of the cotton belt. It can not be considered, therefore, that the problem is as yet completely solved. Better means of control must be devised for the region that is becoming invaded, and, if possible, means must be devised that will reduce the enormous loss that is suffered, especially during unfavorable seasons, in Texas. The principal work of the Bureau of Entomology at this time is in attempting to devise means for this requisite additional control.

For the present there is no occasion to lose hope. Though the eastern planter must expect a more serious problem than that which confronted the farmers of Texas, the means of control outlined in this bulletin, especially the destruction of the hordes of weevils about to enter winter quarters, will enable him to continue production, though probably at a reduced profit. The sooner he adapts his plantation management to the necessary changes the less the loss will be.

WORK UPON WHICH THIS BULLETIN IS BASED.

As has been stated, the danger from the boll weevil was appreciated from the beginning by Dr. L. O. Howard, Chief of the Bureau of Entomology. For about 10 years, more or less continuous work on the vulnerable points in its life history and the possibility of control in various ways has been done. At first this was not extensive, although it showed the essential steps necessary 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 under the first large appropriation by the establishment of a laboratory at Victoria, Tex., and the beginning of extensive field experiments. It has been the practice from the beginning to carry on field experimental work in direct connection with the laboratory investigations. All means of control suggested by the laboratory work have immediately been tested on large field areas. Later the headquarters of the investigation were moved from Victoria, Tex., to Dallas, Tex., on account of the continued spread of the insect and the necessity for a central location. The Bureau of Entomology has conducted experiments during several seasons on a total of more than 10.000 acres of cotton. This experimental work has been located on well-known plantations throughout the infested territory. The special requirements in different regions have been given particular attention. Almost invariably successful crops have been produced, although special damage, due to local conditions in different regions, has sometimes interfered with the success of the experiments. The present bulletin contains a very condensed report of the results of all this work. The recommendations have all been placed in practical operation under the actual conditions prevailing on different cotton plantations.

Aside from the work directly relating 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 in its province. These have dealt with the breeding of cottons to obtain earliness and productiveness and with the extensive demonstration of the ficiency of the system of control devised by the Bureau of Entomology as the result of careful studies in the field and laboratory.

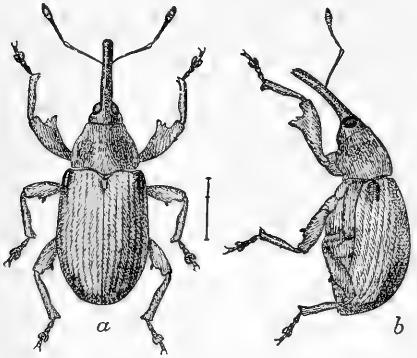

FIG. 2.—Cotton boll weevil: *a*, Beetle, from above; *b*, same, from side. About five times natural size. (Author's illustration.)

In addition to the work done by the Department of Agriculture the States concerned have done their part. Several entomologists have been employed by the State of Texas, namely, F. W. Mally, E. D. Sanderson, A. F. Conradi, and C. E. Sanborn. They have dealt with the boll weevil in connection with the numerous other entomological problems of the State and have contributed valuable results that have been made use of in this bulletin. The State of Louisiana has also done very notable work. Prof. H. A. Morgan and, later, Mr. Wilmon Newell, have added considerably to our knowledge of the weevil and the means of controlling it. In many ways their results are incorporated in this bulletin.

DESCRIPTION AND LIFE HISTORY OF THE BOLL WEEVIL.

The adult boll weevil is about one-fourth of an inch in length, 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 about one-half the length of the body. Variation in size is due to the amount of food the insect has obtained in the larval 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 passes to a gray or nearly black shade in a few weeks' time. The general appearance of the insect will be evident from the accompanying illustration (fig. 2).

Many insects resemble the boll weevil more or less closely. In fact, there are hundreds of species of weevils in this country that may be easily mistaken for the enemy of cotton. Many mistaken reports about the occurrence of weevils far outside of the infested area have been due to mistakes that have arisen on account of this similarity. The only safe way to determine whether any 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 great numbers of squares. However, unfavorable climatic conditions and careless cultivation frequently cause great shedding. If excessive shedding be noticed 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.

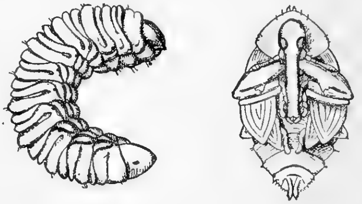

FIG. 3.—Cotton boll weevil: Larva at left, pupa at right. About five times natural size. (Author's illustration.)

The boll weevil passes the winter in the adult stage. 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 3 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 pupal stage (fig. 3, at right), corresponding to the cocoon of butterflies and moths. This stage lasts from 3 to 5 days. Then the adult issues and in about 5 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 2 to 3 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 from depositing in squares visited by other females. This applies throughout most of the season, but late in the fall, when all 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 are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed.

Whenever frost or other unfavorable weather causes the plants to cease putting on squares, the weevils attack the bolls. A conservative estimate of the possible progeny of a single pair of weevils during a season beginning on June 20 and extending to November 4 is 12,755,100.

The cotton-boll weevil, so far as known at present, has no food plant other than cotton. This has been determined by planting various plants related to cotton in the vicinity of infested cotton and

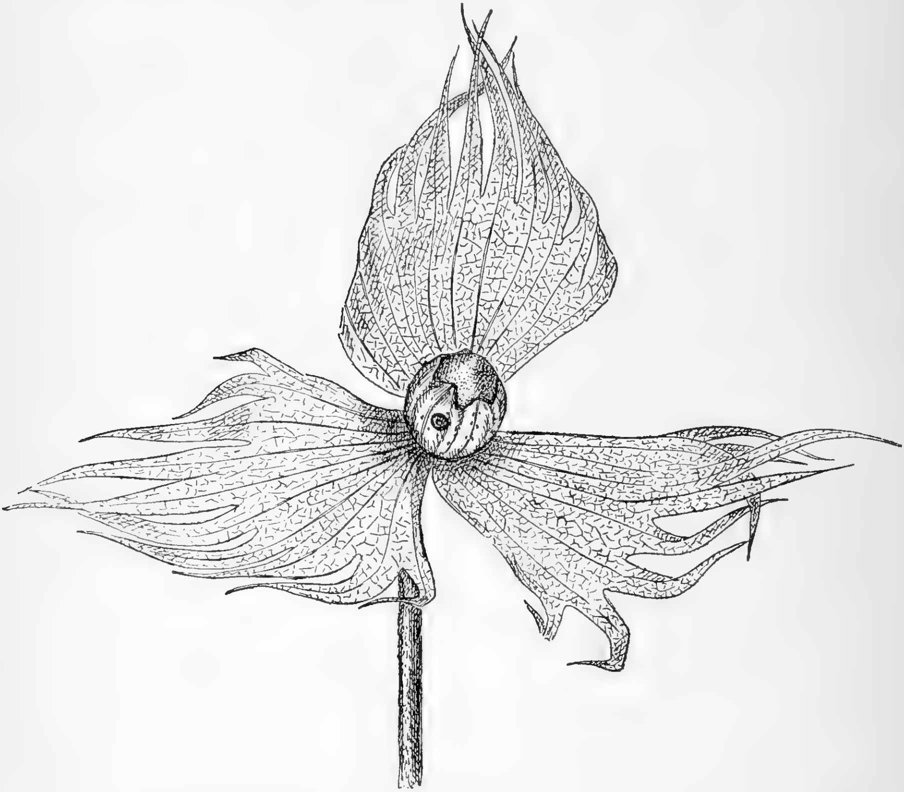

FIG. 4.—Cotton square showing egg puncture of boll weevil and "flaring" of bracts. Natural size. (Author's illustration.)

in cages in which weevils were placed. It has therefore been demonstrated beyond any doubt whatever that the insect is restricted to the cotton plant for food. When confined in bottles, the weevil will partake of various substances, such as apples or bananas; but this is only under the stress of starvation. Under natural conditions they would pay no attention to these substances.

The boll weevil is strictly diurnal in its habits. Repeated observations made in the field at night have shown that it is not active after sundown. Unlike some related insects, it is not attracted to light. The fact that somewhat similar species do come to lights in great numbers at times has frequently caused unfortunate confusion.

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 generally contract their limbs and drop to the ground. This habit is not equally strong in all individuals. It has been taken into consideration in plans of control, as will be described beyond.

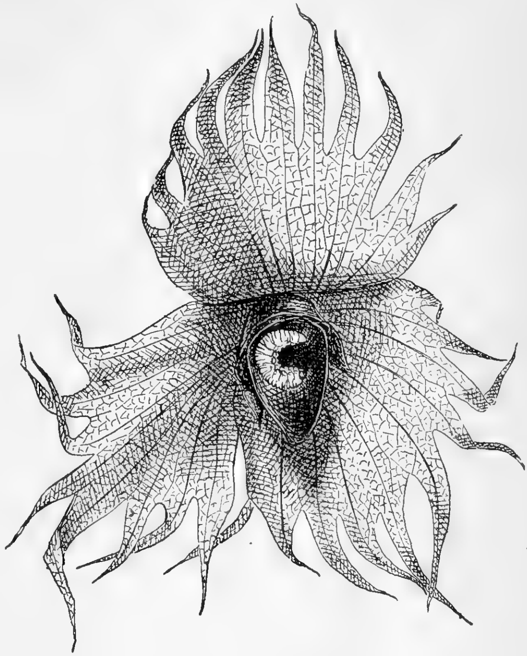

FIG. 5.—Cotton square showing larva of boll weevil in position. Natural size. (Author's illustration.)

The age to which weevils live varies under different 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 60 days. During the cooler part of the year many of them live as long as 6 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.

HIBERNATION.

As has been pointed out, the boll weevil passes the winter in the adult stage. In the fall when frosts occur, immature stages may be found in the squares or bolls. Provided the food supply is sufficient, many of these immature stages continue their development at a very slow rate and adults finally emerge. Thus there may be a somewhat continuous production of adults during the winter. Ordinarily, however, this is not conspicuously 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. The majority of weevils that hibernate successfully do not pass the winter in the cotton fields. This 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 weeds and 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 hibernating successfully has been determined very accurately for different conditions. Out of 25,000 weevils, 2.82 per cent survived the winter of 1905–6. These weevils were placed in a variety of conditions that must have approached those which weevils must naturally encounter. The winter referred to was practically a normal one so far as temperature and precipitation were concerned. In extensive work 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, i. e., from an abundance of protection to practically none. The survival obtained is undoubtedly very close to that occurring under diverse natural conditions of that winter. It must be emphasized that the winter of 1906–7 was abnormally warm. It is undoubtedly true that the rate of survival was much higher than usual. It is supposed that the results of the previous year must approach the average. In other words, less than 3 per cent of the weevils entering hibernation can be expected to survive the winter under average conditions. The tremendous importance of still further reducing this percentage must be evident.

Emergence from hibernation depends primarily upon temperatures in the spring, although there are other minor factors concerned. Generally, from the first to the middle of March the temperature has become high enough to cause weevils to begin to emerge. Naturally, the individuals under the heaviest protection are affected latest by the temperature. The consequence is that emergence from hibernating is a prolonged operation. During one season (1906) it extended from the middle of March to the 28th of June; during another season (1907) from the middle of February to about the first of July. During each of these periods there was a comparatively short time—about 10 days—of rapid emergence, preceded by an initiatory movement and followed by a period during which the number emerging day by day decreased with rapidity.

HOW NATURE ASSISTS IN DESTROYING THE BOLL WEEVIL.

In the preceding paragraph attention was called to the possible production of 12,755,100 offspring in a single season by one pair of weevils. As a matter of fact, nature has provided a number of agencies that serve to prevent such excessive multiplication. The most conspicuous of these agencies 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 very few minutes. The insect in the larval 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 the precipitation is heavy. The more rankly the plants grow and the more the ground is shaded, the less effect in weevil control can be expected from heat. Nevertheless, in many cases in Texas the enormous total of 40 per cent of all the immature weevils in cotton fields inspected has been found to be destroyed through this agency. It was also found, from examinations in many quarters, that the extent of destruction held a direct relation to the amount of shade. When there was no shade practically all of the larvæ and pupæ were killed outright. Some of the important means of control, to be described later, are based upon this consideration.

Insect parasites.—The second of the important agencies provided by nature for the control of the weevil is a large number of predaceous insect enemies. These consist of a variety of forms which prey upon the boll weevil. Forty-five species of these enemies are known. Of these, 23 are parasites, which by means of their ovipositors place eggs on the immature stages of the weevil within the square or boll. The young of the parasite develops by feeding upon the immature boll weevil, which it ultimately kills. Thus a parasite instead of a boll weevil emerges from the injured fruit. Special studies on these parasites have led to many suggestions for practical control. Moreover, the parasites seem naturally to be increasing in numbers and effectiveness against the boll weevil. In one instance in 1907 the mortality due to parasites in a field near Robson, La., was 77 per cent. About the same time 61 per cent of the weevils in a certain field near Victoria, Tex., were killed by parasites. 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 that have occurred in this country for many years. They never feed on vegetation. It is undoubtedly true that they are now turning their attention from the original hosts, which are generally not very numerous, to the boll weevil, which offers abundant and favorable opportunities for reproduction. They thus ally themselves with the farmer for the protection of the cotton crop. In the following pages numerous suggestions will be made regarding the means that the farmers may take to increase the effectiveness of the work of these parasites in reducing the numbers of the boll weevil.

Other insect enemies.—In addition to the true parasites described above, the boll weevil suffers from a number of insects which are not parasites in a strict sense but prey upon it as food. The principal ones of these predatory enemies are ants. Of these, 12 species are known to attack the weevil. They are the minute brown ants and 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 a source of 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 found to be destroyed by ants alone. To find 25 per cent so destroyed is not a rare occurrence. In this bulletin methods will be pointed out for making use of these friends of the farmer and increasing the important effect they naturally have in reducing the numbers of weevils.

Other factors in natural control.—In addition to the principal factors in natural control which have been mentioned there are several of minor importance. Among these may be mentioned proliferation, which sometimes crushes the immature weevils, and determinate growth, which may prevent the development of the fall broods of the weevil. Attention is also called to the agency of birds in the destruction of the boll weevil, which has been given full attention in the publications of the Biological Survey of this department.

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 to 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. Nevertheless, 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 first of September the weevil seems to be seized with an 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 does not fly in any particular direction except as governed 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 individuals carrying the infestation into new regions have been those that happen to radiate in the direction of previously uninfested territory.

The fact that the weevil moves about but little except at one season is of great benefit to the farmer. As the movement referred to does not begin until after the time when a crop is normally made, it amounts to little after a region has become infested. On the other hand, the limited movement at other times 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 of his efforts being thwarted by the arrival of weevils from fields where no precautions have been taken is not so important as it is sometimes considered. In fact, it is not important enough to warrant any farmer in deferring action on account of the indifference of his neighbors.

The above statements give only an outline of the life history and habits of the boll weevil. More complete information can be obtained from Bulletin 114 of the Bureau of Entomology, which may be obtained for 25 cents upon application to the Superintendent of

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Documents, Government Printing Office, Washington, D. C. In this connection the writer wishes to emphasize the following important points that have a direct bearing upon control:

(1) The weevil has no food plant but cotton.

(2) The mortality of the weevil during the winter is very high.

(3) The emergence from hibernating quarters during the spring is slow and prolonged until well into the summer.

(4) Early in the season, on account of comparatively low temperatures, the development of the weevil is much slower than during the summer months.

(5) The drying of the infested squares soon destroys the immature stages of the weevil contained therein.

(6) The weevil is attacked by many different species of insect enemies, the effectiveness of which is increased by certain practices.

(7) The weevil has little ability to emerge when buried under wet soil.

MEANS OF CONTROL.

It will be evident from the preceding statements regarding the life history and habits of the weevil that its control is beset with many difficulties. In fact, it is probably the most serious insect pest that is now known. Its insidious methods of work in the 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, and its enormous power of reproduction and adaptability to new conditions, all tend to place the boll weevil in a class by itself. The difficulties are increased by the necessary procedures in raising cotton. In spite of these difficulties fairly satisfactory means of control are known. A large share of the reasonable success of the warfare against the pest is due to the assistance furnished by natural agencies, which commonly destroy many more weevils in a cotton field than the farmer could by any known method or methods.

Destroying infested plants in the fall.—Foremost among the methods of control is the killing of the hordes of adult weevils that are ready to enter hibernation in the fall and the prevention of the development of millions more that would later emerge to pass through the winter. This is accomplished by burning the infested plants in the fall after the weevils have become so numerous that there is no prospect of the maturity of any additional crop. There are many vital reasons why the wholesale destruction of the weevils in the fall should be practiced by every cotton planter in the infested region. Some of these are stated below:

First. Hordes of adult weevils, many for each plant in the field, are killed outright.

Second. Many more weevils that are in the immature stages, possibly as many as a hundred for each plant in the field, are also killed.

Third. The few adult weevils escaping will be weakened by starvation and the great majority will not have sufficient strength to pass through the winter.

Fourth. The development of the late broods, which experiments have shown furnish the vast majority of weevils that pass through the winter, is cut off immediately. In this way hundreds of weevils that would develop from each plant are absolutely prevented from so doing.

Fifth. The removal of the infested plants with the weevils facilitates fall or early winter plowing, which is the best possible procedure in cotton raising. Moreover, this plowing assists greatly in the production of an early crop the following season.

In short, in the fall the weevil is at the mercy of the planter as it is at no other time. If the planter desires to kill the insect he can do so. Work in weevil destruction at that time far outbalances all remedial measures that may be applied at all other times of the year.

Many hundreds of cases are on record showing the benefit from the fall destruction of plants in the control of the boll weevil. The process has not been taken up so generally as it should be, but individual instances everywhere show its value. A large amount of experimental work by the Bureau of Entomology has all pointed clearly toward the supreme importance of this essential method in control. In an experiment performed by the Bureau of Entomology in Calhoun County, Tex., the stalks growing on 410 acres of land were destroyed early in October. Careful records kept during the following season showed that this work had increased the production more than one-fourth of a bale per acre over the crop on the check area where such work was not done. Computing the increase in the crop at the current prices, the advantage from the work in the experiment amounted to $14.56 per acre. This was about 29 times the cost of uprooting and burning the plants, as shown by the amount actually paid by the department for the work. Circumstances surrounding the experiment, referred to in Circular 95 of the Bureau of Entomology, show that the advantage was probably considerably greater than has been indicated here. At any rate, the estimate given is most conservative. In this instance the cotton destroyed was isolated and the results are perhaps somewhat more conspicuous than would have been the case where there were hundreds of cotton fields in the neighborhood. Nevertheless, experience with fields surrounded by others that have been given no attention has shown a great advantage from taking the proper step in the fall. Of course, concerted action will add to the effectiveness of the work and should be followed in every community.

In addition to the field work by the Bureau of Entomology and by many practical planters, a great deal of work has been done in large cages, where the conditions could be studied most carefully. In this way the exact relative advantage of fall destruction at different dates has been determined. It has been shown in this connection that the earlier the work can be done the better the results will be. For instance, seven times as many weevils survived the removal of the infested plants on November 12 as survived after similar work on October 13.

Mr. J. D. Mitchell, of the Bureau of Entomology, calls attention to a striking example of the value of the fall destruction of the weevils that came to his attention in 1908. On opposite sides of the Guadaloupe River near Victoria, Tex., were two farmers, each having about 40 acres in cotton. In one case the stalks were uprooted and burned in September, 1907, and in the other they were allowed to stand until shortly before planting time in the spring of 1908. They were equally good farmers, and the soil was the same on the two places. In the first case the crop of 1908 was 15 bales and in the other 3½ bales. The work done during the preceding fall plainly increased the crop about fivefold.

No definite rule can be laid down as to the proper time for destroying the weevils upon and in the fruit of the plants in the fall. In general, the proper time is whenever the weevils have reached such numbers as to infest practically all of the squares that are being set. This may occur a month or more earlier in some seasons than in others. Fall destruction as late as November will accomplish much, but several times the number of weevils can be destroyed if the work be done in October. Therefore the rule should be to destroy the infested plants at the earliest possible date in the fall. It is much better to sacrifice a small amount of cotton than to defer the operation. The loss will more than be made good by an increase in the next crop.

Some objections to the work of destroying the weevils in the fall are frequently raised. The principal one is that the labor supply is insufficient to enable planters to have the crop picked out in time for such fall destruction as is recommended.[1] One of the respects in which the boll weevil will make revolutionary changes in the system of producing cotton is that smaller areas than formerly must be cul-

[1] In this connection attention is directed to one of the many advantages of having the crop picked out early. The earlier this is done the cleaner the lint will be, and the better the price. Moreover, the longer the unpicked cotton remains in the fields the greater will be the amount that falls to the ground and soon passes beyond recovery. From every standpoint the cotton should be picked as rapidly as possible.

tivated by each hand. The production can best be kept up or increased by more intensive methods on smaller areas. If this principle be put in operation on plantations in so far as it is practicable, the objection to fall destruction on account of the scarcity of labor will tend to disappear. Another objection raised is that the process tends to impoverish the soil. As a matter of fact, the burning of the stalks removes only a small amount of the fertilizing elements, and, moreover, the practice now is to burn the plants a few months later. In most cases the humus is more important than the fertilizing elements themselves. The use of commercial fertilizers in one case and the practice of green manuring in the other will solve both of these difficulties.

In regions where the loss of organic matter from the burning of the stalks is important the best advice that can be given is to cut the stalks by means of the usual machine for that purpose and bury them deeply as soon thereafter as possible. This will cause the destruction of many of the immature stages in the squares and bolls. The practice will be more effective if the land is harrowed or dragged immediately after the stalks are plowed under. Where none of the practices recommended can be followed it only remains for the planter to uproot the plants and leave them lying in the field. This will cut off the development of squares and thereby deprive the weevils of opportunities for breeding, while the plants remain in the field so that picking can be continued as long as may be necessary.

METHODS OF DESTROYING WEEVILS IN THE FALL.

The reader is referred to Circular 95 of the Bureau of Entomology for particulars regarding methods of destroying the weevils in the fall. In this connection it will be stated that the proper method, in general, is to uproot the plants by means of plows, and to burn them as soon as possible. Other methods are applicable to different conditions. As soon as the plants are uprooted they should be placed in piles or windrows, which will utilize the leaves in the burning. The difficulty in one method of removing the plants—that of cutting them off near the surface of the ground with a stalk cutter or ax—is that during mild seasons many sprouts soon make their appearance to furnish food for weevils that would otherwise starve during the fall or winter. If the ordinary stalk cutter be followed immediately by plows, some of the desired results will be obtained. The great objection is that the innumerable weevils in the bolls and squares will be allowed to develop. Nothing but uprooting and burning will come near meeting the exigencies caused by the weevil.

Plowing under infested squares.—It has been found that the weevil has little ability to emerge through wet soil. This fact can not be taken advantage of by the farmer during the growing season for the reason that deep cultivation would cause injury to the plants. In the summer or fall, however, when the weevils have become so numerous that it is evident that very little fruit will be allowed to develop, the practice can be followed to good advantage. At such times turning plows should be used, running close to the rows and thereby burying the infested squares deeply in the middles. This practice is of greatest benefit in humid regions, where the rains will soon pack the soil, and on heavy soils. In dry regions and on sandy soil it is of very little value.

Grazing.—In some cases the grazing of the fields with cattle, sheep, or goats can be practiced. 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.

Sprout cotton.—A most important result of the proper manipulation of the plants in the fall is that no stumpage or sprout cotton is allowed to grow. The occurrence of such cotton in southern Texas and occasionally in southern Louisiana is there the most important local difficulty in the control of the boll weevil. Sprout plants are sometimes encouraged on account of the production of a small but very early crop. This may have been defensible before the advent of the boll weevil, but at the present time the practice is undoubtedly the worst that could possibly be followed. The sprout plants serve only to keep alive myriads of weevils that could easily be put out of existence by the farmer.

Volunteer cotton.—In addition to stumpage cotton, volunteer cotton, in the strict sense, is of considerable importance in weevil-infested areas. The cotton seed scattered about seed houses and gins frequently gives rise to plants, both in the fall and in the spring, that furnish food and breeding places for weevils. It is needless to call attention to the fact that all such plants should be destroyed. They are merely aids to the enemy.

DESTRUCTION OF WEEVILS IN HIBERNATING PLACES.

After the weevil-infested plants have been removed from the field in the fall the farmer can add strength to the blow he has given the insect. As has been stated previously, many of the hibernating weevils are not to be found within the cotton fields nor in their immediate vicinity. Nevertheless, most of those remaining in the field can be destroyed, and this is undoubtedly well worth the effort that it will cost. In many cases surprising numbers of weevils have been found hibernating in the trash and rubbish on the ground in cotton fields. In January, 1907, in one instance, 5,870 weevils per acre were found, of which 70 per cent were alive. This was undoubtedly exceptional, but most of the many examinations made showed more than 1,000 live weevils per acre in old cotton fields. The insects so found are largely at the mercy of the farmer. He can destroy many by carefully raking up the trash and burning it. Plowing and subsequent harrowing of the land will add to the destruction. This work would be well worth while on general agricultural principles if no weevils whatever were destroyed. With the weevil present, that farmer invites loss who does not clean the fields to the best of his ability.

Of the multitudes of weevils that fly out of the cotton fields for hibernation not all are beyond the reach of the farmer. Many are to be found along turn rows, fences, hedges, and old buildings. The cleaning and burning of hedges, fence corners, and in general the removal of trash from the vicinity of fields will destroy many weevils that would live to assist in the destruction of the crop.

Old sorghum fields, on account of their roughness and the fact that the heavy stubble catches trash moved about by the wind, have been found to furnish very favorable winter quarters for the weevil. The farmer should pay special attention to such fields. They have frequently been found to be the source of the first weevils to damage the cotton in the spring. A little work in the fall or winter will result in the destruction of practically all of the weevils found there. Old cornfields, while not so important as sorghum fields, also furnish favorable hibernating quarters, and should be carefully cleared by the farmer who desires to minimize the weevil damage on his place.

A very practical illustration of the danger of trash in aiding in the hibernation of the weevil has occurred repeatedly on the experimental farm of the Bureau of Entomology near Dallas, Tex. Across a narrow lane on one side of the experimental cotton field of 40 acres is a small peach orchard in which the weeds have been allowed to grow unchecked from year to year. Every season the first weevil infestation in the cotton is found in the immediate vicinity of the orchard. In fact, the infestation always starts at that point and radiates into the field. If it were possible to eliminate the hibernating quarters across the lane—and this means only the prevention of the growth of weeds—there would evidently be a considerable reduction in weevil damage, especially early in the season when it is most critical.

LOCATING FIELDS TO AVOID WEEVIL DAMAGE.

The illustration just given emphasizes a method of averting damage by the weevil that can be followed in many individual cases. All planters that have had experience with the weevil know that the portions of their properties near the timber or other hibernating quarters show the first damage by the weevil and consequently the least production. Of course, it is not always possible to plant other crops in such situations. Nevertheless, very frequently farmers can avoid damage by devoting the particular fields known to be most susceptible to weevil injury to other crops. This is not pointed out as a general recommendation. In many cases it would be entirely impracticable, but its importance should be realized by planters in regions where every possible precaution must be taken.

CROP ROTATION.

Save in very exceptional cases the boll weevil never does so much damage on land where cotton follows some other crop as on land where cotton follows cotton. This is due to the fact, as has been pointed out, that the weevils do not fly very far from their hibernating quarters in the spring. Therefore it is evident that a proper rotation of crops may be followed to assist in the fight against the boll weevil. As in the case of the location of the fields, referred to above, the recommendation here made is no panacea. Nevertheless, rotation can be made to assist in fighting the weevil, aside from the many other advantages that are known to come from it.

PROCURING AN EARLY CROP.

Although the destruction of the weevils in the fall is the great essential step in controlling the insect, it can not be depended on exclusively. The full benefits of the fall work and the maximum crop can not be obtained unless the next great step, procuring an early crop, is also taken. In fact, the success of the farmer in producing cotton in regions infested by the boll weevil will depend directly upon the extent to which he combines the various methods described in this bulletin.

There are certain localities where the conditions cause the soil to be "late" or "slow." For instance, the planters on the Red River in Louisiana state that they can procure early crops on their "front" land, but that such is difficult or impossible on the fields back from the river. This is largely a matter of drainage. In some sections in Louisiana and Mississippi the essential step in obtaining an early crop will be largely a question of drainage. Lands so situated that they can not be drained economically to the extent that allows an early crop must be devoted to crops other than cotton.

The advantage of early planting has been demonstrated in every one of the numerous experiments made by the Bureau of Entomology and has now become the general practice among farmers. The reasons for the efficiency of early planting are not far to seek. The small numbers of weevils passing through the winter must have considerable time to multiply. They are unable to breed until squares are put on by the plants, since the food obtained from the fruit is required before reproduction can begin. Moreover, at the time the first squares are put on, the development of the immature stages is comparatively slow, not reaching the very rapid rate that obtains during the warm days and nights of the summer. For these reasons it is possible for the farmer to rush his crop in such a way that a large number of squares and bolls will be formed before the weevils have multiplied to a serious extent. Of course, under usual conditions the weevils will ultimately multiply so that the crop put on after a certain date will all be destroyed. This, however, is of no importance, since a top crop in weevil regions is entirely out of the question. The time it takes the weevils to recuperate after the vicissitudes of winter, especially after the entirely feasible destruction of multitudes in the fall, can thus be taken advantage of in the production of a crop.

Removal of plants.—The first step in the procuring of an early crop is the early removal of the plants, so that the land may be plowed during the fall or winter and the seed bed given thorough and early preparation. In fact, such preliminary preparation should be followed for the production of the best cotton crop under any conditions. The recommendation made is therefore neither onerous nor revolutionary. The tendency has often been to neglect the cotton fields until spring or at least until "after Christmas." It would repay the farmer many times if he would take the slight additional trouble of plowing the fields before that time. Not only a plowing but one or more harrowings should be given the land during the winter.

Use of commercial fertilizers.—An important step in procuring an early crop under many conditions 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. It has been demonstrated many times by the different experiment stations in the South that the maturity of cotton can frequently be hastened materially by the use of fertilizers, especially those containing a high percentage of phosphoric acid. The recommendation for the use of fertilizers in weevil regions, therefore, does not imply the exhaustion of the soil. It merely means that fertilizers place in the hands of the farmers an important means of averting damage by the boll weevil. 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 soil or different soils upon his own 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.

Use of early varieties of cotton.—Next in importance to early preparation, and fertilization (where necessary), in obtaining an early crop of cotton comes the use of early varieties. In all experiments that have been undertaken the advantage in the use of early varieties has been conspicuous. As in other cases, the greatest advantage in this instance comes with the joint use of the other expedients recommended for weevil control. By far the best method for obtaining seed of early maturing cotton is for the farmer to carry on the selection himself. In many cases, however, this is impracticable. Under such circumstances the farmer should obtain seed of improved varieties from dealers or such individual farmers in the locality as have been able to carry on careful seed selection. A valuable publication on the selection of cotton varieties has been published by this department as Farmers' Bulletin No. 314, "A Method of Breeding Early Cotton to Escape Boll Weevil Damage," by R. L. Bennett. A copy may be obtained by any planter on application to the Secretary of Agriculture.

Standard early varieties of cotton.—There are a number of standard varieties that have been found of value in weevil-infested regions the seed of which may be obtained from seed dealers. Among them are the Rowden, Triumph, Cleveland Big Boll, Cook's Improved, and King. All of these except the King have either medium-sized or large bolls. The King has a small boll, about 80 being required to make a pound, but is remarkably early and has given the best yields in most of the experiments of the Bureau of Entomology.[1] Hawkins'

[1] Some of the early maturing varieties of cotton happen to have small bolls, although the plant breeders hold that there is no necessity of an early maturing cotton having small bolls. In view of the fact, however, that some of the best known early maturing varieties at the present time have undersized bolls, occasional objections have been made to planting them. It is true that the picking of cotton from these varieties sometimes involves difficulties. In some cases it is known that pickers have refused to pick small-boll cottons while any other cotton was available despite the offer of additional payment on account of slow picking in the fields of the smaller bolled cotton. This is an actual, practical difficulty that must be taken into consideration. At the present time it is sufficient to call attention to the fact that the practical disadvantage of small bolls may not be so important as appears at first glance. For instance, if small-boll varieties yield 100 pounds of seed cotton per acre more than ordinary cotton, this gain would permit the farmer to pay 10 per cent more for picking, with profit. Thus:

750 pounds small-boll cotton per acre picket at $1 per cwt., cotton at $3 per cwt., net profit	$15.00
650 pounds large-boll cotton per acre picked at 90 cents per cwt., cotton sold at $3 per cwt., net profit	13.65
Difference in favor of small-boll cotton	1.35

Early Prolific and Simkins have given good results in recent experiments of the State Crop Pest Commission of Louisiana. In all cases it will pay the planter to exercise care in obtaining seed. Wherever possible it should be obtained from the originator.

Heavy cotton seed.—The Department of Agriculture has called attention to the advantage of planting heavy cotton seed. (See Farmers' Bulletin No. 285.) This should be taken into consideration along with other means of obtaining an early and vigorous stand. Another recent suggestion of assistance in obtaining an early start in the spring is that the planting be facilitated by covering the seed with paste. This method will make it possible to use an ordinary corn planter in putting in cotton seed and facilitate the work of check-rowing. This matter is discussed fully in the Farmers' Bulletin just referred to.

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 itself. Naturally no set rule can be laid down as to the proper date for planting. There is much variation in the seasons, and it is sometimes impossible to place the fields in readiness as early as is desirable. 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 made 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 are accustomed to at the present time. This, therefore, is the general recommendation that is made. 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. It is not intended that planting should be made early enough to have this effect upon the plants.

ADDITIONAL EXPEDIENTS IN HASTENING THE CROP.

It was pointed out in connection with the enemies of the boll weevil that under natural conditions a large percentage of the weevils is killed by heat and parasites. The wide spacing of the cotton plants augments the action of both these agencies working against the boll weevil. The effect of sun heat has been studied in many cotton fields. The mortality becomes remarkably high during the hot days of summer. The farmer can take advantage of it, and even increase it. It is very conservative to state that the weevils will be able to multiply only half as fast in fields where there is plenty of distance between the plants as in fields where plants are close together and the branches cross from row to row. It should therefore be the rule of the planter in weevil regions to give considerably more distance to the plants in the drill and to the rows than he would give under ordinary conditions. On land that produces under normal conditions from 35 to 40 bushels of corn per acre the rows should be 5 feet apart. Even on poor soil it is very doubtful, except in dry regions of the West, whether the distance should ever be less than 4 feet.

Check-rowing.—Considerable attention has been attracted in some localities in Texas to the practice of check-rowing cotton to assist in the control of the weevil. Undoubtedly from this standpoint the practice is to be recommended highly. By following it each plant is given the maximum soil that it can use with consequent beneficial results upon its growth. The greatest possible amount of sunlight is allowed to fall upon the ground where the infested squares are found, to destroy many weevil larvæ outright and at the same time to facilitate the work of the numerous enemies of the weevil that occur in every cotton field. Check-rowing, moreover, saves much labor, thereby reducing the cost of production, and also makes easy the control of noxious weeds. The only important objection is that in some localities it may interfere with drainage.

Cultivation.—During the growing season of the crop the fields should be given very careful cultivations. Most of the benefits of early preparation, early planting, and fertilization may be lost in case the fields are not given the utmost attention subsequently. 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 made to apply. 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 causes 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 have 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 certainly prevent the maturity of the later fruit and, moreover, will be forced to attack bolls which would otherwise not be injured.

Effect of late cultivation.—A very conspicuous illustration of the disastrous effects of careless late cultivation came to the attention of the Bureau of Entomology during the season of 1908. It was learned that some planters in the Red River Valley below Shreveport, La., were making fair crops (in one case 600 bales on 900 acres), while others were making very small yields, as, for instance, in one case 200 bales on 800 acres. Upon investigation it was found that all the planters in the neighborhood were compelled to put all their hands on levee work for five weeks to save their places. During that time the cotton remained uncultivated. After the subsidence of the flood the fields were plowed. Where this work was done carefully good crops were being produced. In cases where the plows were run too deeply and too close to the plants excessive shedding had taken place and the weevils prevented the putting on of any more fruit. Careful investigation on several places where the essential conditions were identical left no doubt that the cause of the difference in yields was primarily the difference in summer cultivation.

Occasionally a farmer is found who has obtained better yields on fields where cultivation has been discontinued early. In fact, the writer has seen fields full of grass that were outyielding perfectly clean ones on the same plantation. Such situations have caused erroneous conclusions. As a matter of fact, the explanation is that the late, careless cultivations had done more harm than good. The importance of careful shallow summer cultivations can not be too strongly emphasized.

SPECIAL DEVICES FOR DESTROYING WEEVILS.

The impression is more or less general that the only important way in which weevils may be killed is by the removal of the infested plants and that all other steps in the system of control are merely to avoid damage by the weevils that have survived that destruction, and their offspring. In spite of this impression, however, it is urged that the destruction of myriads of weevils can be accomplished during the growing season. This is to be done by working in cooperation with the natural agencies that destroy the weevil.

In making examinations of many thousands of infested squares from different localities and different situations in cotton fields it was found that mortality was conspicuously greatest where the sunlight was least obstructed and the heat, consequently, the greatest. The mortality in infested squares in the middles was many times as great as in the case of squares which remained under the shade of the branches. The temperature at the surface of the ground during warm days runs considerably higher than at a few feet above the surface. For instance, it was found that when the temperature was 100° F. in the regular Weather Bureau shelter about 4 feet above the ground the thermometer registered 140° F. on the surface. Likewise 90° F. in the shelter was accompanied by 120° F. on the ground and 85° F. in the shelter by 110° F. on the ground. It is not surprising, therefore, that the cotton squares that fall to the ground and are not shaded are very quickly baked, so that the weevils perish—if not from heat, then from the hardening of the food supply. In most cases they are simply roasted, their bodies assuming the appearance of larvæ that have been placed in a flame.

Chain cultivator.—When the foregoing facts came to light efforts were made to perfect a device that would bring the infested squares out of the shade of the plants to the middles of the rows. After much experimental work one of the writer's former associates, Dr. W. E. Hinds, devised an implement that accomplishes the desired work in a satisfactory manner. This implement is known as the chain cultivator or chain drag.

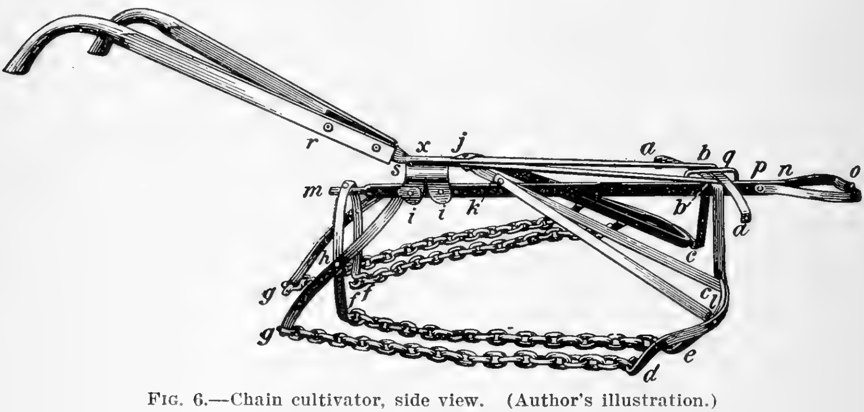

Fig. 6.—Chain cultivator, side view. (Author's illustration.)

The following specifications should enable any blacksmith to construct an effective chain cultivator. (See fig. 6.)

The draft bar (*n m*), made of $\frac{1}{2}$ by $\frac{5}{16}$ inch tire steel, about 52 inches long, is designed to be about 16 inches above the ground, and this is the height of the rear arch (*f h m*), which is of this size and form to allow old cotton roots, etc., to pass through freely without clogging at the rear.

The distance between the rear ends of the chains (*g g*, *f f*) is in each pair fixed at about 10 inches. The distance between a chain of one pair and that of the other at their front ends should be about 9 inches. The chains used are of the size known as "log chains," having short, close links of $\frac{3}{8}$-inch iron. This style of chain can be cut to the length needed in each case. The chain is easily attached by simply making the hooks at *d*, *e*, *f*, and *g* so that the end of the hook is as wide as will pass through the length of the link and narrow enough at the middle of the bend to allow the link to turn and bag the other way. So long as the chains are kept tight they can not become unhooked. The hooks should also be turned, or faced, in such a way that they will not be likely to catch the passing plants or rubbish.

The clevis (*o p*) is simply hinged, so that there will be no tendency to pull the front of the machine off of the ground, and it is also broad enough in front to allow of the point of draft being moved from one side to the other, so that the front of the machine may be thrown closer to one row if desired.

The front guard on each side (*a b c d*) is made of one piece of spring steel, $\frac{7}{8}$ by $\frac{3}{16}$ inch. This size seems sufficiently strong and best adapted to carry the tension of the chains (*d g*) while still yielding to the pressure against the bases of the plants as they may strike the outer, sloping ends near *d*. The inner ends of these guards (*a b*) are horizontal, about 18 inches each in length, and serve to carry the front guard above the draft bar (*n m*) and, passing through the keeper (*q*), guide in the adjustment for width. The machine can not be extended beyond the bent ends at *a* or closed beyond the angles at *b*. The vertical section between *b* and *c* is about 12 inches long, so that the remainder of the front guard from *c* to near *d* will be about 4 inches above the ground. This prevents the pushing of dirt and squares toward the plants and allows the chains to catch them where they lie. The hooks at *d* and *e* are therefore bent downward and somewhat backward through about 5 or 6 inches. Care must be taken especially in forming the outer ends between *c* and *d* to secure best results. The downward bend for the hook at *a* should not be abrupt, as a gradual slope helps to prevent catching on any obstacles. The hooks at *f* and *g* are formed so as to hold the chains firmly and yet not interfere with the passage of rubbish. The method of carrying the rear ends of the outer chains is shown at *i h g*. The piece *k l* is nearly parallel with the chains and may be used for their proper adjustment as to tension by several holes near the end where it is bolted at *k*. The chains are between 30 and 36 inches long. The stand *s* upon which the handles are pivoted by a $\frac{1}{2}$-inch bolt is made of a piece of boiler plate bent and cut so as to have a horizontal top surface about 4 inches square and standing about $2\frac{1}{2}$ inches above the draft bar, to which it is securely bolted. The handles are bolted, as at *r*, to the heavy pieces of iron (about 2 by $\frac{1}{2}$ inch tire steel) which are bent to receive them just behind the pivotal point at *x*, at such an angle as to bring the handles to the proper height and position. In front of *x* these pieces bearing the handles need not be so heavy and may therefore be tapered and welded to smaller steel running forward to *b*, where it is bolted to the front guard. The operation of this arrangement is similar to that of a huge pair of shears—when the handles are pushed apart the front of the machine is spread wider, and vice versa. The braces *j c e* serve to support, strengthen, and carry the front guard. They are riveted to the adjusting irons at *j*, one above and one below the " shear " pieces, to prevent their interference with the closing of the machine. At *c* this iron is bent to conform to the front guard, to which it is riveted between *c* and *l*, at which point it is bent downward and forms the hook *e*. Ordinary tire steel about 1 by $\frac{1}{4}$ inch may be used for all parts like the clevis (*o p*), rear arches (*f h m* and *i h g*), and braces (*k l* and *j c e*). The front guard (*a b c d*) should be of spring steel, as specified. The rivet heads on the front guard should be round and fit smoothly. In nearly all other places the irons are fastened together by $\frac{1}{4}$-inch square-headed bolts, with washers as needed.

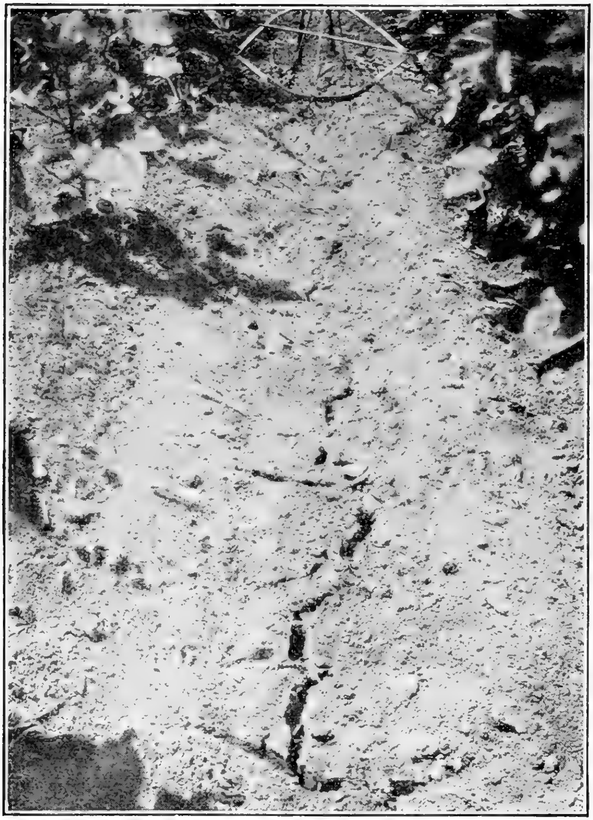

Fig. 7.—Work of the chain cultivator: Cotton row before use of cultivator, showing fallen squares, crack, and rough condition of ground. (Author's illustration.)

In operation the implement is drawn by a single animal. The chains at *d* and *e* pass under the branches of plants and close to the stems. The forward motion of the machine causes these squares to be drawn inward by the chains, which must be kept taut, and leaves them in a narrow pathway where the chains approach within a short distance of each other at the opposite end of the machine. (See figs. 7, 8.) The two chains are provided so that squares that may pass over the first are taken up by the second on either side. In actual practice it has been found that more than 90 per cent of squares may be brought to the middle of the rows. This means that the natural mortality among the weevils due to the effects of sunshine can be at least doubled.

Although the chain cultivator was designed primarily for bringing the squares to the middles, it was found in field practice to have a most important cultural effect. The chains (so-called "log chains") are heavy enough to establish a perfect dust mulch (see figs. 7 and 8) and to destroy small weeds that may be starting. In fact, it is believed that this cultural effect would more than justify the use of the machine, regardless of the weevil. With the effect against the insect and the important cultural effect it is believed that this implement or one similar to it should be used by every farmer in the weevil territory.

FIG. 8.—Work of the chain cultivator: Same row shown in figure 7, after cultivator has passed; majority of squares brought to middle, crack filled, and dust mulch established. (Author's illustration.)

In order that the use of this machine could be obtained by all farmers at the smallest possible cost, a patent has been taken out in name of the Department of Agriculture and for the benefit of the people of the United States. Under this patent it is impossible for anyone to manufacture the machine exclusively and to charge unnecessarily high prices.

Attachments for ordinary cultivators.—Some of the effects of the chain cultivator may be obtained by attaching chains to ordinary cultivators by the use of special attachments. In this way some of the effect of the chain drag will be added to the work of the cultivator. Wherever for any reason it is impossible to obtain chain drags, it is suggested that the principle be incorporated in some simple attachments to cultivators.

The use of an arm or projection that will agitate the cotton plants has frequently been suggested. It was assumed that the knocking of the squares to the ground earlier than they would fall naturally would increase the effect of heat in destroying the immature stages of the weevil. It has been ascertained, however, that throughout much of the territory occupied by the weevil the destruction of the stages in hanging squares is much greater than in those that fall to the ground. For this reason it is evident that the best practice is to allow the squares to hang on the plants as long as they will. In addition to the effect of heat on the immature stages it is important to note that the attack of parasites is much greater in the case of hanging squares. On these accounts our advice is that cross arms or projections on cultivators should not be used except in central and western Texas, where the dryness of the climate brings about a very heavy mortality in fallen squares. In eastern Texas, Arkansas, Louisiana, Mississippi, and Alabama the mortality is greater in the hanging squares, and the planter who causes these squares to fall early merely assists the weevil.

It is sometimes claimed that the use of a crossbar will cause many of the adult weevils to be knocked to the ground where they will be destroyed by heat. In repeated experiments in jarring and beating cotton plants in which known numbers of weevils were found it was ascertained that very few, if any, left the plants by reason of any agitation that would not break the branches or bark the stems. Occasionally, however, a weevil passing over a leaf is jarred to the ground. Often entirely too much stress is placed upon the importance of jarring the adult weevils to the ground. When specimens are collected by hand and thrown on the surface of the ground, especially if it be finely pulverized, the great majority will be killed almost instantly by the heat. This has caused the mistake on the part of careless observers of supposing that many weevils could be killed by jarring them to the ground. The difficulty, as pointed out, is that it is totally out of the question to jar more than one weevil out of many hundreds to the ground by any process that would not injure the plants severely.

HAND PICKING OF WEEVILS.

Gathering the weevils by hand is an operation of limited applicability. Where the fields of cotton are small and there is an abundance of labor it is sometimes practicable to pick the early emerging weevils from the plants and later to pick up the early fallen squares. Everything depends, however, on the conditions being favorable. On large places it will undoubtedly not often be found practicable to carry on this process. In an experiment performed by the Bureau of Entomology on a plantation worked by convict labor, giving the optimum conditions for the experiment, no results whatever followed thorough pickings twice each week for two months in the spring, beginning with the appearance of the first weevils. In another instance, at Gurley, Tex., more than 40,000 weevils were picked on an area of 8 acres by means of paid labor, beginning in April and continuing until July. On the 8 acres where this work was done a crop of about 50 pounds per acre in excess of that on other areas was obtained. This was not sufficient, however, to pay for more than a very small fraction of the work done. From these and other experiments the Bureau of Entomology recommends in a guarded manner the picking by hand of weevils and squares. Undoubtedly good may be accomplished under certain conditions, but planters should be careful not to depend too much upon it and not to make too great an outlay for it. The subject is being investigated carefully in Louisiana. In due time a full report will be published.

Disposition of adult weevils and infested squares.—When adult weevils are picked by hand they should be killed by means of oil or fire or buried deeply in the ground. When infested squares are picked, however, an entirely different procedure should be followed. Many of the weevil larvæ in the infested squares will be found to harbor parasites. It is entirely practical, as has been pointed out by Mr. Wilmon Newell, of the Louisiana State Crop Pest Commission, to let these parasites develop and continue their work against the weevils in the fields. This is done simply by placing the infested squares in wire cages. The parasites, on account of their small size, will escape, while the weevils soon die from a lack of food. The meshes of the wire of the cage should be at least 16 to the inch. However, some weevils will escape through this mesh, and about 5 per cent through a 14-mesh screen. Even if the finer wire can not be obtained, it is advisable to use what can be had. A calculation will show that there is a direct advantage even if a few of the weevils escape, if all of the parasites do. By burning or destroying the squares in any other way the farmer is simply working against and counteracting an agency in the control of the weevil that is much more important than any amount of hand picking he is likely to be able to do.

TOPPING OF PLANTS.

The practice of topping plants is sometimes recommended for fields infested by the boll weevil. The results of work by different experiment stations have shown that topping has exceedingly uncertain general results. As often as otherwise it decreased instead of increased the crop. In any case the topping of plants can probably do no harm in fields that are being damaged by the weevil. It is probable that the general results will be beneficial in causing the more rapid growth of the crop on the lower and middle branches. It has never been possible to demonstrate this in an exact way. Nevertheless, for the general effects stated the topping of plants is included among the recommendations that should be followed, although as one of minor importance.

COTTON LEAF-WORM AND BOLL WEEVIL.

The relation between the formerly dreaded leaf-worm or so-called "army worm" (*Alabama argillacea* Hübn.) and the boll weevil deserves special attention. A quarter of a century ago the efforts of entomologists and planters were directed toward some means of destroying the leaf-worm. The use of Paris green was found to be effective. Various changes in the general system of cropping cotton also caused the injuries to the leaf-worm to become less conspicuous year after year. Even up to the time of the spread of the weevil into Texas, however, poisoning was a more or less regular operation on all cotton farms. The insects never did any considerable damage before the middle or latter part of the season. The object in destroying the leaf-worm was that it prevented the maturity of a fall crop. For this reason the saving of the top crop and in exceptional seasons a part of the middle crop was all that was desired. The work of the boll weevil has changed all this. After the careful studies that have been given the problem it is evident that no top crop of cotton can be expected in infested regions. This, of course, reduces the leaf-worm to an insect of no importance where the boll weevil exists.

The change has actually been even greater than this, for the work of the leaf-worm has a disastrous effect upon the boll weevil. As has been pointed out in the discussion of fall destruction, the late developing weevils are the ones that pass through the winter. Consequently, if the leaf-worms defoliate the plants and stop the formation of squares, a certain degree of fall destruction is accomplished. It can never be so satisfactory as the poorest artificial fall destruction, because the plants continue to leaf out after the defoliation by the worms, thus giving the weevils a supply of succulent food. It is not recommended that the work of the leaf-worm be depended on in place of fall destruction. Nevertheless, allowing the leaf-worms to proceed with their work, or even encouraging them, will assist as a general procedure against the boll weevil at least when, for any reasons, the more important steps are not taken. In some cases where the injury by the leaf-worms begins unusually early, it may still be advisable to check it by poisoning in the well-known manner, but save in such exceptional circumstances it will now be better to allow the leaf-worm to work unrestrictedly.

It has been suggested by Mr. Wilmon Newell that in special cases where there are difficulties in the following of the fall destruction of the plants, it may be advisable to take means to encourage the leaf-worm. This could be done by breeding larvæ and pupæ to be scattered in the fields and by carrying the pupæ from localities, as the hills, where they appear first, to the valley fields, which are normally not reached until some time later.

DESTROYING THE WEEVIL IN COTTON SEED.

It has been abundantly shown that cotton seed is of importance as a medium through which the weevil may be carried. Many individuals that happen to be carried to the gin on the cotton pass uninjured through the gins to the seed houses. Consequently every seed house connected with a gin in the infested territory harbors more or less weevils, depending upon the amount of cleaning the staple is given. Of course such seed is exceedingly dangerous when taken into uninfested regions. Undoubtedly the present absolute embargoes against cotton seed from the infested region are wise. In general, they should be strictly construed. In some special cases, however, when, for instance, it is desired to obtain special improved seed, proper precaution can be taken to destroy all weevils by means of fumigation with carbon bisulphid. The method was described by the writer in Farmers' Bulletin 209, from which the following is quoted:

> The following plan for this work is proposed: A tight matched-board box should be provided having sides 4 feet high, open on top, and of other dimensions to accommodate 12 or more 100-pound sacks of cotton seed placed upright upon the bottom. Another tier of sacks could be added if desired. Into each one of these sacks about 1 ounce of carbon bisulphid should be forced by an apparatus for volatilizing the liquid and mixing the vapor with air. The accompanying illustration (fig. 9) will give an idea of this apparatus. It should consist of three essential parts, as shown in the illustration. *A* is an air pump having sufficient storage capacity to enable it to maintain a steady discharge of air for several minutes without continuous pumping. The stopcock at a_1 regulates or prevents the escape of air, as may be desired. *B* is an ordinary 2-quart bottle fitted at b_1 with a tight stopper of good length, having two openings, through which the inlet and outlet pipes pass. These pipes may be of glass or metal and should be as large as can be used. The inlet pipe, b_2, reaches nearly to the bottom of the bottle and is provided at the lower end with a perforated metal cap as large as will pass through the neck of the bottle. This allows the escape of the air in small bubbles and insures rapid evaporation. The outlet pipe, b_4, reaches only through the stopper. Upon the outside of the bottle is pasted a paper marked with 1-ounce graduations. *C* is a piece of ordinary ⅜-inch iron gas pipe about 3½ feet long, but this may be any desired length. It is closed and roundly pointed at the tip and for about 15 to 18 inches of its length provided with small perforations pointing in all directions to give free escape to the vapor into all parts of the sack of seed at once.

The connections may be of rubber tubing, but as little rubber as possible should be used for this apparatus, as it is affected by the vapor of the bisulphid, and the couplings will have to be frequently replaced. This, however, will not be a considerable item of expense. With the apparatus just described one operator would be able to accomplish the entire work of disinfection. The

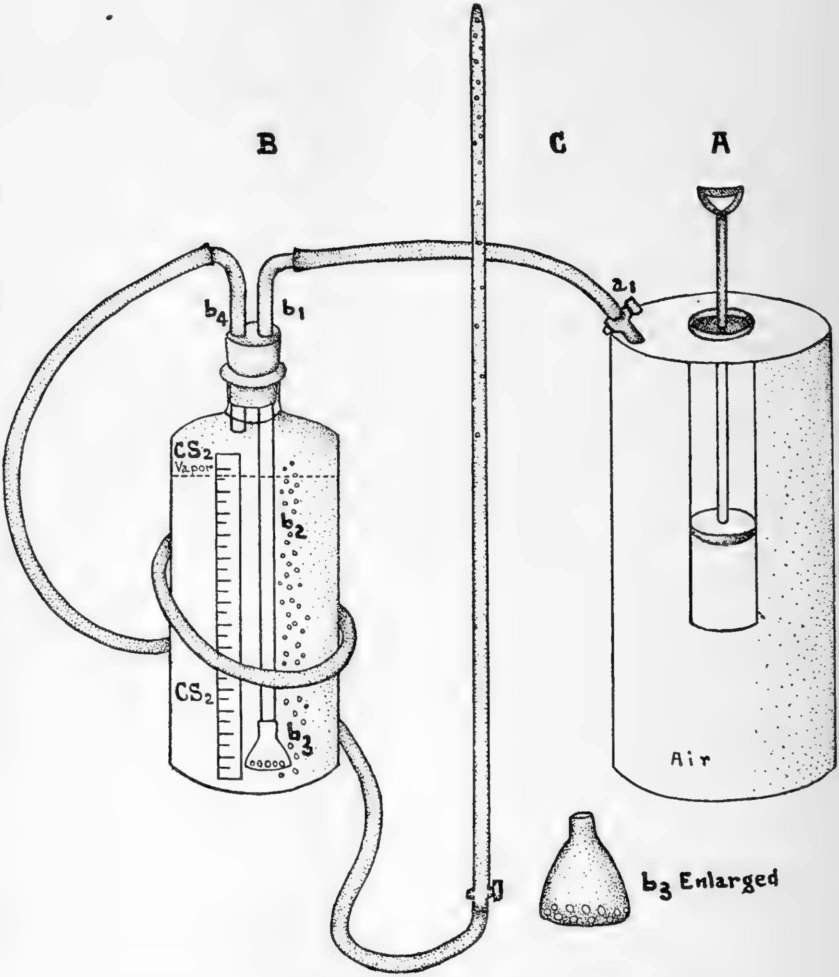

FIG. 9.—Apparatus for fumigating cotton seed in the sack. (Author's illustration.)

amount of carbon bisulphid recommended is about 1 ounce for each 3-bushel sack. It is safe to say that this can be secured for less than 1 cent per ounce when purchased in 25 or 50 pound lots, making the cost of bisulphid not over 1 cent per sack. As it requires but from two to three minutes to vaporize 1 ounce of the liquid in the manner described, the expense for labor in application would not amount to one-half a cent per sack. Fumigation with carbon bisulphid can therefore be effectively made at the slight expense of from 1 to 1½ cents per 100-pound sack.

Application of the bisulphid in this manner reduces the elements of danger to a minimum, as the vapor is almost wholly confined and the slight quantity escaping, mixed with the open air, would not be in either inflammable or explosive proportions. It has been determined that the slight trace of bisulphid vapor in the air would not injure the operator in the slightest degree. The sacks should be left in the box for 40 hours after the gas is injected.

RELATION OF MEANS OF CONTROLLING THE BOLL WEEVIL TO THE CONTROL OF OTHER INSECTS.

The cotton bollworm.—The most important insect enemy of cotton in the United States, aside from the boll weevil, is the bollworm (*Heliothis obsoleta* Fab.). This pest has existed in this country for many years, and frequently reduces the crop very considerably. The annual damage to cotton in the United States has been conservatively estimated at over $8,000,000. In addition to the injury to cotton, this insect is a very important enemy of corn, tomato, okra, cowpeas, and some other crops. Careful studies of the bollworm were conducted by Mr. 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 resorted to 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 Mr. Quaintance on this subject:

> The steps in the production of early cotton, outlined above, 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 cotton aphis.—Of the numerous minor enemies of the cotton plant in the United States there is one, the cotton aphis, or plant louse (*Aphis gossypii* Glov.), that may occasionally cause unusual damage by reason of early planting. This will only happen to any appreciable extent during wet seasons. Under such conditions the aphis may sometimes make it necessary to replant.[1] Nevertheless, this is not an important difficulty. It is not of sufficient moment to be considered at all, in view of the enormous benefit in avoiding damage by the boll weevil by means of early planting. If the other steps in the control of the boll weevil be taken and the fields made clean during the winter and the rubbish in the fence corners and along the turn rows destroyed, it is not likely that the aphis will do any considerable damage, even during the coolest and wettest springs.

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[1] On the contrary, cases have been noticed where early breaking and thorough working caused a lessening in the number of aphides, due to the destruction of the ant that protects them. Mr. Wilson Newell calls our attention to an instance of this kind in Louisiana in 1908.

The injury inflicted by several other insects, such as the cotton-square borer (*Uranotes melinus* Hübn.), webworm (*Loxostege similalis* Guen.), and cutworms often makes the crop somewhat later, and consequently likely to be injured by the weevil.

GENERAL CONTROL THROUGH QUARANTINES.

There is no doubt whatever that the weevil can not be prevented from extending its range to the extremes of the cotton belt in this country. However, the damage is so great and the disturbance of economic conditions so extensive that all reasonable precautions should be taken to prevent the early accidental importation of the weevil to uninfested regions. Practically all of the States in the cotton belt have enactments designed to this end. Undoubtedly they should be enforced to the fullest extent.

At one time considerable inconvenience was caused the shipping interests by the lack of uniformity of quarantines in different States and the inclusion of articles in which there is very little danger. At the present time these difficulties have largely been removed. All that it is advisable to include in the absolute quarantines are cotton seed, seed cotton, cottonseed hulls, and baled cotton. These commodities are likely to carry the weevil with them. In fact, it has been amply demonstrated that the insects are frequently carried in this way. Other articles, and even empty cars, may occasionally transport weevils, but the degree of danger is so much less than in the cases of the articles specified above that they do not need to be taken into consideration.

It is entirely feasible to eradicate small isolated colonies of the boll weevil. An important office of the State authorities concerned in State quarantines should therefore be to investigate reported outbreaks of the weevil and be prepared to take the necessary steps toward eradication at the earliest moment. The Bureau of Entomology will assist the State authorities in any cases of this kind.

ATTEMPTS TO POISON THE BOLL WEEVIL.

From the very beginning of the fight against the boll weevil attempts have been made to poison it. At different times advocates of various poisons have enlisted a considerable following. In order to understand the difficulty of poisoning the weevil it must be remembered that during the growing season the insect feeds only by inserting its beak into the squares or bolls. During this season, therefore, it is entirely out of the question to place the poison in a position where the insect will feed upon it.

Early in the season, however, before squares are formed the hibernating weevils feed on the opening leaves of the so-called bud of the cotton plant. At this time it is possible to destroy a considerable percentage by the application of poison. Exhaustive experiments performed by the Bureau of Entomology and other agencies demonstrated that Paris green can not be used to advantage at this time. More recent work with powdered arsenate of lead by Mr. Wilmon Newell, formerly of the Louisiana State Crop Pest Commission, seems to show that this poison can be used to advantage when the plants are small and the weevils abundant. Experiments performed in Louisiana in 1909 showed that cotton treated with powdered arsenate of lead yielded an average of 71 per cent more than similar cotton which was not treated. For two years the Bureau of Entomology has been experimenting with this poison. In many cases its use has resulted in increased yields more than sufficient to offset the cost of the application. In other cases there has been a loss. It is evident that under some circumstances the poison can be used with profit by the planter. Experimental field work now under way in Louisiana is expected to show the exact practical application of this poison in the control of the boll weevil.

Sweetened poisons.—Many attempts have been made to cause poisoned substances to be attractive to the weevil by introducing sweets and other ingredients. All these have failed completely. Some known sweets, such as honey, have a slight attraction for the weevil, but not enough to assist in practical control even regardless of their expense.

Contact poisons.—Poisons designed to kill the weevil by suffocating rather than by being taken into the digestive organs have been proposed. They can not, of course, be effective against the immature weevils within the cotton fruit. The difficulties in reaching the adults are in their manner of work. Normally these insects are found inside the bracts of the squares, where they can not be reached by sprays. In fact, nature designed the bracts to prevent the heaviest rains from reaching the square within. An additional difficulty is in the expense of applying sprays, not only on account of labor, but on account of the special machinery that is necessary. Although there is some very remote possibility that dry poisons may be found of assistance in controlling the weevil, on account of the facts mentioned it is not at all probable that liquid sprays can ever be used.

Effect of confinement.—There is one peculiarity of the weevil that has led to many unwarranted claims as to the efficacy of remedies. The insect will die within a very short time when confined in a bottle or jar or even in a cage. Even when cages are placed over growing plants it is found that numbers of the insects die and fall to the ground, though no poison has been applied. In many instances experimenters have applied their preparations under such conditions and have found dead weevils later. They have made no allowance for the weevils that would have died under these conditions without any treatment whatever. In such experimental work special pains should always be taken to provide one or more careful checks upon the weevils that have been subjected to treatment.

FALSE REMEDIES.

The extreme seriousness of the boll-weevil problem has called forth many hundreds of suggestions in control. These have covered such methods as changes in manner of planting, attracting the insects to food plants or lights, soaking the seeds to make the plants distasteful, sprays, machines, smokes, 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 fallacious methods that have been proposed.

Late planting.—Foremost among the futile means of control is late planting. At various times different persons have suggested that late planting, especially if following early fall destruction, would so lengthen the hibernating period that no weevils would be permitted to 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 performed in Kerr County, Tex., the plants were removed very thoroughly early in November. No stumpage or volunteer plants were allowed to grow during the winter. There was no other cotton 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. A similar experiment was carried out under different conditions by the State Crop Pest Commission of Louisiana and the results published in Bulletin 92 of the Louisiana Experiment Station. The results obtained in Louisiana agree in every way with those obtained by the Bureau of Entomology in Texas.

The reasons for the failure of late planting are evident from a study of the habits of the insect. 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 between 6 to 12 weeks after emergence. This ability to survive without food, together with the late emergence, render it entirely out of the question to exterminate the boll weevil by late planting. Moreover, there are always to be found along roads, turn rows, in cotton fields, and elsewhere, a considerable number of volunteer plants which come from seed scattered accidentally or blown from the bolls during the fall. 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, regardless of how late it might be. In 1906, for instance, at Dallas, Tex., it was found that 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.

Trap rows.—The idea of attracting weevils to a few early plants or trap rows seemed hopeful at one time. Practical work in the field, however, has shown that nothing whatever can be expected from this means. The difficulty is that the early plants exert very little attraction. Moreover, before the majority of the weevils have emerged from hibernation the planted cotton is always large enough to furnish them plenty of food. In practice it has been found impossible to defer planting long enough to concentrate any appreciable number of weevils on the trap plants. Trapping weevils to hibernating quarters is an equally mistaken idea. They can not be induced to resort to any particular places. It is likewise impossible to attempt to make the cotton fields more favorable for hibernation than places outside of the field.

There is one way in which trapping may occasionally be resorted to with good effect. When the plants are destroyed in the fall and the weather is so warm that the majority of weevils have not entered hibernation, many of them will be found upon the plants that are left. Under these conditions the farmer can leave a few trap rows to good advantage. They should be uprooted and burned within 10 days of the time the other plants are destroyed, to kill the weevils that may be found upon them. Hand picking at frequent intervals before destruction may be practicable where labor is inexpensive.

Attraction to lights.—Many insects more or less resembling the boll weevil are attracted to lights. This has caused many persons to attempt to destroy the cotton pest by taking advantage of the supposed habit. It has been found, however, that the boll weevil is not attracted to lights to any extent whatever. In one experiment a number of strong lanterns were placed in cotton fields in Victoria County, Tex. In all, 24,492 specimens of insects were captured, representing about 328 species. Of these, 13,113 specimens belonged to injurious species, 8,262 to beneficial species, and 3,111 were of a neutral character. Not a single boll weevil was found among all these specimens, notwithstanding the fact that the lights were placed in the midst of fields where there were millions of these insects.

Chemical treatment of seed.—It is scarcely necessary to call attention to the fallacy of attempting to destroy the boll weevil by soaking the seed in chemicals in a hope of making the plants that are to grow from them distasteful or poisonous to the insect. Any money expended by the farmer in following this absurd practice is entirely wasted.

Other proposed remedies.—Many remedies for the destruction of the weevil, consisting of sprays, poisons, and fumigants or "smokes," have been proposed. Hundreds of these proposed remedies have been carefully investigated. The claims of their advocates in practically all cases are based upon faulty observations or careless experiments. The strong tendency of the weevil to die in confinement, which has been referred to, has caused many honest persons to suppose that the substances they are applying have killed it. Moreover, an insuperable difficulty that these special preparations have encountered is the impracticability of application in the field. Hundreds of known substances will kill the weevil when brought in contact with it. The difficulty is to apply them in an economical way in the field. A striking instance of the unwarranted claims of some discoverers of "remedies" for the weevil was the case of a man who demonstrated the efficacy of his preparation by placing a feather in the bottle containing it and applying this to a weevil in his hand. Of course the death of the weevil was very far from a demonstration of the practical working of the supposed remedy. On account of the many difficulties in reaching the weevil and the necessity of obtaining special machinery for applications of poisons or sprays in the field, it is now considered, after much careful experimentation, that there is only the remotest hope of any such substances being of any practical avail whatever in the fight against the boll weevil. 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.

Mechanical devices.—Many machines have been constructed to collect the weevils from the plants, or the bolls and squares from the ground. These have consisted of suction and jarring devices. Many of them will destroy a certain number of weevils, but the habits of the insect are such that none has been found to yield results that pay even a small portion of the cost of operation. It is emphasized in this connection that there are plenty of proper ways in which all available mechanical ingenuity may be utilized in the fight against the weevil. There is great need for effective machines for assisting in the destruction of the weevils in the fall, and also for assistance in the cultivation of the crop. The present implements for cultivation, while effective in their way, could be improved in many respects, especially for the purpose of hastening the maturity of the crop. For instance, cultivators like the chain cultivator mentioned in this bulletin, to establish a dust mulch rather than to plow the ground, are much needed. There are some cultivator attachments, such as the spring-tooth attachment, which are exceedingly useful tools in maintaining a surface dust mulch, but these are not as yet in general use.

SUMMARY.

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 studies 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 consisting of several parts. The planter can insure success in proportion to the extent to which he combines the different essential parts.

(1) Destroy the vast majority of weevils in the fall by uprooting and burning the plants. This is the all-important step. It results in the death of millions of weevils. It insures a crop for the following season. If it is not practicable to burn the stalks they should still be uprooted. This will stop the development of the weevils but allow the cotton to be picked as the supply of labor permits. If the plants can not be uprooted turning plows should be used, in humid regions, to cover the fallen squares deeply as soon as the fields become heavily infested in the summer or fall. The practice is of little value in dry regions, but in humid regions it will result in the death of many of the weevils in the buried squares.

(2) Destroy also many weevils that have survived the preceding operation and are found in the cotton fields and along the hedgerows, fences, and buildings. This is done by clearing the places referred to thoroughly. (See pp. 22–23.)

(3) So far as possible, locate the fields in situations where damage will be avoided. This can not be done in all cases but can frequently be done to good advantage.

(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) Provide wide rows, and plenty of space between the rows and the plants in the drill, for the assistance of the natural enemies of the weevil, which do more against the pest than the farmer can do himself by any known means. Check-rowing, wherever practicable, is an excellent practice.

(6) Insure an early crop by early planting of early-maturing varieties, and by fertilizing where necessary.

(7) Continue the procuring of an early crop by early 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) In humid regions, if the labor is sufficient, pick the first-appearing weevils and the first-infested squares. Do not destroy the squares but place them in screened cages. By this means the escape of the weevils will be prevented, while the parasites will be able to get out and continue their assistance on the side of the former. (See pp. 34–35.)

(9) Do not poison for the leaf-worm unless its work begins at an abnormally early date in the summer.

(10) Do not go to the expense of buying special preparations for destroying the weevil. Disappointment and loss is certain to follow. In case of doubt communicate at once with the Bureau of Entomology or with the entomologist of the State experiment station.

SPECIAL TREATMENT OF SMALL AREAS.

In some cases, where, for instance, a farmer has a small area of cotton growing for seed selection, it is practicable to resort to special means of control that would be impossible in general field practice. For the benefit of the many farmers in the infested area who are beginning to improve their cotton by selection, the following suggestions are made: The plat or plats should be far from timber, hedgerows, seed storage houses, and other protection for hibernating weevils. On the appearance of the earliest weevils the plats should be carefully picked over by hand. This should be continued until well after the squares begin to fall. If the falling of the squares continues it will be found practicable to rake them by hand to the middles or entirely outside of the plats to a bare place, where the sun will soon destroy the larvæ within. Of course all other general suggestions that are applicable in the field should be added to these special ones.

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THE STABLE FLY.

BY

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 15, 1913.

Sir: I transmit herewith a manuscript entitled "The Stable Fly," by F. C. Bishopp, of this bureau. This insect is a pronounced enemy of domestic animals, frequently, as in the season of 1912, causing much loss among cattle and horses. It also becomes of great importance on account of its proved carriage of the disease known as "infantile paralysis" among human beings, and of its suspected carriage of pellagra. It is important that stockmen and medical men should know at an early date everything possible about this pest, and the accompanying manuscript has been prepared for this purpose. I recommend that it be published as a Farmers' Bulletin, in order to enable its wide distribution.

Respectfully,

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

Hon. D. F. Houston,
Secretary of Agriculture.

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THE STABLE FLY.

INTRODUCTORY.

The wide distribution of the stable fly (*Stomoxys calcitrans* L.), its intimate association with man, and its close resemblance to the so-called house fly or typhoid fly (*Musca domestica* L.) have led many to consider it identical with that species. Not until the stable fly becomes so numerous as greatly to harass live stock, or until the acute pain which accompanies the insertion of its proboscis is felt by the farmer himself, is man usually brought to a realization of the presence of a fly different from that distributor of typhoid germs, the common house fly. Severe outbreaks of the stable fly have led many to observe the flies more closely and to note their identity. Thus many individuals in certain sections speak of the stable fly as the "wild fly," "straw fly," or "biting house fly," to differentiate it from the ordinary house fly. The common name "stable fly" is applied to it because of its continual presence around stables, except during cold weather, and its comparative scarcity about the dwellings of man. Until very recently the stable fly received little attention at the hands of the entomologist or others. The recent demonstration by Drs. Rosenau and Brues of the possibility of the transmission of a distressing disease of man, known as infantile paralysis, through the agency of this fly, greatly stimulated interest in the study of the insect. A similar effect was also produced by the possible connection of this pest with the transmission of pellagra in man, as pointed out by Messrs. Jennings and King of the Bureau of Entomology. The investigations of authorities in this and other countries indicate that an important relation exists between certain diseases of domestic animals and this fly. Aside from the rôle played by the insect in disease transmission, it is an all-too-common and persistent pest to domestic animals. It will thus be seen that the stable fly may be of importance in three ways, namely, as a tormentor of live stock, as a carrier of diseases of domestic animals, and as a transmitter of diseases in man.

DISTRIBUTION AND ABUNDANCE.

The stable fly is one of the most widely distributed of insects. It appears to occur commonly in all parts of the world inhabited by man and the larger domestic animals. In those parts of the tropical, subtropical, and temperate regions in which domestic animals are reared, especially where those animals are kept in considerable numbers, the fly is a pest of importance. The absence of severe cold in the winters and the moist warm conditions prevailing in many of the countries bordering on the Tropics allow almost continual breeding; hence in these regions the fly is of importance throughout the entire year.

The stable fly has been in the United States for many years. Although it is probable that it was introduced from Europe with live stock brought here by the earliest colonists, we have no definite knowledge regarding its first occurrence in this country. The strong flight of the fly and its close association with domestic animals has permitted it to spread to all parts of the country.

The abundance of the species appears to be dependent largely upon local and seasonal conditions. In the southern part of the United States the insect is a pest of more or less importance throughout the year, but is usually most abundant in the latter part of the summer and during the fall. In the North and West it seldom becomes sufficiently numerous to cause annoyance to stock until the latter part of the summer and the early fall, the injury diminishing rapidly after heavy frosts. It appears that the fly is of much more importance as a pest in the grain belt than elsewhere. This point will be discussed more fully in another part of the paper.

From time to time climatic and other conditions have been favorable for the production of flies in great numbers, but little definite information is at hand regarding severe outbreaks which occurred prior to 1912. Old residents in the north-central part of Texas state that exceedingly large numbers of flies were present during the summer of 1867. Another outbreak occurred in parts of Texas in 1894 or 1895, and in 1905 the flies were again numerous enough to cause serious loss.

Notes have been published from time to time, in early entomological papers, on the injuriousness of this insect. In September, 1888, we find in Insect Life a reference to it as a pest to horses in Oregon. The correspondent in this case stated that the fly made its appearance at Salem, Oreg., two or three years before, though this information can scarcely be considered as reliable. This same issue of Insect Life also includes the statement that in the spring of 1888 the fly was reported to have caused considerable annoyance to cattle in Maryland and New Jersey.

In Kansas and Nebraska it has been determined that it is a pest of some importance every year throughout the grain belt of those States, but occasionally it appears in much greater numbers than normal. Statements made by farmers in other sections of the country where grain is grown extensively, notably in the Dakotas and Minnesota, indicate that the fly is sufficiently numerous nearly every year to cause considerable trouble. In the Southwestern States it sometimes becomes very abundant, although records of serious outbreaks have not been made. In central and southern Louisiana it is often very annoying to all live stock. This is especially true in the region where rice is grown extensively. It appears from investigations conducted in the central part of Florida that the stable fly is seldom present in sufficient numbers to attract attention. Prof. C. P. Gillette, of the Colorado Agricultural College, says in a recent letter, "Possibly the common stable fly is really the worst pest [of live stock in Colorado] on account of its being so abundant and ever present." In northern Colorado and southern Wyoming, at altitudes of from 5,000 to 7,500 feet, the writer has observed the insect to annoy horses and cattle greatly during the latter part of summer. From a statement made by Prof. J. M. Aldrich we learn that it is troublesome to cattle in Idaho, and Prof. R. W. Doane states that it is one of the worst fly pests to live stock in California.

THE SEVERE OUTBREAK OF THE STABLE FLY IN 1912.

During the late summer and early fall of 1912 an unprecedented outbreak of this pest occurred in northern Texas. The area of greatest abundance was practically coextensive with regions where grain was extensively produced that season. The most severe injury was experienced in Grayson, Cook, Collin, and Denton Counties, in northern Texas. The fly was also abundant as far south as Hill County and as far west as Wichita County, and in parts of southern Oklahoma it also caused much alarm. In certain parts of Kansas and Nebraska it was also said to be more abundant than normal.

In Texas the flies appear to have become seriously numerous about August 12 and the outbreak to have continued in its severe form until the end of August. Flies were, however, very numerous throughout September and the greater part of October, but rapidly diminished after cold weather began. Under a number of the succeeding topics reference is made to conditions which prevailed during this outbreak. Some of these illustrate the severity of the pest during such an occurrence.

A study of the conditions existing in northern Texas during 1912 showed that the flies were breeding to a great extent in straw stacks. Unusually heavy rains occurred in the early part of August, and as most of the straw was freshly threshed and had not become settled, the rain deeply penetrated the stacks. The straw became heated immediately and formed very attractive breeding places for flies. The grain crop of 1912 was one of the largest ever produced in Texas, and as the straw was also heavy a great number of straw stacks were present to furnish their quota of the pest. In fact, the flies were so numerous around these stacks that many men in plowing their fields avoided, so far as possible, the portions adjacent to them. Although the stacks dried out rapidly on the surface, the straw beneath continued moist for several months, and flies continued to emerge from these stacks where the straw was not destroyed or where breeding was not otherwise prevented.

Dr. L. O. Howard published a note a few years ago calling attention to a report by Prof. Iches on an invasion by this fly of a large estate in the Province of Santa Fe, Argentina. This occurrence appears to have been very similar to the recent outbreak in Texas. The flies were found by Prof. Iches to be breeding in wheat and flax straw after threshing.

HOSTS.

Practically all warm-blooded animals are attacked by this insect. Some of our domestic species, however, are much freer from injury than are others, owing to protection afforded the host by its hair or by some habit. Mules in general seem to be more annoyed by the flies than any of the other domestic live stock. Horses and cattle are, however, heavily attacked and often suffer severe injury. Those animals which are not easily disturbed and irritated act as hosts for a greater number of flies, but the result is probably not so serious as with more nervous individuals, which are consequently more easily worried. Sheep and goats are attacked on parts of the body not protected by wool, particularly the legs. Hogs are often attacked, especially when they are free in pastures. The flies are not attracted to the hog pens as are house flies, and where the animals have access to mud they are seldom bitten to any great extent except when flies are extremely abundant. Dogs and cats have also been seen with flies feeding upon them. Dogs with thin hair are exceedingly susceptible to injury and are greatly worried by the attacks. In some cases the flies become sufficiently numerous, especially on the ears, where they are inclined to feed most commonly, to cause the blood to trickle from the bites. In a few instances chickens have been seen with flies feeding upon their combs; however, healthy poultry are so active, as well as so largely protected, that they are seldom annoyed. Man is also frequently attacked by this pest, although the attack is usually quickly discovered on account of the pain caused by the insertion of the beak. During severe outbreaks men engaged in field work are often greatly annoyed by the flies, which not only attack exposed portions of the body but are able to bite through shirts or other comparatively thin garments as well. The flies also frequently attack the ankles of people, especially when low shoes are worn.

CHARACTER OF INJURY AND LOSSES.

As has been indicated, this fly is of importance in a number of ways. There is little doubt that it is a potent factor in disease transmission, although it has been definitely proven to carry only a few diseases. Among live stock there is no doubt that the tropical disease of camels, horses, and cattle known as surra is transmitted by this insect. This disease fortunately does not occur in this country, but unless great care is exercised in importing stock it may be introduced at any time. Another related disease of cattle, horses, and sheep, known as souma, and still another malady of hogs and cats are carried, at least in part, by this same insect. In this country anthrax in domestic animals and man is also probably disseminated to some extent by this fly. Some investigators also consider it to be an agent in transmission of septicemia in man and glanders in horses and other animals, and the disease known as infectious æenemia or swamp fever of horses is thought by some to be carried by this pest. A number of years ago it was found to act as an intermediate host for a species of roundworm which infests cattle. Thus it will be seen that the transmission of a formidable array of diseases is chargeable to this one species of biting fly.

Aside from its importance as a disease conveyor this insect is of much importance on account of the worry produced by its bites. During severe outbreaks this is probably the most important factor in bringing about losses. During periods of great abundance all live stock are compelled to keep up a constant fight against flies from early morning until dark. At such times the flies are not only present around barns but in towns and cities and open fields. Animals which are being worked in the streets or kept in stables suffer alike. During the severe outbreak which occurred in 1912 many horses and cattle became so weak that they gave up the fight against the pest and the flies swarmed over them in countless numbers. In a few of these cases, where the animals were not promptly protected from attack, they succumbed in a short time. The loss of blood during severe outbreaks is a very important consideration. When fully engorged the abdomen of the fly is greatly distended, and it has been found that the blood extracted at one feeding is soon digested and the fly is ready for another meal. Thus animals continually exposed must serve to engorge thousands of individuals each day, each of the flies ingesting several drops of blood during a meal.

In the portion of the United States where Texas fever occurs, in addition to the live stock actually killed by worriment and loss of blood, a considerable number of cattle are lost from Texas fever. In most of these animals, although the disease organisms are latent in the blood, no apparent injury would result under conditions favorable to live stock. Under the strain of continually fighting the flies and with the weakened condition brought about by the loss of blood, however, an acute form of Texas fever is induced. When animals begin to suffer from the fever they are less energetic in fighting the flies and consequently become the more ready victims. During the outbreak in 1912 acute Texas fever was certainly produced as a result of fly attack. Owing to the continual biting of the insect the fever could not be reduced in many cases and the animals speedily died.

During severe outbreaks the loss brought about by the reduction of the milk supply in fly-infested zones is an important item. In the 1912 outbreak many dairymen found that their output of milk was reduced from 40 to 60 per cent, and that in some cases cows were completely dried up. For several months after the pest had abated, the effects of the outbreak were apparent in the reduced milk production. Even in cows which freshened several months after the pest had abated, the effect on milk yield was said to be still apparent.

During 1912 all animals in the fly zone were greatly reduced in flesh. Cattle which were fat enough for market in many cases were so much reduced that they could not be sold. Horses and mules in many cases lost from 10 to 15 per cent in weight during the outbreak. Some dairy herds which were usually shown at the State fair suffered such marked injury that they were not fit for exhibit.

In many cases the joints of both horses and cattle became so swollen and stiff, from standing in water where they sought protection from flies, that they could scarcely walk. The incessant stamping of the animals also had the effect of injuring the feet and joints. A number of liverymen found it necessary to discontinue making drives into the country, and some of their animals were completely disabled for regular work.

Another source of loss to farmers was their inability to proceed with their usual farm plowing and other operations at the proper time. In many sections the flies were so bad on the horses that they could not stand both the work and flies. Some men resorted to night work as a means of escaping the attack, but this was too severe for the teams, as the flies allowed them no rest during the day. Numerous instances of horses becoming frantic from irritation were recorded; these often resulted in runaways and consequent destruction. Animals which were not being worked sometimes received injuries from running into barbed wire fences in endeavoring to escape the flies.

The total loss due to the outbreak in 1912 is difficult to estimate. It is believed that in northern Texas over 300 head of cattle, mules, and horses were killed directly or indirectly as the result of the fly attack. This actual death loss may be conservatively placed at $15,000. The loss due to the reduction in milk supply may reasonably be placed at $10,000, and other losses far surpass these two items. Moreover, these were the losses experienced only in the few counties in northern Texas where the fly was most abundant and does not include the more or less serious injury sustained in practically all parts of the United States.

ACTION OF ANIMALS ATTACKED.

All animals are usually greatly annoyed by the attack of this fly. Less nervous individuals sometimes permit the flies to feed without particular effort to drive them away, while others of more nervous temperament are driven almost frantic by the attack. In general, mules seem to be worried rather more than horses, and most cattle are less irritated than either mules or horses. Sheep and goats are much annoyed by the presence of the insect, but because they are largely protected by the wool they are able to keep the flies off their legs by frequently moving them. A great difference in the degree of annoyance produced among dogs has been noticed. Some individuals are greatly irritated by the presence of a single fly and frequently change their positions, going from one place to another to seek protection. Horses and mules that are being driven sometimes pay little attention to flies, while in other cases they may lie down and roll or even run away in their frantic efforts to escape. During times of unusual fly abundance animals, when free in pastures, frequently bunch up on knolls where they are exposed to the wind and apparently secure some protection by contact and concerted fighting. When streams or pools of water are accessible both horses and cattle, particularly the latter, take to them for protection. Cows often lie down in the water so as to be almost completely covered, and the coating of mud obtained in such situations offers some protection from fly attack. Stock often temporarily rid themselves of most of their annoyers by running through trees and brush. If permitted to reach stables or barns, the animals usually crowd within and remain inside throughout the day. During the severe outbreak in 1912 it was almost impossible to get some animals to leave the stables and go into pastures, even after nightfall, on account of their fear of the flies. Although the bunching of the horses in the stable affords some protection, yet this by no means exempts them from fly injury, as the pest is often as bad within such places as without. Sheep and hogs exhibit similar habits in endeavoring to secure protection; they often lie in close groups in shady places and keep their heads and legs protected by placing them against or beneath one another. When mud-holes are accessible, hogs largely escape the flies by lying in the water and becoming covered with mud.

It is possible to determine, even at considerable distances, by watching the actions of the animals, whether the stable fly or horn fly is bothering cattle. When the stable fly is present the continual stamping of the feet and striking at the legs with the head and tail indicate the point of attack, while when the horn fly is present the animals pay particular attention to the back and sides. The bite of the stable fly is evidently much more severe than that of the horn fly, as it causes very great annoyance even when the flies are present in much fewer numbers.

SUMMARY OF LIFE HISTORY.

Like all other flies, this species has four stages in its life history, namely, the egg, larva, pupa, and adult.

The egg.—The eggs of this fly are elongate ovoid and of a creamy white color. They are about one twenty-fifth of an inch in length and under a magnifying glass show a distinct furrow along one side. When placed on any moist substance they hatch in from one to three days after being deposited. In hatching a small slit is made around one end of the groove, and the minute maggot crawls out. Figure 1 shows four eggs on a piece of straw; the two at the right have hatched.

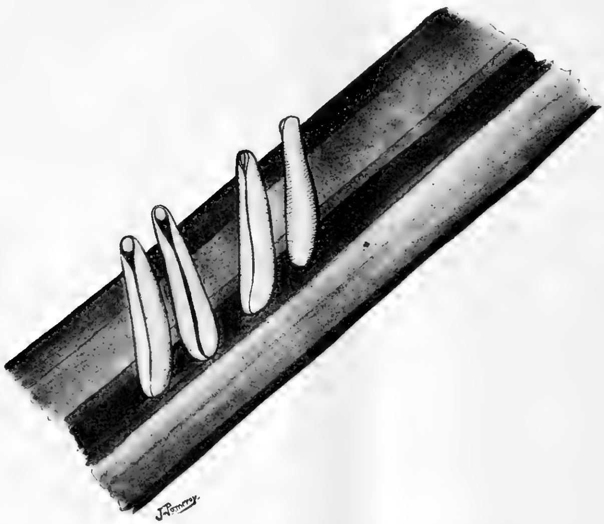

FIG. 1.—Eggs of the stable fly (*Stomoxys calcitrans*) attached to a straw. Greatly enlarged. (Original).

The larva, or maggot.—When first hatched the larvæ, or maggots, are about one-twelfth of an inch in length and, being translucent, are not easily seen with the naked eye. Development takes place fairly rapidly when the proper food conditions are available, and the growth is completed within eleven to thirty or more days. When full grown the larvæ (fig. 2) are pale yellow or nearly white and about four-fifths of an inch in length. They have the typical shape and action of most maggots of this group of flies. The hind end is large and the body tapers to the head. The larva moves quite rapidly by means of minute projections on the edge of each segment along its underside. When exposed to the light it quickly disappears again in the straw or other matter in which it is breeding.

The pupa.—When the larvæ are full grown they shorten and become thicker, and the skin contracts and hardens to form the case in which the transformation to the adult is to take place. This puparium, or pupal case, is rather soft and yellowish at first but soon becomes harder and changes to a reddish brown color. It is elongate oval, slightly thicker toward the head end, and from one-sixth to one-fourth of an inch in length (fig. 3). During this stage the insect is completely dormant, the transformation from maggot to adult fly going on within the puparium. This resting stage requires from six to twenty days, or in cool weather considerably longer.

FIG. 2.—The stable fly: Larva or maggot. Greatly enlarged. (Original.)

The adult.—When the fly has completed its development within the puparium it pushes its head against the end until the shell splits open. It then crawls out as an adult fly but so different from the fly ordinarily seen that one would scarcely recognize it. The color is pale and the head considerably produced in front between the eyes. At this time the wings are only small, wrinkled sacs. In a few minutes air is forced into the wings, and they slowly unfold, the fly becomes gradually darker in color, and its body becomes harder. Up to this time the beak is not visible, as it is bent downward between the legs. It soon becomes almost black and is brought forward in its natural position so that the tip may be seen from above. When completely dried out the adults show four rather distinct, dark, longitudinal markings on the thorax, as well as several dark spots on the abdomen. The male is usually slightly smaller than the female, the body of which measures from one-fourth to five-sixteenths of an inch in length. The adult, as seen from above, is shown in figure 4, and a side view of a female specimen engorged with blood is shown in figure 5.

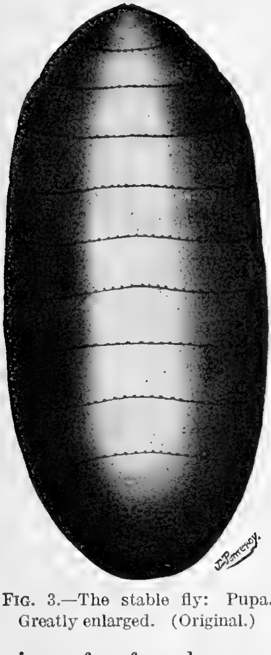

FIG. 3.—The stable fly: Pupa. Greatly enlarged. (Original.)

This insect is closely related to the house fly, as can be readily seen by its close resemblance to that insect. It may be distinguished from the house fly, however, by the long, sharp, biting mouth parts, a portion of which may be seen projecting forward from beneath the head. The proboscis of the house fly is short and broad and not capable of piercing. The stable fly is usually slightly stouter than the house fly, and the spots on the abdomen also aid in distinguishing it from that species.

The horn fly is also related to this species but is of much smaller size, and the color is considerably different. When on a host these

FIG. 4.—The stable fly: Adult female as seen from above. Greatly enlarged. (Original.)

flies may be readily differentiated by the attitudes they assume. The stable fly usually attacks the lower portions of the legs of its host and nearly always sits with the head up. The horn fly is more inclined to feed on the back and sides of the animal and always feeds with the head downward, while the house fly may be seen sitting in any position but never with its head pressed into the hair as though feeding.

DEVELOPMENT AND HABITS.

BREEDING PLACES.

Horse manure has long been considered the normal breeding medium for this pest. Investigations made during the outbreak in 1912 showed clearly, however, that the vast majority of the flies bred out in straw stacks, and investigations made around stables and barns indicate that while the fly breeds in pure horse manure it favors a mixture of this substance with straw. The fly was found to be breeding in much greater abundance in oat straw than in wheat straw. This appeared to be due to the softer stems and the greater amount of leaves in the oat straw, which furnished better food and allowed the stacks to become more compact. Rice straw was also found to furnish suitable breeding conditions, and there is little doubt that barley and rye also often serve as food for the immature stages.

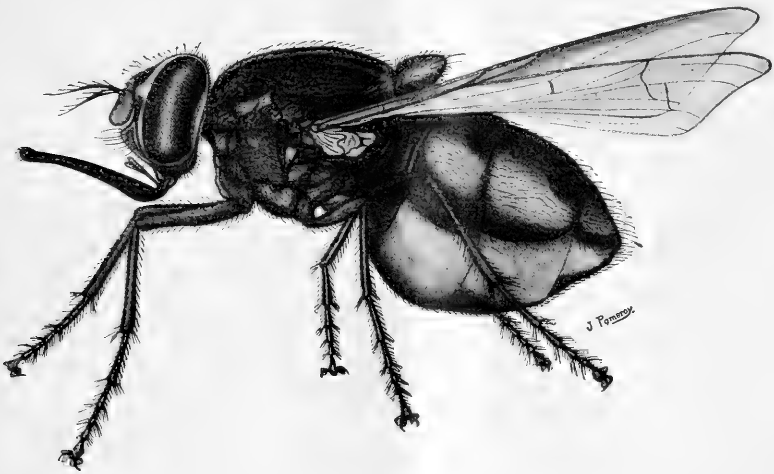

FIG. 5.—The stable fly: Adult female, side view, engorged with blood. Greatly enlarged. (Original.)

As has been stated, it was found by Prof. Iches to breed in great numbers in the débris left after thrashing flax. A careful examination of portions of alfalfa stacks which were moist and readily accessible to numbers of flies showed that they were not infested. This was also found to be true of accumulations of weeds and bunches of grass in open fields. It is probable, however, that the insect may occasionally breed in broken-up masses of hay or dead grass, especially when they are permeated with liquids from manure. The manure piles commonly found by stables where horses are kept furnish suitable breeding conditions. This is especially true in the early spring, when the warmth of the manure appears to be very attractive to the flies for egg laying. Cow-lot manure which has become broken up, especially when mixed with waste feed, is also utilized as a breeding place for the insect. This has also been found to be true of ensilage, particularly when mixed with straw, as is often the case when the bottom of a silo is cleaned out. Experimentally, a few specimens have been reared from pure cow manure, but this substance seems to be unattractive to the adult and not favorable for the breeding of the larvæ on account of its very compact texture. A Russian investigator, Prof. Portchinski, has made the statement that the larvæ have been found in the leaves of growing plants. This, however, must be a very rare occurrence. This species has never been found breeding in human excrement and does not frequent malodorous places, which are so attractive to the house fly. Hence it is much less likely to carry typhoid and other germs which may be found in such places.

The development of this insect is somewhat slower than that of the house fly, and it is therefore more essential, in order that it may breed out successfully, that the eggs be deposited in rather large accumulations of material. The larvæ are very sensitive to drought and soon succumb if the material in which they are breeding is not kept rather moist.

HABITS OF THE ADULT.

Both the male and female of this species feed on the blood of animals. They appear to discover their host mainly by sight and usually, especially on cattle, pass quickly to the lower portion of the legs (fig. 6), particularly on the outside, where the hair is somewhat shorter than on other parts of the animal and where they are less likely to be struck by the tail of the host. When the flies are very abundant their attack is by no means confined to the legs, as both cattle and horses have been seen practically covered with flies on all parts of the body. They seldom remain on the host long without inserting the beak. Before blood is extracted they are easily disturbed and often move about several times before settling down for final engorgement. After the beak is well inserted and the blood begins to flow they usually become engorged in from two to five minutes. During feeding the abdomen becomes greatly distended (see fig. 5) and often of a distinctly reddish color. When the appetite of the fly has been satisfied it withdraws its beak and flies rather sluggishly to some near-by object, where it rests while digesting its meal. During this process numerous drops of clear liquid excrement are voided. This also takes place while the fly is feeding. The insertion of the beak is accompanied by a rather severe, sharp pain. This accounts for much of the worriment caused to the host by this species. After blood extraction has begun little or no pain is felt. When the proboscis is withdrawn a drop of blood usually exudes from the wound. Numerous small flies have been seen to frequent the blood which exudes in this way, and it is not improbable that the screw-worm fly may deposit its eggs on these spots and thus cause infestation of the host with these maggots.

During warm weather the blood is digested rapidly and the flies may feed again the same day. When the weather is cooler they usually require about a day for the digestion of the blood. After partaking of a meal the flies, during hot weather, ordinarily alight on the walls of buildings or on foliage of plants in shady situations. When the temperature is lower they remain in the sunlight, but in all cases they tend to avoid strong wind.

Adults frequently follow for considerable distances teams traversing roads and, when engorged, settle on near-by objects. Other teams which pass along the same highways are thus frequently attacked by flies which have completed the digestion of their previous meal, and this has given rise to the idea that the flies are breeding in weeds, grass, and hedges along the highways. This is also a means by which the flies invade territory beyond that in which they develop. Adults have also been observed to travel many miles in the passenger coaches of railways. Few individuals are carried in this way, but doubtless the spread of the species is aided and, what is more important, diseases might be spread in this way by infected flies.

FIG. 6.—Legs of a steer attacked by the stable fly. (Author's illustration.)

Feeding may take place a number of times. Experimentally, individual flies have been induced to engorge as many as 14 times. Flies have been observed to partake of water and to feed to some extent on succulent fruit. They commonly feed on the moisture on fresh manure and on rotting straw. Although man is occasionally bitten by these flies, horses and cattle seem to be preferred as hosts.

REPRODUCTION.

Mating of the flies takes place while they are not on hosts, and egg laying soon follows, provided the flies have fed a sufficient number of times. It seems that at least three feedings on blood are necessary for the production of eggs. After the third meal is digested the flies seek suitable places for deposition. When the weather is cool additional feedings are often necessary before eggs are produced. The adults appear to have a keen sense of smell and are able to detect moist straw and suitable manure very quickly. This is especially noticeable when a straw stack which is dry on the outside is opened up so as to expose the moist and rotting interior.

Very soon after a stack is opened flies are seen to come to the moist straw in numbers and begin depositing eggs. They usually crawl into the loose straw, sometimes going to a depth of several inches. When laying eggs the fly greatly extends the ovipositor and uses it as an organ of touch in locating a suitable spot in which to deposit. The eggs are laid in irregular masses, although occasionally single ones are deposited. The female usually moves several times during deposition so that each mass contains from a few to as many as 25 or more eggs. The greatest number of eggs which has been observed to be deposited before another meal of blood is taken is 122. After all of the eggs have been deposited the female again seeks a host, and this feeding is again followed by deposition. Three of such depositions commonly take place in this species. It is sometimes necessary, especially during cool weather, for a fly to become engorged twice before each deposition following the first. The greatest number of eggs which has been seen to be deposited by a single female during her life is 278.

LENGTH OF LIFE OF THE ADULT.

A considerable number of experiments have been made to determine the length of life of the adult fly. A knowledge of the longevity of the adult is important in order that its possibilities as a pest may be determined and that we may ascertain whether the species may act as a true host of disease organisms; that is, whether disease germs can multiply within the fly before being capable of producing the disease in a higher animal. Individuals kept in small tubes without food or water during hot weather died within two days. When water and sugar sirup were supplied to flies, in a screen cage about 1 foot square, one specimen out of a large number of males and females lived for 23 days. Individuals which had access to blood at frequent intervals lived 17 days, and a few specimens, among a considerable number which were kept in large cages with cattle and suitable material in which to deposit eggs, lived for 29 days. When flies had been supplied with fruit and moist straw, but had not had access to host animals, they frequently lived for 10 days.

THE LARVA AND ITS HABITS.

The larvæ begin feeding as soon as they hatch from the eggs and continue to do so throughout their growth. Portions of moist straw or other material in which they are breeding are torn off by their mandibles, which are located on the narrow or head end of the maggot. When very small they frequently penetrate between the layers of the stalk or leaves of grain when moistened in the straw stack. When larger they frequently feed within the straws, and transformation to the resting state sometimes takes place in this protected situation.

The duration of the larval stage has been found to vary from 11 to 30 days. During very cold weather this stage is probably considerably longer than one month. The character and abundance of food as well as the amount of moisture present have an important influence on the development of the maggots. The larvæ follow the moisture inward as the material in which they are breeding becomes dry on the surface. Pupation occurs anywhere in the breeding material; however, it frequently happens that the larvæ, when breeding in small masses of straw or manure, work downward as the material dries and pupate at the surface of the soil.

LIFE CYCLE.

It has been found that the complete development from the deposition of the egg to the emergence of the adult fly may be completed in 19 days. On the average the period is somewhat longer than this, generally ranging from 21 to 25 days where conditions are very favorable. The longest period observed for complete development was 43 days, although it is certain that in the late fall and during the winter months a much longer period is often necessary. The finding of full-grown larvæ and pupæ in straw during the latter part of March, 1913, in northern Texas shows that development may require about three months, as these stages almost certainly developed from eggs deposited the previous December.

SEASONAL HISTORY.

The stable fly is particularly abundant and injurious in the late summer and fall. This is especially true in the Northern States, where development begins later in the spring. Mr. C. T. Brues states that the flies first appear in noticeable numbers about June 1, in the vicinity of Boston, Mass. The fly has been observed to be sufficiently numerous to annoy cattle considerably at Dallas, Tex., as early as March 1, and in the western part of Texas it has been observed feeding on live stock in considerable numbers early in May. At Batesburg, S. C., Mr. E. A. McGregor found the adults to be commonly attacking live stock about the middle of March in 1913. In the extreme southern part of the United States, however, there is no month during the year in which flies are not annoying to horses and cattle.

The number of generations of this insect annually has not been determined, but it is estimated that seven broods may readily develop in one year in the Southern States. In the Northern States probably five broods is about the usual number.

HIBERNATION.

In the southern part of the United States there is no true hibernation of this insect. The adults have been found to emerge at various times throughout the winter, and during warm periods at Dallas, Tex., they have been observed to feed on animals. Mr. W. V. King reports that considerable numbers of adults were present throughout the winter of 1912–13 at New Orleans, La. In fact, they appeared to be even more numerous in midwinter than during the previous fall. At Victoria, Tex., Mr. J. D. Mitchell found them to annoy stock throughout the winter. Although no egg laying appeared to take place during the winter of 1912–13 at Dallas, Tex., it may sometimes occur at that latitude and probably occurs throughout the winter in the extreme southern part of the United States. It would seem that most of the individuals which pass the winter successfully hatch from the eggs laid in the fall and continue development slowly during winter, emerging in early spring when conditions are favorable for further reproduction. Examinations of straw stacks in northern Texas, made during the latter part of March, 1913, showed a few full-grown larvæ and large numbers of puparia. These almost certainly developed from eggs deposited the previous December. In the northern part of the United States it is doubtful if many flies emerge during the winter months, the winter being normally passed in the larval and pupal stages. Near Boston, Mass., Mr. C. T. Brues observed adults to be active in heated stables in the dead of winter. These individuals probably bred out in refuse within the warm barns and were not hibernating adults. In 1913, at Clarksville, Tenn., Mr. D. C. Parman found that the adults began emerging about March 30.

AGRICULTURAL PRACTICES IN RELATION TO FLY ABUNDANCE.

A number of agricultural practices which are commonly in vogue in the United States are calculated to favor greatly the development of this species. As has been stated, this species breeds most commonly in straw and horse manure or a mixture of these two substances. The usual custom of allowing the manure from the horse stable to accumulate just outside of the stable doors absolutely insures the presence of a considerable number of stable flies at all times when climatic conditions are suitable for breeding. Allowing barnyards, especially around dairies, to become knee-deep in manure is also calculated to produce flies in abundance.

In the grain belt it is the general practice for farmers to thrash the grain in the fields by means of self-stacking thrashing machines. The individual stacks cover much ground and the straw is very loosely piled. In many cases for convenience a large number of stacks are formed in various parts of a field. This condition, when followed by more or less heavy summer and fall rains, is certain to produce great numbers of flies. In fact, this is precisely the condition which occurred in 1905 and in 1912, when the serious outbreaks of the fly occurred in Texas. In many instances straw stacks are not protected from live stock. The animals soon scatter the straw about and by adding manure to the straw still further favor the breeding of flies. These straw stacks are usually allowed to remain from one year to the next without any attention whatever. When the succeeding crop is planted the area occupied by the stacks is simply left uncultivated. In a number of instances 50,000 square feet have been found occupied by a single stack, and in many cases several of these stacks occurred in a field of 60 or more acres. A railroad official recently computed that the area covered by wheat stacks in Kansas alone is no less than one-fourth of a million acres. Such stacks are usually allowed to remain throughout the fall and winter and in a few cases are burned the following spring. More frequently, however, they are left from year to year and the new straw added to the old stacks, destruction only taking place when the stacks become exceedingly large. It will be seen that these practices not only encourage the breeding of the stable fly, but when the straw becomes sufficiently rotten and compact the house fly as well breeds in it in abundance. Throughout the grain belt a very considerable amount of valuable land is untilled and the full manurial value of the straw is lost. Of course the stacks serve some purpose as shelter and food for live stock kept in the fields during winter. In fact, this is the only legitimate reason for not scattering them or burning them in the late summer or fall.

NATURAL CONTROL.

CLIMATIC EFFECT.

The adults feed when the temperature is very high and the sun bright and hot as well as during cool and cloudy weather. They have also been observed to attack animals during drizzling rain, and when somewhat protected by sheds and stables they often feed during heavy rain. The lowest temperature at which flies have been observed to partake of blood was 55° F. When the temperature goes below 60° F. their desire to feed is less marked. Between 40° and 48° F. they lose their ability to fly, and complete inactivity occurs when the temperature ranges between 31° and 45° F. This range of activity is due to variation in individual flies, to the rapidity of the decline or rise in temperature, and to the minimum temperature experienced by the individuals. No adults appear to be killed when the temperature does not go below 27° F., and some at least are able to survive temperatures considerably below this point. All of the adults at Dallas, Tex., seem to have been killed when the temperature reached 8° F. As has been stated, the flies always seek shady places during hot weather, but when the temperatures are low they delight to dart about in the sun in a manner very similar to that of the house fly.

The maggots, or larvæ, are very susceptible to drying. This is particularly true soon after they are hatched. Excessive moisture is also detrimental to their development, and flooding kills them in a few hours. They appear to be able to endure rather high temperatures when abundant moisture is at hand, although the heat produced in manure and straw stacks is often sufficient either to kill them or to drive them outward. No doubt the generation of heat within the breeding places stimulates the development of the immature stages during the fall and winter months. Light is detrimental to the development of the larvæ. When placed in bright daylight, even though sheltered from the sun, larvæ have never been known to complete development. These facts make it possible successfully to destroy the pest in this stage of its life.

The pupæ of the insect, being in the resting stage, are much less susceptible to all climatic extremes. They appear to be able to withstand low temperatures and are not very susceptible to heat or drying, especially after development of the fly has proceeded for some time.

PREDACEOUS ENEMIES.

Hogs, as well as chickens and other poultry, are capable of destroying great numbers of the immature stages of the stable fly. They are attracted to the straw stacks and manure piles partly by the grain to be found, but incidentally they destroy the maggots and pupæ which they find. A number of insects are also important destroyers of these stages. Certain beetles devour them in considerable numbers. The adult flies fall prey to numerous enemies. Among the more important enemies of the adults are the large robber flies, which may be seen in great numbers around straw stacks, pouncing upon flies which are depositing eggs or resting upon straw. A number of wasps capture the flies that are attacking stock or flying about. When filled with blood the adults are comparatively sluggish and much more easily caught by these enemies. When in this condition spiders often devour numbers of them.

PARASITES.

Two species of small wasplike insects have been found to breed within the pupæ of the stable fly. These insects deposit their eggs through the hard puparium, and instead of an adult fly the little parasite emerges. In some cases, where the immature stages of the fly were concentrated in great numbers, as high as 40 per cent of the pupæ were found to be destroyed by these parasites. At least one of these parasites, known scientifically as *Spalangia muscidarium* Richardson, appears to have a wide distribution in this country. It has been found in Massachusetts, Washington, D. C., southern Kansas, southern Louisiana, and a number of points in northern Texas.

ARTIFICIAL CONTROL.

As is the case with most insects, the destruction of the stage which is actually doing the injury is most desired by those concerned. With this species, as with many others, this is very difficult of accomplishment, and we must determine some more easy way of securing the desired end. With the stable fly the natural point of attack is found in the immature stages, and there is every reason to believe that by properly caring for substances in which it breeds the insect may be kept well under control.

PROTECTION OF LIVE STOCK FROM ATTACK OF THE STABLE FLY.

When adult flies are present in great numbers it is necessary to devise some means of protection against them, especially since we know that every individual is capable of feeding a number of times before it dies. During the recent outbreak in Texas many different substances were tried with a view to repelling the flies from live stock. Most of the materials used were found to be ineffective, and although some gave a measure of protection for a time, none had a lasting effect. In addition to the temporary value of these substances, in many cases injury was produced by their application, especially if persisted in often enough to keep the flies away.

Many malodorous mixtures, particularly of an oily nature, have some value as repellents, but in preparing these care should be taken that they are not made too strong, particularly when animals are being worked in the hot sun, as they are likely to cause overheating and often produce shedding of the hair. A mixture of fish oil (1 gallon), oil of pine tar (2 ounces), oil of pennyroyal (2 ounces), and kerosene ($\frac{1}{2}$ pint) was found to be very effective in keeping the flies off live stock when applied lightly, but thoroughly, to the portions of animals not covered with blankets or nets.

Work animals may be largely protected from the pest by means of coverings. One type which was found very effective and inexpensive during the recent outbreak in Texas consisted of a blanket made of double thickness of burlap so arranged as completely to cover the back, sides, and neck of the animal (fig. 7). The legs are then covered by means of old trousers slipped on over the feet and tied over the back. Leather nets or strips of leather attached to the bridle also aid in keeping the flies from the head. The ordinary flynet has been found to be of little value as it only tends to displace the flies temporarily and cause them to settle in places not covered by the net.

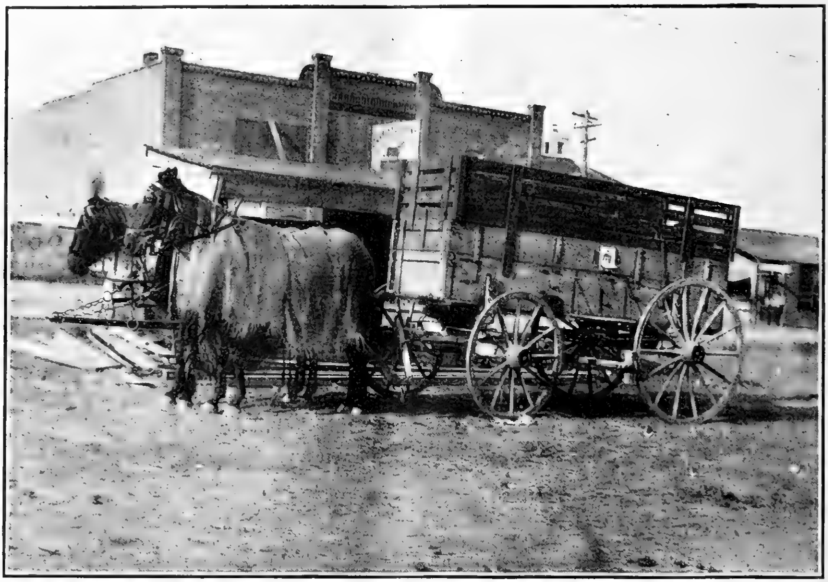

FIG. 7.—Horses with one form of covering used to protect them from the stable fly. (After Felt.)

Completely darkened stables offer much protection from the flies. The lack of ventilation resulting from such an arrangement is very objectionable, however. The thorough screening of all windows and doors is, therefore, much more desirable. When screened barns are used care should be taken to brush the flies from the animals, when they are about to enter, by means of nets over the doorway, or with sacks. Little can be done to protect range stock from the flies. On hog farms a freshly plowed trench offers considerable protection to the swine. The sides of these trenches may be smeared with petroleum which is rubbed off on the animals and acts as a repellent. The trench may be used also for protecting sheep, but the petroleum in their case is unnecessary.

TRAPPING THE FLIES.

It is impossible successfully to capture adult flies by means of the traps ordinarily used for the house fly. However, a trap has been designed by Prof. C. F. Hodge which may be utilized in capturing adults as they enter or leave barns. This trap is undoubtedly very effective under certain conditions and has the advantage of catching not only the stable fly but the house fly and other obnoxious species. In order to employ the trap for the stable fly it should be built in a frame so as to fit closely in a window, preferably on the brightest side of the barn and close to the cows or horses which are kept within. Other windows should be darkened by hanging gunny sacks over them. This may be done so as not to interfere with ventilation, and by flapping in the wind and darkening, both drive and cause the flies to be attracted to the light trap-window.

Fig. 8.—The Hodge flytrap, showing where the flies enter. (After Hodge.)

Prof. Hodge has very kindly permitted the use of some of his illustrations of this trap (figs. 8, 9, 10), and his description of its construction has also been followed. At the bottom of the trap a space about one-fourth of an inch wide running entirely across the window is left on both sides of the frame. This crack admits the flies beneath a roof or ridge of screen wire having holes large enough for flies to go through punched along its top at 2-inch intervals. In order to capture the house fly, bait consisting of any material which is attractive to them is placed in pans beneath this ridge. The flies enter this space and then ascend through the holes and are unable to escape. The sides of the trap, also, are made of ordinary screen wire bent inward and upward in two horizontal folds running across the window, one toward the bottom and one toward the top. The ends of the screen are then securely tacked and a series of small holes punched along the inner edge of each of the folds. The trap-folds and ridge must not be too sharp or flies will not go up to the angle. They should not be less than 45°. The flies, in trying to go in and out through the window, crawl into the folds and enter the holes at the apex, but never escape, as on the inside the holes are along the projecting ridge. Prof. Hodge states that a trap set in a window in a basement barn near a cow within caught nearly 5 quarts of flies from July 1 to November 1. The stable fly constituted 90 per cent of these flies, this being practically all that appeared on the place.

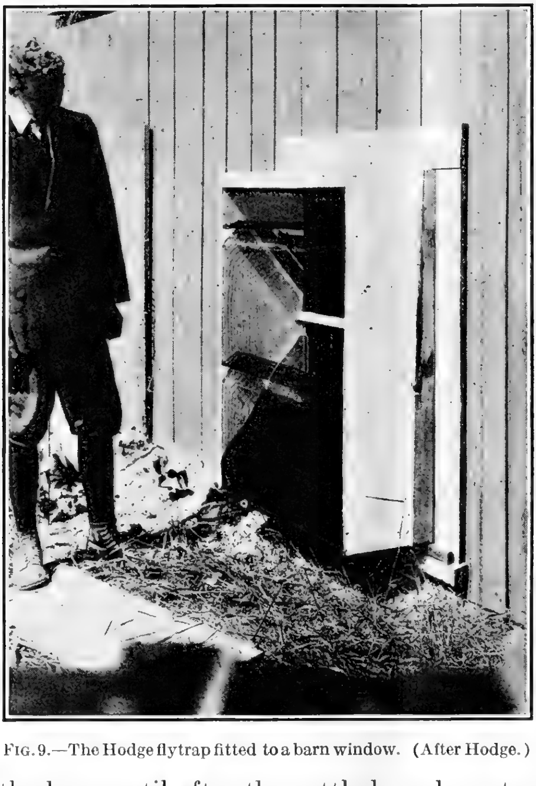

FIG. 9.—The Hodge flytrap fitted to a barn window. (After Hodge.)

This trap is inexpensive and can be made by anyone with a box, or box lumber, and screen wire. It is especially well adapted to well-made barns where the flies do not have numerous places for entrance and exit. It is also more applicable to small barns in which animals are kept more or less constantly than to large dairy barns where the cows are brought in only at milking time. Under the latter conditions the flies enter the barns on the cows and many remain on the walls of the barn until after the cattle have been turned out. In some cases where flies are concentrated in dairy barns in this manner they have been driven out by forcing live steam into the building from the boilers used for sterilizing purposes. Where such arrangements are made the flies may be caught in such traps as the one described, as they are endeavoring to escape from the barn, which should first be tightly closed.

If such barns are tightly closed, as above, during the light part of each day, the flies will practically all "catch themselves" in trying to escape through the trap-window or windows.

DESTRUCTION OF IMMATURE STAGES AND PREVENTION OF BREEDING.

Since straw stacks have been found to be the principal breeding places of this insect in the grain belt, the proper care of the straw is by far the most important step in control. The straw should be stacked more carefully than is ordinarily done, when it is desired to keep it for protection and food for live stock. This may be accomplished by making the sides of the stack nearly vertical and rounding it up well on top, in order the better to shed the rain.

So far as possible, all straw which is not required for winter feed for stock should be disposed of immediately by burning, or by scattering it over the land soon after thrashing and subsequently plowing it under, or by burning the stacks. The plowing under of the straw is the most advisable method of procedure, as by this practice large amounts of humus are added to the soil. Oat straw is most generally used for feeding purposes, and it is this straw which forms the principal

FIG. 10.—Pile of flies caught in a Hodge flytrap. (After Hodge.)

breeding ground for flies. It is therefore important that all of the oat straw needed for feed or bedding be baled and stored under cover and that the remainder be promptly burned or scattered.

All straw stacks not consumed by stock during the winter should be promptly disposed of in the early spring, as these stacks furnish flies continuously during spring and summer. Often the flies reared in such situations are abundant enough to cause great annoyance to live stock during early spring, and by multiplying throughout the summer an almost incredible number of flies are produced by fall. An examination of an oat-straw stack at Gainesville, Tex., in March, 1913, showed a very large number of pupæ, from many of which flies were emerging. In portions of this stack it was estimated that 300 pupæ were present in each cubic foot of straw. This illustrates the importance of disposing, in spring, of straw which has been carried over the winter. Disposition of the stacks in spring may be accomplished in the same way as has been suggested to be followed in the fall.

The conditions which produced the unusual outbreak in 1912, that is, the heavy rainfall on the freshly thrashed straw, rendered the straw largely unfit for food for live stock, as the stacks in many cases were wet through and soon became heated and rotten. In such instances, where the flies are already breeding in these stacks, their immediate destruction by burning or scattering is necessary to relieve the conditions. When stacks are scattered the work should be done thoroughly, so as to expose the straw completely to the influence of the sun, wind, and light. By this procedure practically all of the larvæ and many of the pupæ are destroyed.

It is best to plow under the scattered straw soon after it has become well dried out. In many sections of the grain belt plowing is not generally practiced, the land being simply shallowly disked prior to seeding. The scattering of straw over the ground in such cases is less practicable than where the land is plowed. Of course, the practice of disking land is not a commendable one, and wherever plowing can be done it should be adopted.

In sections of the country where headers instead of binders are used, and consequently a smaller amount of straw is accumulated, the straw is much more easily disposed of by the methods just outlined. The general adoption of the field thrashers, which thrash the grain without cutting it, would completely solve the question of the straw stack. It is reported that this machine reduces the expense of harvesting from 14 cents to 2 cents per acre. The straw is left standing in the field and the chaff scattered over the ground, the entire refuse being turned under at plowing time.

The use of poisons or other substances, with a view of destroying immature flies in the substances in which they are breeding, is neither practicable nor advisable. Enormous quantities of these materials would be required to permeate the straw or manure piles to kill the flies, and, even though the flies were destroyed, the straw would be rendered dangerous to live stock.

Although straw is the principal breeding place for flies within the grain belt, there is no doubt that thousands of stable flies develop in manure piles. Moreover, such material is utilized extensively as a breeding place for the house fly and horn fly. Hence the proper care of all sorts of animal refuse is essential for successfully combating the pest. Manure should be hauled out and scattered at regular intervals, as is recommended for the control of the house fly, and any accumulations of straw or hay, especially adjacent to stables, should be disposed of, as these are often utilized for the breeding of the stable fly when larger accumulations of horse manure and straw are not available.

The need of properly caring for stable refuse is still further emphasized by the fact that there are far more manure piles than straw stacks. Furthermore, the stable manure is usually in close proximity to the habitations of man and thus furnishes flies which have freer access to man, with consequent greater potentiality as disseminators of human diseases.

Issued July 18, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 543.

COMMON WHITE GRUBS.

BY

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1913.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 19, 1913.

Sir: I have the honor to transmit for publication as a Farmers' Bulletin a brief account of the common white grubs.

A thorough study of the white-grub problem throughout the United States has recently been undertaken by the Bureau of Entomology, cooperating with the office of State entomologist of Illinois, and with the further aid of the Indiana Agricultural Experiment Station and Purdue University. As this investigation has only fairly begun, the present publication is in no sense a report, but is merely intended to give a brief summary of the life history and habits of these insects, as now understood, together with the best known means of controlling them. The bulletin has been prepared with special reference to the destructive outbreak of 1912 and the seemingly strong probabilities of a similar infestation in 1915.

This subject is of the greatest importance to farmers, whose cooperation is much needed in carrying out the work and securing practical results therefrom.

Respectfully,

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

Hon. D. F. Houston,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

COMMON WHITE GRUBS.[1]

The common white grubs (fig. 1), or grubworms, as they are often called, have for years been recognized as among the most serious pests to farm crops, notably corn and timothy, while strawberries, potatoes, and nursery plantings, particularly of conifers, have all been frequently and seriously affected.

These pests have never been given extended economic study, except by Dr. S. A. Forbes,[2] State entomologist of Illinois, to whom we are indebted for nearly all of our practical knowledge of the parent May beetles (fig. 2) and their progeny, the white grubs.

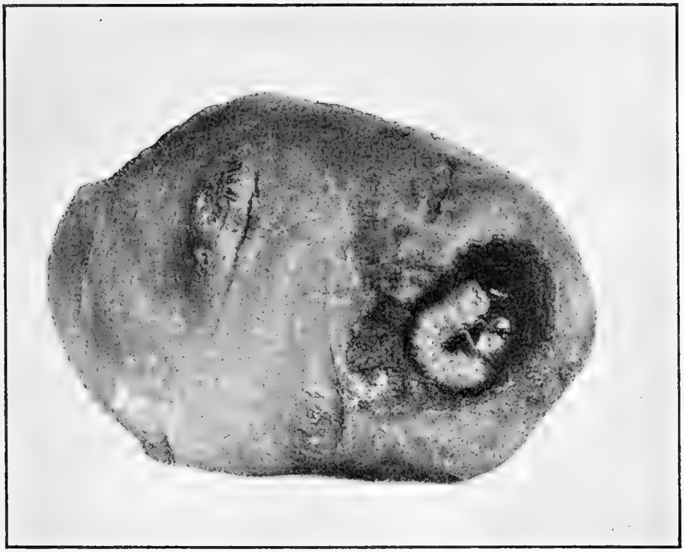

FIG. 1.—White grub working in a potato tuber, Tabor, S. Dak., 1912. (Original.)

THE OUTBREAK OF 1912.

Probably the most serious outbreak of white grubs in the history of American agriculture occurred in 1912, following an abundance of beetles in 1911. Injury was reported from almost every section of the country north of the Ohio River and westward to South Dakota. (See fig. 3.) In the West the center of abundance was in southwestern Wisconsin, while in the East it seemed to be in northeastern Pennsylvania and southeastern New York.

[1] *Lachnosterna* spp.

[2] Insect Life, vol. 3, no. 5, pp. 239–245, 1891; 18th Rept. State Ent. Ill., pp. 109–144, 1894; Ill. Agr. Exp. Sta., Bul. 116, 1907.

Infestation occurred, however, as far west as Tabor, S. Dak., and though no serious general injury was found west of eastern Iowa there were scattered occurrences in western Iowa and southern Minnesota. Throughout the southern third of Wisconsin and in northern Illinois the grubs were abundant, especially in the western portions of those sections. Many infestations were also reported from southern Michigan and scattered ones from northern Indiana and eastward through Ohio. These infestations again became general in northeastern Pennsylvania, southeastern New York, in Connecticut, and in parts of New Jersey.

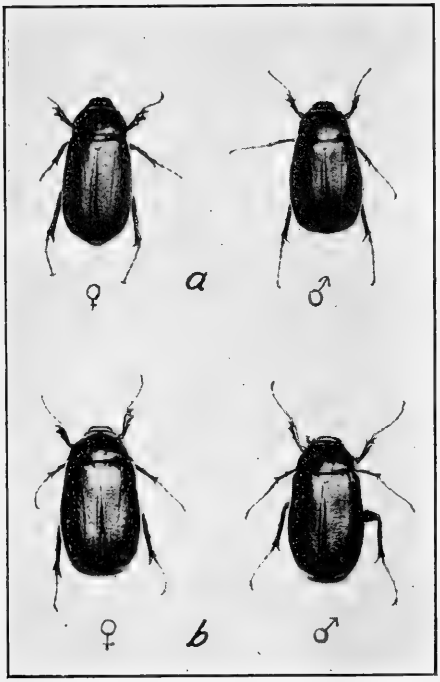

Fig. 2.—Typical examples of May beetles: *a*, *Lachnosterna crenulata*; *b*, *Lachnosterna fusca*. Natural size. (Original.)

In the worst infested districts it was not at all unusual to find from 40 to 60 grubs in a single hill of corn. Indeed, in a cornfield near McGregor, Iowa, devoted to timothy the previous year (1911), Mr. R. L. Webster and the writer found seventy-seven 2-year-old grubs in an area 2½ feet square and 5 inches deep. This really represented less than a single hill of corn, for the hills in this field were 3½ feet apart.

From a personal survey of the infested territory made in 1912 in Iowa (fig. 4), Wisconsin (fig. 5), and Illinois (fig. 6), as well as from reports of farmers and others, we have a very conservative estimate of the damage to corn, timothy, and potatoes in these States, aggregating not less than $7,000,000. The damage to the same crops in the other infested areas can not be figured at less than $5,000,000, which brings the total loss in 1912, exclusive of strawberries, nursery stock, lawns, and miscellaneous crops, to not less than $12,000,000.

POSSIBILITY OF AN OUTBREAK IN 1915.

Available records show that May beetles were unusually abundant in 1908, the grubs causing considerable damage in Wisconsin, Illinois, and other localities in 1909 and again in 1912. The damage, however, was more pronounced in these localities in 1912. As previously noted, the beetles were very abundant in the spring of 1911, thus giving rather conclusive evidence that the life cycle of the more abun-

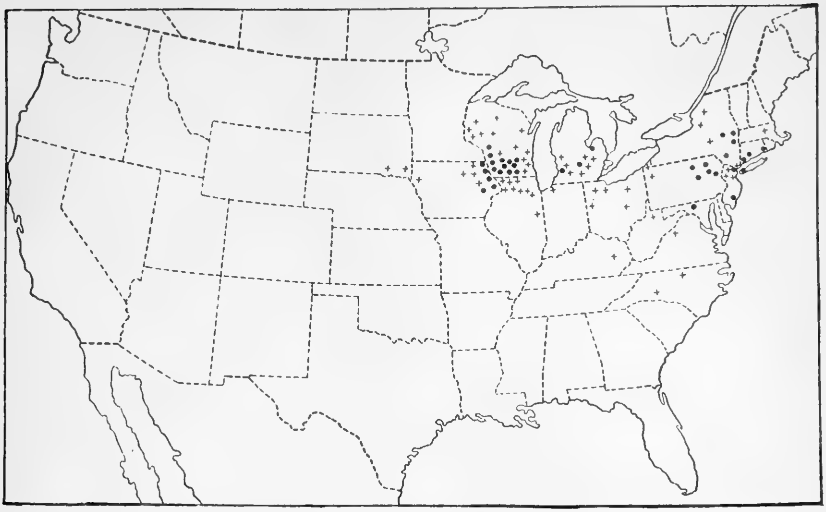

FIG. 3.—Map showing the invasion of white grubs in 1912. (Original.)

FIG. 4.—A 60-acre cornfield completely destroyed by white grubs, Farmersburg, Iowa, 1912. (Original.)

dant and injurious species in those localities is uniformly three years. We may, therefore, be reasonably certain that in 1914 the beetles will again be unusually abundant, and the year following (1915) the grubs will as a consequence be exceedingly abundant and destructive unless their numbers are materially reduced by natural enemies, by artificial means, or by adverse climatic conditions.

LIFE HISTORY AND HABITS.

Our knowledge of the life histories of the white grubs of the genus Lachnosterna is very meager. There is only one published record, involving a single species, in which an individual belonging to this genus has been reared from egg to adult. In the case of this species (*L. arcuata* Smith) the life cycle in the latitude of Washington, D. C.,

FIG. 5.—A cornfield showing characteristic injury by white grubs, Lynxville, Wis., 1912. (Original.)

proved to be three years.[1] From observations reported by Forbes, and from our own observations and rearing experiments, it appears quite certain that in the Northern States the total life cycle of the more injurious species is three years. However, in the case of *L. tristis* Fab., a small species, and one which we have recently reared from egg to adult, the life cycle is only two years. Mr. W. R. Dickeson, of Austin, Tex., writing of the damage by *L. farcta* Lec., says, "One year the grub bothers us and the next year the May beetle," which is circumstantial evidence that this species has only a 2-year cycle in Texas. The total life cycle in all the species occurring in the Southern States may be only one or two years, and in the central

[1] U. S. Dept. Agr., Div. Ent., Bul. 19, n. ser., p. 77, 1899.

parts of Canada it may possibly extend over a period of four years, for such is the variation of the life cycle in the closely related European white grub,[1] which has a 4-year cycle in northern Germany but only a 3-year one in southern Germany.

A résumé of the life of the injurious generation of 1912 is as follows: Eggs (fig. 7) deposited by the female beetle in the spring of 1911 hatched a few weeks later, and the young grubs fed the first season on decaying and living vegetable matter in the soil. As winter approached they protected themselves from the cold by burrowing deeper into the ground, remaining there inactive until the spring of the following year (1912), when they returned to a

FIG. 6.—A cornfield injured by white grubs, Galena, Ill., 1912. (Original.)

position near the surface, feeding on the roots of such crops as were available. In this the second year they did the maximum amount of damage. In the fall they again went deep into the soil, to return near to the surface in the spring of 1913, where they will feed as before on the plant roots until about June. They will then prepare oval pupal cells in the ground, become more or less inactive, and later change to the pupal or true dormant stage. The adult beetles, which will emerge from the pupæ a few weeks later, will remain in the pupal cells over winter and will emerge the following spring (1914) to feed and mate in the foliage of trees and shrubs and to deposit their eggs in the soil for another generation.

[1] *Melolontha vulgaris* L.

Unlike the grubs, the different species when in the beetle stage have as a rule different food preferences. Certain species feed almost exclusively on the oak, others prefer the ash, some feed indiscriminately, etc. The trees which the beetles ordinarily frequent at La Fayette, Ind., are the ash, oak, poplar, elm, willow, locust, soft maple, and hackberry. In certain localities the pine seems to be the preferred food. Mr. H. P. Loding reports that in the vicinity of

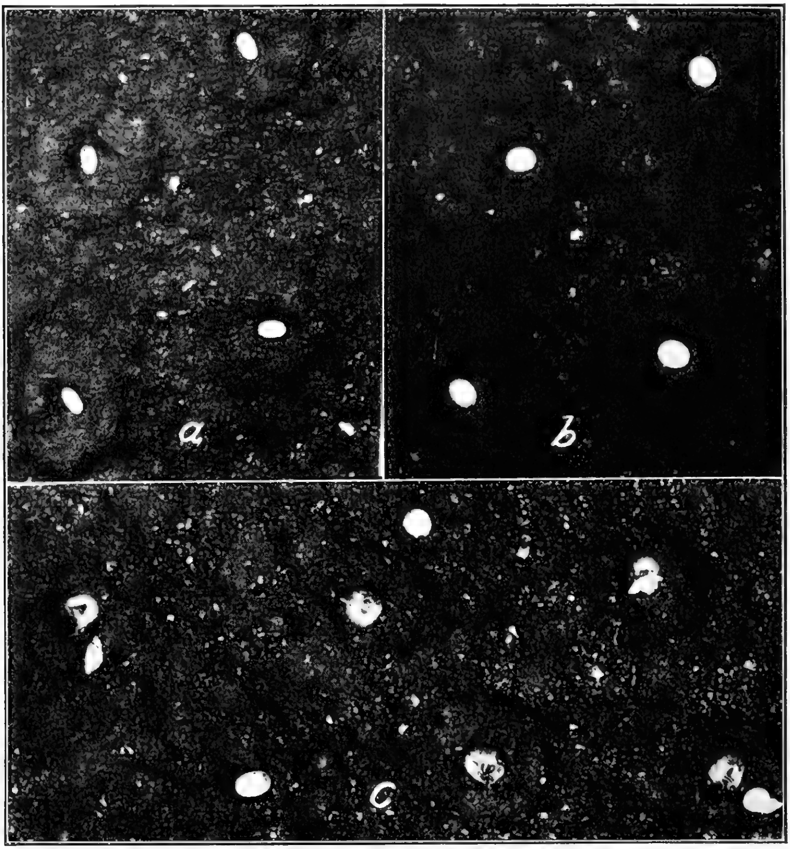

FIG. 7.—Eggs of white grubs in their natural cells: *a*, Immediately after deposition; *b*, six or seven days later; *c*, white grubs hatching. (Original.)

Mobile, Ala., he has collected *L. prununculina* Burm. and *L. micans* Knoch feeding on the longleaf pine, which indeed appears to be their favorite and in some cases possibly their sole food.

In the latitude of Indiana the beetles make their first appearance the last of April or first of May and continue to be present until the first or middle of July, the period of greatest abundance being between the middle and last of May. They swarm to the trees at dusk and remain there feeding and mating till just before dawn, when they return to the soil, only to reappear the following evening.

When abundant the beetles are capable of defoliating large acreages of timber, often resulting in the death of many of the trees thus attacked. In 1911, 40-acre tracts of timber were completely defoliated by the beetles in southwestern Wisconsin. According to witnesses, the dropping of excrement and of detached leaves at night, when the beetles were feeding, sounded like hail. The following year, 1912, numbers of dead and dying trees were observed in these timber tracts, their death in most cases doubtless resulting from the loss of foliage the year before.

Not only do the different species have individual food preferences, but they also differ in the dates of emergence, some appearing early and remaining throughout the season, others appearing about midseason and remaining only a few weeks. Some species, also, occur only at the higher elevations, while others appear to be common only at the lower levels; but whether this difference is due to a difference of elevation or to the character of the flora, or to a combination of the two, has not as yet been determined.

The beetles (fig. 2) prefer to deposit their eggs in ground covered with vegetation, in the immediate vicinity of timber, usually choosing for this purpose the more elevated parts. For these reasons the grubs are ordinarily found most abundant in the higher portions, especially near wooded tracts, of fields of timothy (fig. 8), blue-grass sod, and small grains, or in any ground which during the previous year was in one or another of these crops.

The eggs (fig. 7, *a*, *b*, *c*) are pearly white and when first laid are elongate, measuring about one-tenth inch in length, but six or seven days after oviposition they become swollen and almost spherical. They are deposited in the soil at a depth ranging from 1 to 8 inches, within oval cavities in the center of balls of earth, the particles of earth forming the balls being held together by a glutinous secretion supplied by the female beetle.

The very young grubs seem to prefer decaying vegetation, although under certain conditions, especially when they are very numerous, they will attack living roots, as was the case in Wisconsin in 1911 when the young grubs damaged timothy fields (fig. 8). As might be expected, the grubs do the greatest amount of damage in their second year and to the early plantings in their third year. While grubs show a preference for certain food plants, from our present data the grubs of different species do not appear necessarily to have different food habits. We have no authentic records of injury to such crops as clover, alfalfa, and buckwheat, and from all observations small grains are less attacked and injured than are corn, timothy, strawberries, and potatoes.

GRUBS LIKELY TO BE MISTAKEN FOR COMMON WHITE GRUBS.

It is important that the grubs of May beetles should not be confused with similar but noninjurious grubs and with such other grubs as may be injurious but which, because of their different habits and life history, necessitate different methods for their control. Probably the most universal mistake is the general belief that the common white grubs of the field and the white grubs found in manure heaps and rotten logs are identical. The grubs of May beetles are not known to breed in manure or refuse of any kind. The most common grubs found in manure are the immature forms of certain brown beetles[1] which, like the May beetles, frequent lights, and would doubtless be mistaken for the latter by an inexperienced person.

FIG. 8.—A piece of sod overturned to show the white grubs underneath, Lancaster, Wis., 1912. (Original.)

Another grub commonly mistaken for a grub of a May beetle is that of the southern green June beetle,[2] which has frequently been reported as injuring grass and other vegetation in localities south of latitude 39°, or even farther north along the Atlantic coast. The grub of the green June beetle seems to prefer soils more or less heavily fertilized with manures, and besides, entirely unlike the common white grubs, it makes definite burrows which usually open at the surface and which it may inhabit continuously for longer or shorter periods of time. For this reason grubs of this species will come to the entrance of their burrows and even crawl out upon the ground

[1] *Ligyrus gibbosus* De G. and *L. relictus* Say.
[2] *Allorhina nitida* L.

when the land is flooded with water. This characteristic also offers us a satisfactory means of controlling the grub of the green June beetle when in lawns or small areas. (See p. 20.) Again, this grub may be distinguished from the true white grubs by its general appearance, and especially by its peculiar and characteristic method of crawling on its back when placed on the surface of the ground.

NATURAL ENEMIES.

The white grubs and May beetles are preyed upon by numerous birds, mammals, and insects, all of which are more or less useful in reducing their numbers. Probably the most important of these enemies are the birds, especially crows and crow blackbirds. Fields of

FIG. 9.—Timothy field after harvest, showing sod overturned by crows in their search for white grubs, Galena, Ill., 1912. (Original.)

timothy sod have been literally overturned by crows in their search for grubs (see fig. 9), and in some fields the grubs were almost exterminated by them. Crows have often been observed following the plow in infested fields, eagerly picking up every grub that was unearthed. Mr. Henry Holzinger, of Lancaster, Wis., said that crow blackbirds followed the plow in great numbers where he was turning over a sod field in the spring of 1912. In one instance he watched a single blackbird eat many grubs, apparently its full capacity, and then gather as many as it could hold in its beak and fly away. In this case the bird destroyed in all 20 grubs in about 1 or 2 minutes. This habit of eating a large number of grubs and then flying away with its beak full was reported as a common occurrence with the blackbird. Mr. Fred Nelson, of Tabor, S. Dak., stated that his attention was directed to the unusual abundance of grubs in his field in the fall of 1911 by the blackbirds which came in flocks and followed him as he plowed. He soon learned that they were gathering grubs. After picking up several grubs each bird would fly back to the trees a short distance away and soon return. Thus there was a continuous flight from the trees to the ground and from the ground to the trees. Besides crows and blackbirds practically all of our common birds feed on white grubs or their adult forms, the May beetles. The Biological Survey has found these insects in the stomachs of more than 60 species of birds.

Domestic fowls may properly be classed as natural enemies of white grubs, although their usefulness is largely controllable. All farm poultry are fond of these insects, and where possible should be given the run of infested fields at the time of plowing. The turkey especially is valuable in this capacity, and the writer has seen infested timothy and sod fields literally overturned by these birds in their search for grubs.

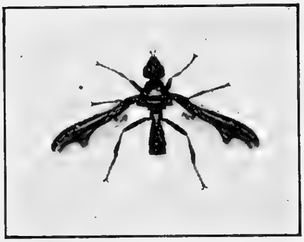

FIG. 10.—*Pyrgota undata*, a fly parasite of May beetles. Natural size. (Original.)

Among the undomesticated mammals which feed on the grubs the skunk, or so-called polecat, is probably the most valuable,[1] and, indeed, some farmers have gone so far as to attribute the increase in these insects to the decrease in numbers of the skunks, which are being rapidly killed off by trappers. In a field of winter wheat at Lagro, Ind., the grubs were reported cutting off the young wheat plants, and when the fields were examined a few days later (November 3, 1911) a skunk hole 3 to 5 inches in depth was found at nearly every stool of wheat which had been attacked by the grubs, and in every case the animal had invariably captured the culprit. In northeastern Iowa many large landowners observed the grub-eating habits of the skunk during the recent severe outbreak, and have signified their intention from now on of protecting this friend of the farmer. Innumerable instances of this nature illustrating the value of skunks could be cited.

A number of predaceous and parasitic insects have been reported as attacking the grubs and May beetles, and of these enemies it is probable that such common and generally distributed forms as the black digger wasp, *Tiphia inornata* Say, and another wasp, *Elis sexcincta* Fab., both of which attack the grub, together with a fly, *Pyrgota undata* (fig. 10), which attacks the adult beetle, are the most

[1] The domestic hog is the most efficient of all grub destroyers where it can be utilized. It is fully discussed in this connection under "Methods of control," p. 16.

beneficial. The Tiphia larva, after devouring the grub, forms a characteristic cylindrical-ovate, light brown, woolly cocoon about three-fourths inch in length (fig. 11, *b*), and from this the jet black digger wasp emerges the following spring. It in turn mates, and the female reenters the soil and there deposits its eggs on the grub, usually fastening them on the back of the latter just behind the head. The Elis cocoon (fig. 11, *a*) differs from the Tiphia cocoon (fig. 11, *b*) in that it is elliptical, slightly longer, and comparatively smooth. The adult emerging therefrom is about the same size as the Tiphia wasp, or slightly larger, and the black abdomen is transversely striped with yellow. The cocoons of both of these parasites are frequently turned out by the plow, especially in fields badly infested with white grubs. The parasitic fly *Pyrgota undata* Wied.[1] (fig. 10) attacks only the beetle, usually depositing its egg within the body of the beetle as the latter flies from leaf to leaf or to the ground at night. The larvæ hatching from these eggs gradually kill the beetle, although as a rule the latter, if a female, is capable of copulating and of depositing eggs for some days after being parasitized; consequently this parasite may not be so valuable as might at first be anticipated.

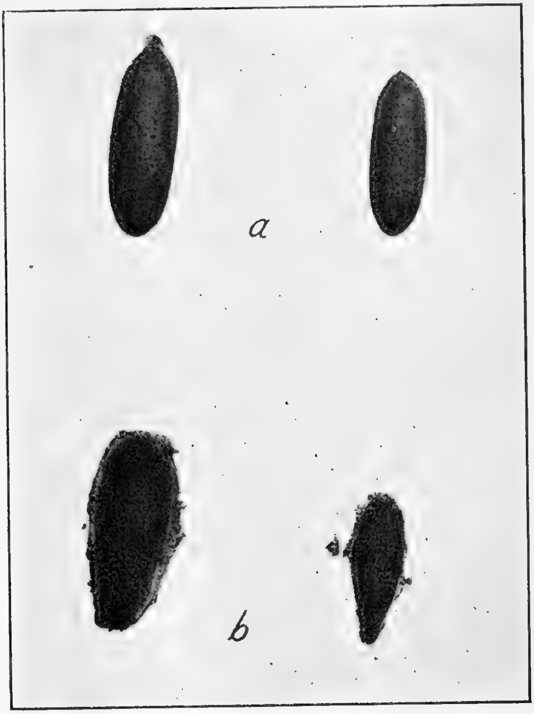

FIG. 11.—Cocoons of wasps that prey on white grubs: *a*, *Elis sexcincta*; *b*, *Tiphia inornata*. Natural size. (Original.)

Several fungous and bacterial diseases have been reported attacking the grubs and beetles, but the knowledge of these is as yet superficial. Occasional outbreaks of these diseases have been reported, and it is highly probable that they serve as valuable natural checks. In Europe certain of these diseases have been artificially grown and used to destroy the grub, but there seems to be a divergence of opinion

[1] It has been found that another species of Pyrgota (*P. valida* Harr.) is parasitic on the beetles, and this species may prove to be equally as important as *P. undata*.

as to their value when used in this manner. and the feasibility of their use for this purpose is still an open question.

METHODS OF CONTROL.

All general measures here discussed and recommended are preventive rather than remedial, for once white grubs are present in a field of corn or other crop there is no means as yet known of protecting that particular crop from its ravages. On the other hand, there are certain cultural and other practices which will greatly minimize the damage in succeeding years.

FIG. 12.—Pasture sod overturned by swine in their search for white grubs, Lancaster, Wis., 1911. (Original.)

UTILIZING HOGS AND POULTRY FOR DESTROYING THE GRUBS.

An infested field may be thoroughly cleared of grubs by pasturing it with hogs. and this method should be followed wherever possible. Hogs are very fond of grubs and will root to a depth of a foot or more in search of them. (See fig. 12.) Such pasturing may be done at any time during the summer. but it should not be delayed later than the middle of October nor should it be practiced earlier in spring than April in the latitude of central Indiana or May in the latitude of Wisconsin. since at other times the grubs will probably be in their winter quarters, deep in the ground, and a large percentage may then escape the hogs.

It should be noted here that the giant thorn-headed worm,[1] an intestinal worm attacking swine, passes one of the early stages of its life within the white grub, and hogs become infested with these worms by feeding on infested grubs. The grubs in turn become infested through the excrement of infested swine. In the grub-infested localities of Iowa, Illinois, and Wisconsin visited by the writer this intestinal worm is quite prevalent, but inasmuch as most of the swine in these regions are slaughtered before they are 1 year old the prevalence of the worms in this region is of little if any importance. Precautions should be taken, however, to protect the animals from infestation where possible. In this connection Dr. S. A. Forbes says:[2]

Pigs which have never been pastured are certain to be free from these parasites, and grubs growing in fields which have not been pastured by pigs are likewise certain to be free from them. The use of such pigs upon such fields would consequently be without danger from this source, and a little attention to these facts will avoid any injurious consequences. That is, if pigs not previously allowed to run out are turned into fields on which pigs have not been pastured within three years, there will be no danger that they will become infested by these thorn-headed worms.[1]

In 1912 the writer observed a field in which half of the corn was uninjured and free from grubs, while the other half was badly damaged. The previous year both halves of this field had been in timothy, but with this difference: The half where the injury occurred was left for hay and the other half was fenced off and pastured with dairy cows. The only plausible explanation seems to be that the trampling of the ground by the cows killed the eggs and grubs in the field, or else that the ground had been trampled sufficiently previous to the flight of the beetles to prevent them from entering the soil and laying eggs.

Domestic fowls should be given the run of infested fields, and especially when the land is being plowed, for they are very fond of grubs and will destroy large numbers.

During the years of great abundance of the beetles hogs should be turned into orchards and timber lots during the period of flight (May and June), since a majority of the beetles pass the day just below the surface of the soil beneath or near the trees upon which they have been feeding the night before, and will be eagerly sought and eaten by the hogs.

FALL PLOWING.

Where it is impracticable to pasture hogs in an infested field much good can be accomplished by plowing the land in the fall. The plowing should be done late in fall, but, on the other hand, it should not be delayed until cold weather sets in or until the ground becomes chilled and frosty, for then the grubs will have gone down to their

[1] *Echinorhynchus gigas.*

[2] Forbes, S. A. On the life history, habits, and economic relations of the white grubs and May beetles (Lachnosterna). Ill. Agr. Exp. Sta., Bul. 116, p. 479, August, 1907.

winter quarters beyond the reach of the plow. Ordinarily the best time to plow is between October 1 and October 15. *In 1913 deep plowing at any time in the fall, especially in early fall, will be of special value in those regions where the grubs were so destructive in 1912, since the grubs will then have changed to pupæ and adult beetles, and these will be destroyed if the pupal cells in which they pass the winter are disturbed.*

ROTATION OF CROPS.

Since the beetles usually deposit their eggs in fields of grass, timothy, and small grains, the crops planted in these fields the year following a season of beetle abundance should be those which are the least susceptible to grub injury, such as small grains, buckwheat, clover, alfalfa, and peas. Care should always be exercised in the selection of a crop to follow sod or old timothy ground, even though the beetles were not noticed as especially abundant the preceding year. Where hogs can be pastured on the land the fall or spring previous to planting, as discussed in another paragraph, the grubs will be practically eliminated.

COLLECTING THE GRUBS AND BEETLES.

Where it is possible to secure cheap labor, collecting the grubs after the plow is practicable, especially where the grubs are numerous. In Europe children are often employed to gather grubs in this manner and to collect the beetles as described below.

Collecting the cockchafer or Maikäfer, a beetle very closely related to the May beetle, is a common practice in European countries, but so far as known the attempt to collect May beetles on an extensive scale in the United States has never been made. Three methods may be employed in beetle destruction: (1) Collecting from plants upon which they feed at night, (2) trapping at lights, and (3) poisoning their food plants.

In Europe beetle collecting has proved of value largely because the years of abundance of the beetles have been definitely known in advance, while in America this has not been the case. Now, however, there is proof that the beetles occurring in such abundance in many parts of the United States in 1911 (the parents of the destructive generation of grubs in 1912) have a life cycle of three years, and it is reasonably certain that they will continue to be exceptionally abundant in these regions every three years unless killed off by their natural enemies, by artificial means, or by unfavorable climatic conditions. Beetle collecting in the Old World has also proved practicable, first, because of the organized cooperative movement by the farmers for the collection of the beetles; second, because a small bounty is paid for the beetles; and, third, because of laws which in some countries require each farmer to collect a certain quantity of the grubs or beetles each year. Individual action is useless, and only where whole communities or neighborhoods cooperate in the work is it effective.

In collecting from food plants large cloth sheets are placed under the tree and the latter jarred, or in the case of large trees individual branches may be shaken by using a long pole provided with a hook at the end. The beetles are then gathered up from the sheet and placed in cans, bottles, or boxes and afterwards killed with carbon bisulphid. Killed in this manner they may be fed to chickens, pigs, etc., but if they are not to be used for such purposes they may be killed by dropping them in cans containing water and just enough kerosene oil to cover the surface. Different species have different food preferences, but as a rule beetles are most abundant on the oak, walnut, poplar, hackberry, willow, ash, and elm. Collections may be made at any time during the night, but the best time for this work is in the early morning, before 4.30 o'clock, at a time when the beetles are easily jarred from the foliage. It is essential that collecting be begun as soon as the beetles appear in the spring—that is, before the beetles have begun to lay their eggs—and it should also be borne in mind that each female beetle destroyed early in the season means the destruction of from 50 to 100 grubs which she might have produced.

Light traps have not as yet proven satisfactory as a means of control against May beetles, the prime objection to this method being that the light attracts the males to the almost total exclusion of the females. Further tests with this method must be made, and it is possible that the light may prove attractive to the female beetles in years of unusual abundance if placed close to the trees or shrubs upon which they feed.

SPRAYING.

Spraying trees upon which the beetles feed, with Paris green or arsenate of lead, is effective against the beetles, but ordinarily this method is impracticable owing to the large size of the trees, which would necessitate large and expensive power sprayers. With a more definite knowledge of the preferred food plants, it may be found practicable in some localities to plant low-growing trees and shrubs about fields as traps for the beetles, which might then be destroyed by spraying.

SPECIAL DIRECTIONS.

In those regions in which the grubs were so abundant and destructive in 1912 certain special directions and precautions may prevent a repetition of the damage in 1915. As has already been stated, the parents of the grubs of 1912 appeared in the spring of 1911 and laid the eggs which hatched into the grubs. Practically no damage occurred that year, but in 1912, when about half grown, the grubs caused great loss. These grubs will continue active in the spring of 1913 and may injure certain early plantings, but by early June most of the grubs will have become more or less inactive and later will change to the dormant or pupal stage, transforming to beetles about August. They will remain in the soil as beetles over winter, appearing above ground in the spring of 1914. Small grain may, with comparatively safety, be planted in 1913 on land infested in 1912. If infested ground must be utilized for corn, potatoes, or other susceptible crops in 1913, planting should be delayed as long as possible, in which case injury will be minimized or may be wholly prevented. In 1914 a maximum acreage of such crops as corn and potatoes should be planted, and these should be kept thoroughly cultivated during the flight of the beetles. Land which is planted to small grain, timothy, and other crops which cover the ground with vegetation at the time of the flight of beetles should be planted in fields farthest from trees, and such fields should be planted the following year (1915) to crops least susceptible to white-grub injury, such as clover, alfalfa, small grains, and buckwheat. In addition, the methods which have already been discussed, namely, the use of hogs and domestic fowls, fall plowing, and the gathering of beetles and grubs, should be practiced.

IN THE LAWN.

No reliable remedy can be offered for the destruction of grubs in lawns. Where possible, poultry, especially turkeys, should be allowed the run of the infested area. Hogs will of course rid the ground of grubs, but they will likewise tear up the sod and are not usually desirable in cities. When badly infested, the removal of sod and the gathering of the grubs by hand, and later, fall plowing, will probably prove satisfactory. If the infestation is not severe, liberal applications of commercial fertilizer will assist the grass in overcoming the grub injury. It has been demonstrated in Europe by Decoppet[1] that carbon bisulphid injected into the soil at a depth not exceeding 6 inches, at the rate of 1 to 1½ ounces in six or eight holes per square yard, will considerably diminish the number of grubs. Decoppet experimented with an European white grub,[2] and it appears quite probable that this method would prove satisfactory for our white grubs when they appear in lawns. It might be mentioned here that carbon bisulphid may be injected with excellent results into the holes of the grub of the southern green June beetle, which is frequently quite destructive to lawns in the Southern States. In using carbon bisulphid care should be exercised never to permit a spark of fire to come near it, for it is extremely inflammable, and its vapor, mixed with air, is explosive. Holes in which the carbon bisulphid is injected should be closed with a plug of soil or sod immediately after the injection, to prevent the escape of the fumes.

[1] Bul. Soc. Vaud. Sci. Nat., 5me ser., t. 48, no. 176, pp. xxxv–xxxvi, June, 1912. Abstr. in Internat. Inst. Agr. (Rome), Bul. Bur. Agr. Intel. and Plant Diseases, vol. 3, no. 6, pp. 1456–1457, 1912, and in U. S. Dept. Agr., Experiment Station Record, vol. 27, no. 7, pp. 661–662, 1912.

[2] *Melolontha* sp.

Issued July 26, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 547.

THE YELLOW-FEVER MOSQUITO.

BY

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1913.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., May 1, 1913.

SIR: I have the honor to transmit for publication a paper dealing with the yellow-fever mosquito. It is intended to be a companion to Farmers' Bulletins 444 (Remedies and Preventives against Mosquitoes) and 450 (Some Facts about Malaria), and should therefore be published in the same series. This manuscript has been adapted from a Monograph of the Mosquitoes of North and Central America and the West Indies, by L. O. Howard, Harrison G. Dyar, and Frederick Knab, published by the Carnegie Institution of Washington.

Respectfully,

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

HON. D. F. HOUSTON,
Secretary of Agriculture.

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ILLUSTRATIONS.

THE YELLOW-FEVER MOSQUITO.

(*Aedes calopus* Meig.)

HOW TO RECOGNIZE THE YELLOW-FEVER MOSQUITO.

The only species of mosquito which has been shown to transmit yellow fever is a small form well known in the Tropics. It is somewhat variable in size, but on the whole is so small as to require a mosquito bar of 20 strands, or 19 meshes, to the inch to prevent its entrance to screened rooms. Both males and females can pass through a netting containing 16 strands, or 15 meshes, to the inch. It is a strikingly marked, and, on the whole, when seen under the lens, a beautiful insect. Its general color is dark, but its thorax is marked with a silvery white, lyre-shaped pattern; the abdomen is banded with silvery white, and there is a silvery white spot on each side of the abdominal segments. The legs are banded alternately with black and pure white, and the long palpi of the male are also alternately banded with black and pure white. As with many other species of mosquito, the antennæ of the male

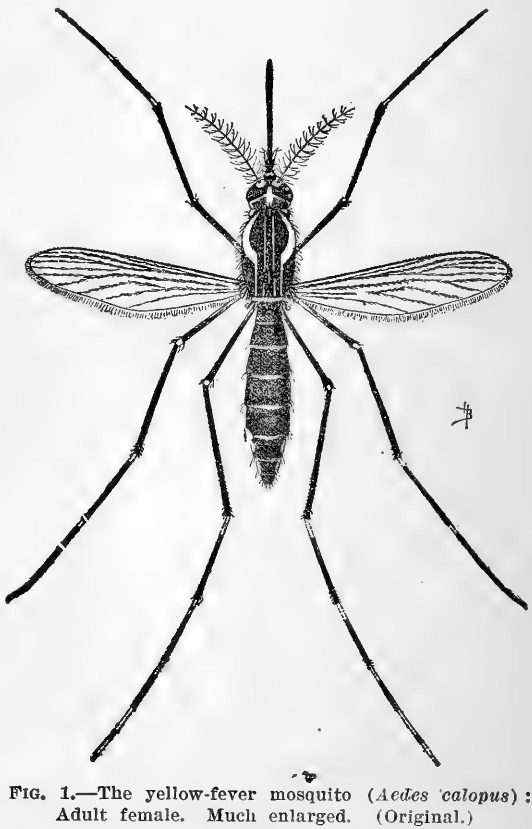

FIG. 1.—The yellow-fever mosquito (*Aedes calopus*): Adult female. Much enlarged. (Original.)

are broadly feathered, while those of the female are only slightly feathered. The accompanying illustrations (figs. 1–3) well indicate the general appearance of the insect.

DIFFERENT NAMES BY WHICH IT HAS BEEN CALLED.

Popularly the yellow-fever mosquito has been called in the Tropics the house mosquito, the day mosquito, the banded-legged mosquito, and is now generally known as the yellow-fever mosquito. Sometimes also it is known popularly by one of its discarded scientific names, the Stegomyia mosquito.

FIG. 2.—The yellow-fever mosquito: Adult male. Much enlarged. (Original.)

Scientifically this species was first known as *Culex fasciatus* Fabr. After the publication of Theobald's Monograph of the Mosquitoes of the World it was known as *Stegomyia fasciata* Fabr. Later, after Blanchard pointed out that the name *fasciata* was preoccupied in the same group, it was known as *Stegomyia calopus*. Recent investigations have shown that Stegomyia is not a valid genus, and the insect is now known as *Aedes calopus* Meig.

DOMESTICITY OF THE SPECIES.

The yellow-fever mosquito is inseparably associated with man in the Tropics. It is essentially a town mosquito, and normally it is never found at a great distance from habitations. It shows a very decided preference for human blood, and it must have blood for the development of its eggs. Both sexes inhabit houses, and when there is a supply of water the entire life cycle takes place indoors. Its long association with man is shown by many of its habits. It approaches stealthily from behind. It retreats upon the slightest alarm. The ankles and, when one is sitting at a table or desk, the underside of the hands and wrists are favorite points of attack. It attacks silently, whereas other mosquitoes have a piping or humming note. The warning sound has doubtless been suppressed in the evolutionary process of its adaptation to man. It is extremely wary. It hides wherever it can, concealing itself in garments, working into the pockets and under the lapels of coats, and crawling up under the clothes to bite the legs. In houses it will hide in dark corners, under picture moldings, and behind the heads of old-fashioned bedsteads. It will enter closets and hide in the folds of garments.

HABITS OF THE ADULT.

FEEDING HABITS.

The female sucks blood when it is available, and needs blood to develop her eggs. In captivity she has been kept alive for a long

FIG. 3.—The yellow-fever mosquito: Adult female, side view. Much enlarged. (Original.)

time on honey or other sweet substance. She is attracted to portions of the body covered with perspiration. A female will bite within 18 to 24 hours after she emerges from the pupa. Virgin females will bite, but fertilized females are more greedy. After a meal of blood she is very sluggish; she flies with difficulty, seeking a hiding place for digestion. Several hours are consumed in digestion, and then the female is anxious for another meal of blood. The species normally sucks blood repeatedly. In 31 days a female is recorded to have sucked blood 12 times. By biting a number of different individuals the chances of becoming herself infected with yellow fever and transmitting the disease are greatly increased.

The yellow-fever mosquito can subsist upon the blood of any warm-blooded animal, but shows a decided preference for man. It prefers the white race to dark races, and among the whites attacks by preference young, vigorous persons of fine skin and good color rather than anemic or aged people. It will also feed upon birds, and it has been carried alive from Brazil to Europe by being fed upon canary birds. Instances are on record of the biting of corpses.

TIME OF ACTIVITY.

The popular name in the British West Indies, "day mosquito," is derived from the fact that this species is usually active and bites only in the daytime, although, where there is a light in the room, it may also bite at night. It is especially voracious early in the morning about sunrise and again late in the afternoon. It does not bite in the bright sunlight out of doors, and in fact is not in evidence in the open. On cloudy days it bites at all times. Antimosquito lotions for the skin, used in unscreened houses at night, are not so apt to be effective against this species as against other semidomesticated species, such as *Culex quinquefasciatus* and the species of Anopheles, for the reason that at the time when the individual is soundest asleep, in the early morning hours, the lotion will largely have evaporated, and the yellow-fever mosquito begins to bite only when the sunlight first enters the room.

LENGTH OF LIFE OF ADULTS.

Adult females have been kept alive for long periods by feeding them upon bananas and other fruit, upon honey, molasses, and other sweet substances. Beyond the fortieth day the mortality becomes great. They will live longer where the atmosphere is moist. Guiteras, in Cuba, kept five infected adults alive for 101 days and one for 154 days. The oldest male that has been kept in captivity lived for 72 days. The question of how long infected yellow-fever mosquitoes may be capable of conveying the disease has received some attention. Having acquired the infection from a yellow-fever sufferer they are dangerous after the twelfth day, and probably continue dangerous as long as they are capable of biting.

INFLUENCE OF TEMPERATURE.

The cessation of former yellow-fever epidemics in the southern United States on the appearance of the first cold weather in November and December was due to the fact that the yellow-fever mosquito is killed by cold. It is, in fact, extremely sensitive to differences in temperature. It displays the greatest activity when the thermometer is in the neighborhood of 82° F. As the temperature rises or falls a few degrees above or below that point there is a markedly reduced activity. Beyond 102° F. heat is fatal. When the thermometer falls below 62° the mosquito becomes sluggish and will not feed. At from

54° to 57° F. it becomes torpid, flies with difficulty, and no longer stands firmly on its legs. It dies quickly when the temperature is at the freezing point. When exposed for a brief period to a temperature of 49° and then placed in a warm room it will revive, but it dies at a temperature of 39° maintained for more than an hour. It may be kept alive for some time at temperatures of 45° to 48°.

DISTANCE OF FLIGHT.

The yellow-fever mosquito is a strong flier; nevertheless, it does not fly very far and, as has been already pointed out, is rarely found away from houses. It apparently never flies very high and is found by preference in the lower stories of houses. There is conflicting evidence regarding the effect of a strong current of wind on this species, and it is recorded that strong air currents produced by a mechanical ventilator had no effect upon flight. Other observers have searched for it in vain in situations exposed to the wind.

The distance of flight has an important bearing upon the distance at which ships should be anchored from fever-infected ports, but with vessels anchored at given distances it is most difficult to determine whether yellow-fever mosquitoes which may be found on board have flown from the shore or have been carried by boat parties visiting the vessel, perhaps concealed under coat collars or hidden in other parts of clothing. There is no positive evidence that vessels anchored more than half a mile from the shore will be visited by the yellow-fever mosquito by natural flight.

DISTRIBUTION BY ARTIFICIAL MEANS.

Although, as indicated in the preceding section, the yellow-fever mosquito apparently does not fly far, it is readily carried to great distances accidentally by artificial means. Vessels, once infested, may carry the species to far-distant ports. The yellow-fever mosquito has been found in New York upon vessels coming from Vera Cruz, and it is by such carriage of infected mosquitoes that the early outbreaks of yellow fever in Philadelphia and other northern cities are to be accounted for.

Railway trains also carry this mosquito, frequently in large numbers. It has spread inland from Vera Cruz, first to Cordoba and later to Orizaba, entirely by means of the railway. Almost every summer the yellow-fever mosquito is carried in railroad cars from New Orleans, Mobile, and other southern cities, on through trains, to Washington, Baltimore, and New York. It has been seen and captured on these trains by competent entomologists.

MATING.

The mating of the species usually occurs during flight, although the female sometimes alights during the act and before its completion. The act requires but a fraction of a minute. Temperature has a great influence upon sexual activity. Below 68° F. mating seldom occurs. The same male may have frequent connections in rapid succession with various females.

RELATION OF FOOD TO EGG LAYING.

It seems certain that the female can not develop her eggs without having had a meal of blood. After a meal eggs will be deposited in a few days. If a fertilized female is fed upon sweet substances, the eggs will not develop. If afterwards, say after 15 or 20 days, she is fed blood, the eggs will then develop. Blood food, however, in hastening the development of the eggs shortens the life of the mosquito. A diet of honey, on the other hand, prevents the development of the eggs and prolongs life. The shortest interval between a blood meal and egg laying is apparently two days, and the longest seven days.

BREEDING HABITS.

EGG LAYING.

The eggs are laid separately in several lots, the individual lots being laid at intervals of several days or more. They may be laid near the water, close to its edge, or upon the surface of the water. Oviposition on the surface of the water, however, is probably rare, and possibly occurs only under abnormal conditions, when the mosquitoes are being studied in captivity. Normally it appears to be the custom to lay them on the sides of a receptacle containing water, just above the surface of the water, so that a slight elevation of the water will submerge them. They have been found upon a leaf floating upon the water.

Sometimes the female will lay but one lot of eggs. Others will lay two lots, and others from three to seven. According to J. R. Taylor, the total number of eggs laid at a time varies from 35 to 114. Other observers have increased the number to 150. Undersized females rarely lay more than 50 eggs. The death of the female after egg laying seems to indicate that all the eggs have been laid.

THE EGGS.

The eggs are small and black in color and are well shown in figure 4. As has been stated, they are ordinarily laid above the margin of the water, and here they may remain dry for long periods, hatching when reached by the water. They develop better after having been dry for some time. In fact, it seems that they will preserve their vitality dry for six months or even longer. Freezing does not destroy the fertility of the eggs. The duration of the egg stage, when the eggs are laid upon the water, is about two days; when deposited above the water they hatch promptly when submerged. When laid upon the surface of the water they are easily sunk by any disturbance, and when they sink hatching is retarded and often some of the eggs do not hatch, particularly if the temperature of the water is rather low. When submerged soon after being laid on the surface of the water they generally perish.

BREEDING PLACES.

The probabilities are that the yellow-fever mosquito originally bred in water in holes in trees, but it has so perfectly adapted itself to the human species that it has become a true domestic insect and is practically dependent for its existence upon the conditions that surround human habitations. This adaptation is undoubtedly of very ancient development. The yellow-fever mosquito is essentially a town mosquito, and the larvæ are found practically exclusively in artificial receptacles in and about houses. It can be said that its larvæ are never found in swamps, in pools, or even in temporary puddles, even when these are in close proximity to houses. In the Tropics the large earthen jars in which drinking water is kept are the most frequent and unfailing habitat of the larvæ. Rain-water barrels are abundant breeding places. Rain-water tanks, so universally behind the houses in southern cities like New Orleans, Galveston, and Mobile, are the source of most abundant supplies of these mosquitoes. The larvæ are also found in sagging gutters containing rain water, in tin cans, in cesspools, in horse troughs, in water-closet tanks, in the drain traps of stationary washstands, in the urns in cemeteries, in the holy-water fonts in churches, in pools accumulating under the water tanks, in water pans in the chicken yards, and in the water receptacles of grindstones.

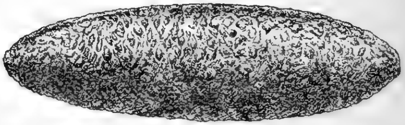

FIG. 4.—The yellow-fever mosquito: Egg. Greatly enlarged. (Original.)

The observations of Busck and Knab in the West Indies and Central America indicate that the yellow-fever mosquito breeds almost always in clear water and seldom in foul water. These observers always found it in artificial receptacles, except a few times in tree holes near houses, and in one case in a street gutter. In the last case it is probable that this larva came into the gutter by the emptying of some household vessel. Discarded bottles and tins about houses are favorite breeding places. The larvæ occur in tree holes only when the latter are in close proximity to human habitations.

BEHAVIOR OF LARVÆ.

The larvæ (fig. 5), when suspended from the surface film of the water to take in air, hang almost perpendicularly. They are very easily alarmed and then go quickly to the bottom, where they remain a considerable time. They can live under water for a long time without rising to the surface. When water is poured from a receptacle inhabited by these larvæ they quickly seek the bottom, and their presence may not be suspected, although the vessel is in constant use. They cling so closely to the bottom that unless the jars are rinsed and tipped up so as to empty them completely, which is not usually done, nearly all the larvæ will remain in the jars. On account of this habit they are not easily disposed of by pouring out the contents of a barrel.

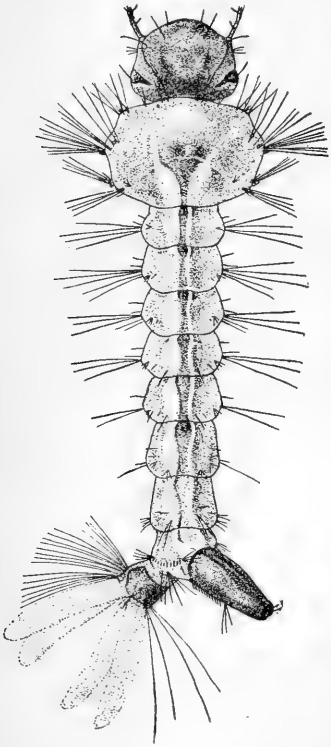

FIG. 5.—The yellow-fever mosquito: Larva. Much enlarged. (Original.)

FOOD HABITS OF LARVÆ.

The larvæ occur most frequently in clear water in rain-water barrels or in drinking-water receptacles in houses. The water in such receptacles contains more or less animal matter as well as vegetable refuse, and such probably is generally the food of the larvæ. The larvæ feed at the bottom, where they mouth over the organic sediment, even when the water is very deep. Larvæ in confinement may be observed chewing vigorously on dead insects or larval or pupal cast skins. They are sometimes cannibalistic, the larger larvæ devouring the smaller ones.

The growth of yellow-fever mosquito larvæ is hastened by the presence of a small amount of fecal matter in the water. Observers in Habana at the time of the Cuban war found that the larvæ which bred in the tin cans used for carrying away human excrement from the hospitals developed rapidly, and other observers have recorded the fact that by adding fecal matter to the water in which were larvæ under observation the development was hastened until the life cycle was completed in from six to eight days.

DURATION OF EARLY STAGES.

Temperature has the greatest influence, not only upon the hatching of the eggs but also upon the subsequent development of the larvæ. The effects of various temperatures on the early stages were carefully investigated by the American commission in Cuba and by the French commission in Rio de Janeiro, and the results of both agree very closely. The shortest period of development to imago observed by Reed and Carroll during summer weather in Cuba was 9½ days, divided as follows: Incubation, 2 days; larval stage, 6 days; pupal stage (fig. 6), 36 hours. This, however, was believed to be exceptional. In average summer temperature the time required for the complete metamorphosis ranges ordinarily from 11 to 18 days. The French observers in Rio de Janeiro found that the most favorable season for rapid development was when the night temperatures ran from 79° to 81° F. and the day temperatures from 82° to 88° F. They found that some of the larvæ of this mosquito reached the pupal stage seven days after the hatching of the eggs, and the adult condition on the ninth day, and that generally most of the larvæ from the same laying of eggs produced imagoes about the tenth day.

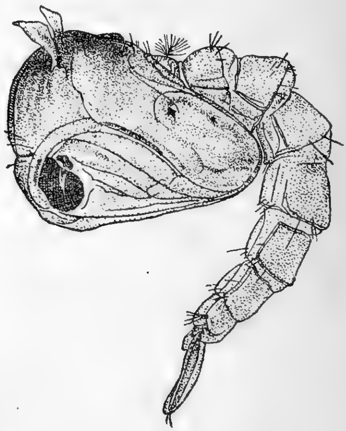

FIG. 6.—The yellow-fever mosquito: Pupa. Much enlarged. (Original.)

RESISTANCE OF LARVÆ TO ADVERSE CONDITIONS.

Larvæ of the yellow-fever mosquito have been found in nature in brackish water containing 35 per cent of sea water. With 40 per cent sea water the larvæ still survived and produced imagoes. Experiments have shown that the larvæ may in nature survive in water which, through evaporation, has reached a high degree of salinity, and if afterwards, through rains, the water becomes again diluted, the larvæ may develop to imagoes.

The degree of resistance to desiccation of both larvæ and pupæ is important from the practical standpoint. The first yellow-fever commission to Vera Cruz found that in that dry climate larvæ died quickly when the water containing them was poured on the ground. In moist climates the larvæ may, under favorable circumstances, live out of water a considerable time, and the pupæ show great resistance to drying. Experiments made by Peryassu in Brazil showed that when larvæ were placed upon filter paper none lived nine hours. When placed upon moist ground, according to temperature and evaporation, they survived as much as 13 days, and when again put in water developed to imagoes. Pupæ dried upon filter paper survived up to 9 hours and 30 minutes.

GEOGRAPHIC DISTRIBUTION.

In considering the geographic distribution of the yellow-fever mosquito it should be pointed out at the start that it has two distinct regions—one in which it is capable of breeding continuously and another over which it spreads during warm weather, to be annually exterminated by cold after breeding for an indefinite number of generations. The first may be termed the permanent region and the second the temporary summer region. The permanent distribution is limited in a general way by the frost line. Where frost does not occur the species generally may breed permanently. As has been already shown, this mosquito does not thrive below a temperature of 80° F., so that in a uniform climate with a temperature much below 80° the species will not continue to exist. Such climates are rare, however, in regions where frost never occurs.

The temporary summer distribution is determined by the means of carriage that happen to be available. It has been shown that the yellow-fever mosquito is a domestic species, having a fairly long life in the adult stage and having the custom of hiding itself in the most ingenious ways. It is therefore particularly subject to carriage for long distances on board vessels, in railway trains, and even packed securely away in baggage. In the old days of sailing vessels on very long voyages it was not only possible for the yellow-fever mosquito to breed continuously in the more or less exposed water supply of vessels, but undoubtedly this was of common occurrence. Every year it is carried to the north in the United States upon railway trains and may breed for a generation or so hundreds of miles north of its permanent breeding places. Thus while the species breeds permanently only in the extreme southern portion of the United States, it will be found every summer breeding for a generation or so in localities to which it has been carried by trains. In 1904, for example, it was found breeding abundantly upon the grounds of the St. Louis exposition, and had one or more persons suffering with incipient yellow fever come to the exposition, the mosquitoes were there in numbers to carry the disease. Everywhere almost throughout the southern United States in midsummer will this mosquito be found, and this explains why epidemics of yellow fever have occurred in years past on the Atlantic coast of North America even as far north as Montreal.

On the Pacific coast, on the other hand, the nights are so cold that this species does not seem to be able to survive. This applies to points north of San Diego. The species breeds permanently in all of the west coast Mexican seaports, and must frequently be brought to the California coast in vessels, but it has never been known to breed there. This seems at first sight strange, since the mean annual temperature of California is much above that of eastern cities where epidemics have occurred, and in San Diego and Los Angeles one sees tropical vegetation on every hand growing unprotected, and severe cold is unknown; yet the nights are cold even in the summer, and it is to this condition—the low minimum nightly temperatures—that freedom from the yellow-fever mosquito, and consequently from yellow-fever epidemics, is due.

ORIGINAL HOME.

The original home of the yellow-fever mosquito must clearly be identical with that of yellow fever. Early history points very strongly to the West Indies and the adjacent mainland as that original home. There has been much discussion of the question, and ingenious arguments have been adduced to prove that yellow fever is of African origin and was imported into America through the slave trade. All things considered, however, the probabilities are that yellow fever is one of the very old diseases of mankind in the New World, and that it was taken from the New World to the Old.

DISCOVERY OF THE RELATIONS OF THIS MOSQUITO TO YELLOW FEVER.

Physicians had been theorizing about the cause of yellow fever from the time when they began to treat it. It was thought by many that it was carried in the air, by others that it was conveyed by the clothing, bedding, or other articles which had come in contact with yellow-fever patients. There were one or two early suggestions of the agency of mosquitoes, but practically no attention was paid to them, and they have been resurrected and considered significant only since the beginning of the present century.

With the discovery of the agency of microorganisms in the causation of disease, a search soon began for some causative germ of yellow fever. Many microorganisms were found in the course of autopsies and many claims were set forth by investigators. All of these, however, were virtually set at rest by Sternberg in his "Report on the

Etiology and Prevention of Yellow Fever," published in 1890. But a claim made by Sanarelli in June, 1897, for a bacillus which he found in 58 per cent of yellow-fever cases, and which he called *Bacillus icteroides*, received considerable credence. This was found afterwards by several investigators in considerable abundance, but later it was shown by Reed and Carroll that the organism in question is identical with the bacillus of hog cholera and is in no way concerned with yellow fever.

In 1881 Dr. Carlos Finlay, of Habana, proposed the theory that yellow fever, whatever its cause may be, is carried by means of a certain mosquito from man to man. His original paper shows that he had carefully studied the habits of house mosquitoes and had determined all of the factors in the life history of the species now known as the true yellow-fever mosquito, which have since been shown to be essential in its rôle of transmitter of the disease. It was this careful study of the mosquito and the disease, conducted through many years in the most favorable locality, the city of Habana, that gave him a firm conviction that the two were interdependent. On this account his theory has true scientific merit. It was based on intensive study, and not, as had been the case with his predecessors, on vague suspicions. Subsequently he published a number of important papers, in which his views were modified from time to time. He thought out carefully the question of immunization and concluded that this might be brought about by mild infection through the bite of a single mosquito. In one of his papers he published experiments with 100 individuals, producing 3 cases of mild fever. None of the cases, however, was under his full control; and as the possibility of other methods of contracting the disease was not excluded, his claims were not accepted.

In 1900 the facts were determined by scientific methods. An American army being at that time stationed in Cuba, a medical board was appointed by Surg. Gen. Sternberg for the purpose of investigating the acute infectious diseases prevailing in the island. The board consisted of Walter Reed, James Carroll, Jesse W. Lazear, and Aristides Agramonte. Dr. Reed was the chairman of the board. In the course of the work yellow fever naturally received the main measure of attention. The claims of Sanarelli's *Bacillus icteroides* were disproved, and Reed and his associates began a careful and thoroughly scientific investigation of the possibilities of mosquito carriage of the disease. Experiments carried on by the board were as perfect in their methods as it was possible for scientific acumen and hard common sense to make them. Every possible element of error seems to have been guarded against. The final and conclusive tests made during the autumn of 1900 were conducted with a spirit of earnestness, self-sacrifice, and enthusiasm which affected everyone connected with the work, even in the most subordinate positions, private soldiers not only offering themselves for the presumably dangerous tests, but insisting that they should be accepted as subjects for experimentation. Dr. Reed, the master spirit of the investigation, was, moreover, a man above all men for this work, no less in his ability to compel the greatest confidence and enthusiasm than in the absolutely complete manner in which the experiments were conducted. While the work was going on criticism was invited and urged from Habana physicians, from visiting surgeons, and from everyone interested, but so perfect were the plans that it seems impossible that any criticism could have been made.

An experimental sanitary station was established in the open, a mile from Quemados. Two houses were built, tightly constructed, with windows and doors protected by wire screens. In one of these houses soiled sheets, pillowcases, and blankets were used as bedding, and this bedding was brought straight from the beds of patients sick with yellow fever at Habana. For 63 days these beds were occupied by members of the Hospital Corps for periods varying from 20 to 21 days. At the end of this occupation the men, who were all nonimmunes, were taken to quarantine for five days and released. Not one of them was taken ill. All were released in excellent health. This experiment was of the greatest importance, as it demonstrates that the disease is not conveyed by fomites; hence the disinfection of clothing, bedding, or merchandise formerly supposed to have been contaminated by contact with yellow-fever patients is unnecessary. This disinfection work, which hitherto had been carried to the extreme in the case of yellow-fever epidemics in our Southern States, was shown to have been perfectly useless.

In the other house, which was known as the "infected mosquito house," there were no articles which had not been carefully disinfected. The house contained two rooms, and nonimmunes were placed in both rooms. In one room, separated from the other by a wire screen partition, only mosquitoes which had bitten yellow-fever patients were introduced. In the other room they were excluded. In the latter room the men remained in perfect health. In the mosquito room 50 per cent of the persons bitten by infected mosquitoes (that had been kept 12 days or more after biting yellow-fever patients) were taken with the disease, and the yellow-fever diagnosis was confirmed by resident physicians of Habana who were above all others familiar with the disease in every form. Persons bitten by mosquitoes which had bitten a yellow-fever patient within less than 12 days did not contract the disease. In another series of experiments seven persons were bitten by infected mosquitoes by placing the hand in a jar containing the insects, and five of them, or 71 per cent, contracted the disease.

It was also found that yellow fever was produced by the injection of blood from the general circulation of a patient. Subcutaneous injections of 2 cubic centimeters of blood were followed by the disease, and the definite conclusions were reached that the parasite of yellow fever must be present in the general circulation, at least during the early stages of the disease, and that yellow fever may be produced, like malarial fevers, either by the bite of the mosquito or by the injection of blood taken from the general circulation. From these results the important corollary was reached, to quote Dr. Reed's own words:

> The spread of yellow fever can be most effectually controlled by measures directed to the destruction of the mosquitoes and the protection of the sick against the bites of these insects.

The organism that causes the disease has never been discovered. It is doubtless a protozoan, too small to be seen with the microscope, whose life cycle is partly in man and partly in the mosquito.

SUBSEQUENT DEMONSTRATION.

The finality of the work of the American Army commission was almost immediately accepted by sanitarians throughout the Tropics. Measures were at once instituted in the city of Habana, then under American control, looking to the eradication of yellow fever through antimosquito measures. The enormous success of this work, carried on under the direction of Maj. (now Col.) Gorgas, is a matter of history, and by the use of similar methods the same efficient sanitarian has since that time wiped out yellow fever in the Isthmian Canal Zone. Similar work has been done by the sanitary officials in Brazil and in Mexico and other countries.

A striking instance of the value of this discovery was shown during the yellow fever outbreak in New Orleans in 1905. Down to the middle of June of the summer of 1905 this outbreak threatened to parallel the disastrous outbreak of 1878, and even to exceed that disaster in severity. Antimosquito measures were undertaken, however, and pushed with great energy and with much expenditure of funds, the result being a perfectly obvious saving of from 3,000 to 4,000 lives during that summer which would undoubtedly have been lost six years earlier.

REMEDIES.

The general question of remedies for mosquitoes is considered in Farmers' Bulletin 444, and it will therefore be unnecessary to enter upon this subject in this bulletin. Readers are also referred to Farmers' Bulletin 450, on malaria, as related to this general subject.