THE WILT DISEASE, OR FLACHERIE, OF THE GYPSY MOTH

How to aid the Spread of this Disease

By WILLIAM REIFF, Bussey Institution of Harvard University,
under the direction of F. W. RANE,
State Forester

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F. W. RANE, STATE FORESTER.

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INTRODUCTORY.

Anything that offers promise of being effective in our warfare against the gypsy moth is hailed with delight by our Massachusetts people.

It is with pleasure that the State Forester is able to offer this publication, setting forth the work with the "wilt disease," or "Flacherie," of the gypsy moth, which has been carried on during the past two years by Mr. William Reiff, under the supervision of Prof. W. M. Wheeler of the Bussey Institution of Harvard University. Professor Wheeler's co-operative interest in the moth-suppression work in the State is highly appreciated by the State Forester, and the results shown in this bulletin will prove, we are sure, of great interest generally.

This bulletin is a companion, in a way, to that issued on parasites, in that it is another method of attacking our foe. We desire to have as many strings as possible to our bow in fighting this pest. That this "wilt disease" is a most hopeful remedy there is little question. We anticipate carrying on even more extensive work with it the coming season.

Upon reading this bulletin it will be readily apparent that any one can easily assist in furthering this work at little, if any, expense; and it is to be hoped that many will not only acquaint themselves with the methods employed, but experiment on their own initiative. If the State Forester can assist you in any way do not hesitate to call upon him.

Acknowledgments.

The experimental work and writing up of the data in this bulletin was done by Mr. William Reiff of the Entomological Laboratory of the Bussey Institution of Harvard University.

The State Forester decided that the work undertaken by Mr. William Reiff during the season of 1909 was well worthy

of being continued upon a much larger scale, and co-operative plans were happily agreed upon with Dr. Wheeler, with the results as outlined in this bulletin.

Besides Professor Wheeler and Mr. Reiff, there are the field agents and local superintendents of the regular moth staff, who made it possible to get results. To these we are also under obligations for their loyal support and co-operation.

F. W. RANE,
State Forester.

BOSTON, MASS., March 21, 1911.

THE "WILT DISEASE," OR "FLACHERIE," OF THE GYPSY MOTH.[1]

I. Caterpillar Diseases in General.

The production of diseases is one of nature's methods of quickly checking the overproduction of living things. Animals, including man, and plants all have their own specific infectious diseases, which usually appear whenever a species becomes so numerous that it menaces the prosperity of the coming generations. In the animal kingdom the possibility of overproduction is especially apt to occur in insects, since they form by far the largest portion of the world's fauna, and have a high rate of reproductivity. Insects, small though they are individually, form in their totality an immense mass of living matter. Of this mass we can get only a slight conception, even when we consider that insects are everywhere present, not only as a few scattered individuals, but in such enormous numbers that they constitute, as it were, a world in themselves. We may say without hesitation that among all the conditions which arise from and are caused by animals, there is none more widely distributed, more many-sided and which interferes more deeply with life on our planet than that which is brought about by insects. As Graber says: —

> Man may unwisely neglect these creatures — as he does many things; but their power for evil crushes him the more; indeed, it may destroy him if he persists in his neglect.

Now, such a power may be checked by nature by one of the most efficient means which she possesses, — the infectious diseases.

Owing to the profound influence which insects exert upon us and our culture, attention has been drawn to their diseases. A close study has been made of some of these; especially of

[1] Contributions of the Entomological Laboratory of the Bussey Institution, Harvard University, No. 36.

those known to occur in the silkworm (*Bombyx mori*) and in the "nun" moth (*Psilura monacha*), which latter destroys the forests of Central Europe.

The first scientific knowledge which we have of caterpillar diseases we owe to the valuable investigations of the French scientist Pasteur. Since his time many other investigators have been engaged in this study, among them the Germans Standfuss and Emil Fischer, the Italians Verson and Bolle, and the Americans Snow and Forbes. By their experiments and investigations we are now able to recognize the character of the more common caterpillar diseases.

We may mention some of those diseases with which the lepidopterist will come in contact in the course of a few years.

A very frequent disease of caterpillars is the *common diarrhœa,* which is produced in most cases by too juicy or too wet food. This is shown by the unusually wet excrement, the fluid part of which is green. If the disease is of longer standing, the excrement does not cling together, but is voided as a pulpy mass, in which the single vegetable particles swim around undigested. This disease in itself is not dangerous, since it is not infectious, but it may prepare the way for the attack of other infectious diseases, which will be mentioned further on.

In another disease, which has no popular name as yet, and which I shall call *bead disease,* the excrement masses hang from the body like a string of beads. This intestinal disease is probably due to unhealthy food, but the specific cause has not been determined. Apparently this disease, too, is not infectious.

Of much greater importance is the disease known as *muscardine.* This is really a collective name for a series of fungous diseases, which convert the infected caterpillar in a short time into a stiff, swollen mass, with the skin invested with a grayish-white coating. Very hairy caterpillars are especially susceptible to muscardine, but in extremely wet years even smooth caterpillars suffer from fungous diseases. It is easy to determine whether muscardine is present in a given locality because the diseased caterpillars crawl toward the exposed tops of grass blades, poles or stems, and remain there after death, thus be-

coming visible for a considerable distance. On a trip which I made in June, 1910, to Raymond, N. H., I saw thousands of brown-tail moth caterpillars dead from muscardine, and commonly hanging in this characteristic manner. Since these fungous diseases are extremely infectious, and propagate with incredible swiftness, and since healthy caterpillars are much inclined to gnaw at dead ones, the artificial production and propagation of muscardine has been hopefully considered during the last few years as a means of destroying the brown-tail moth.

There are two fungi, especially, which are responsible for the death of most caterpillars; these are *Botrytis bassiana* Bals and *Entomophthora aulicae* Reichhardt. Experiments with fungous diseases of the brown-tail moth are being conducted by Mr. A. T. Speare, under the direction of Dr. R. Thaxter of Harvard University.[1]

The *pébrine* or *pebrina,* which has become so notorious through the great damage it has caused to the silk industry, is the caterpillar disease which has been studied so far most thoroughly. Caterpillars with this disease always have a wet anus, and if they are hairy, the hairs on this region of the body stick together. Smooth caterpillars also change their color considerably; for instance, green caterpillars turn yellowish, and are often mottled with dark, irregular spots; gayly colored caterpillars lose their brilliancy. This disease does not kill in a few hours or days, but the infected caterpillars languish slowly, lose their appetite, and become transparent and ill-nourished. They then shrink more and more, till finally at death only the flabby dry skin remains. Pébrine appears preponderatingly in wet years, and its cause seems to be lack of nourishment. The specific cause, however, the disposition, has not yet been absolutely determined. The carriers of the disease are known under the name *Corpuscoli di Cornalia,* and have been described by Lebert [2] as the fungus *Panhistophyton ovatum* (*Micrococcus ovatus*). Here it might be of interest to cite from a review in "Deutsche Entomologische

[1] "Seventh Annual Report of the State Forester of Massachusetts," 1910, pp. 98–101.
[2] "Berliner Entomologische Zeitschrift," 1858, p. 170.

National Bibliothek," No. 3, Jahrg. II., 1911, where it is stated that the botanist Naegeli described the carrier of the pébrine, as early as 1857, as *Nosema bombycis*. This review, moreover, mentions the fact that W. Stempell (38. Jahresber. Zool. Sekt. Westf., Prov. Ver. f. Wiss. u. Kunst, 1909–10, p. 37) has made artificial infection experiments with this parasite, and found that it develops with extreme rapidity and great virulence, not only in caterpillars of the silkworm, but also in caterpillars of several local species of the same family. Thus Stempell reached the conclusion that this susceptibility of the individuals towards the pébrine parasite might be used practically in combating injurious caterpillars. He further mentions that his researches on this and other *Microsporidia* are of biological interest, since it would seem that there must be organisms so minute that they cannot be seen, even with our most modern optical instruments. In several infectious diseases the carriers of the disease have not yet been optically demonstrated, and it may be that these carriers are such small organisms. These little oval shining bodies are now no longer regarded as plant organisms, but as belonging to the *Psorospermii,* a group of Protozoa. Pébrine is extremely infectious, and is carried over, as Pasteur has proved, from generation to generation in the eggs, with increasing destructiveness.

We come now to the last and probably most important of all the common caterpillar diseases, the disease called *Flacherie, Flaccidenza* or *caterpillar cholera,* and in America known also under the name " wilt disease." This disease is characterized as follows: a caterpillar suffering from it soon stops eating, becomes weak and lazy, and usually crawls up on some object, as the trunk of a tree, a fence, a wall, or other vertical surface, where it remains without motion. In a few hours there drops from its mouth and anus a dirty, blackish, foul-smelling liquid; the caterpillar becomes more and more flaccid, one leg after the other looses its support, and finally the creature, reduced to a black skin, hangs dead, still holding on with one or two of its false feet or with the anal claspers. The slightest touch now suffices to break the skin, and a thin, dark, offensive-smelling

liquid flows out. Flacherie kills the older more quickly than the younger caterpillars. Young caterpillars, indeed, often live several days before they are killed by the disease. It is not positively known what organisms produce Flacherie. The bodies of caterpillars which have died of this disease show extremely small bacilli, innumerable schizomycetes, and, more particularly, many small strings of micrococci; but which of these micro-organisms, if any, is the real carrier of the disease is still unknown to specialists.[1] To the investigations of Dr. E. Fischer, in Zürich, Switzerland, we owe considerable information regarding the primary causes leading to Flacherie, and the manner in which the disposition to this disease may be induced. He has pointed out that a decrease in the nutritive value of the food of the caterpillars, which induces a disturbance in their metabolism, is the first condition leading to the contraction of the disease. As a result of these disturbances the organisms responsible for the disease immediately find conditions suitable for their growth. One of the main causes of the disease is therefore to be sought in the predisposition of the caterpillars, while the specific infection of Flacherie is to be regarded as coming more or less secondarily; in other words, without this predisposition infection cannot take place, and the predisposition can be brought about artificially by insufficient nourishment.[2] Flacherie seems to be influenced by climate and weather conditions less than any other caterpillar disease. We meet with it both in the old and the new world, in wet, in dry and in normal weather. As a result of its comparatively great abundance and its extremely easy infection, Flacherie has become the "guardian angel" of the Central European forests. When the "nun" (*Psilura monacha*) makes its appearance in some places in Europe in vast numbers, man with his wit and the powerful means at his command is quite unable to stop the destruction, but Flacherie always comes to his assistance. Although this disease has been much studied, it has not yet been positively

[1] Very recently C. Sasaki, in Tokyo, Japan, found that there were also polyhedral corpuscules present in caterpillars which were sick from Flacherie ("Deutsche Entomologische National-Bibliothek," Jahrgang II., 1911, No. 1, Referat). Since polyhedric corpuscules, however, are found chiefly in caterpillars which have been infected by the pébrine, a close relationship of these two diseases is highly probable.

[2] See Fischer's detailed accounts in the "Biologisches Centralblatt," Band XXVI., No. 13-16. Leipzig, 1906.

established whether it is hereditary or not. There is at present no argument that can be brought against the heredity of the disease, while there are some important facts which indicate its heredity. These will be considered later.

II. Résumé of Some Experiments with Flacherie in 1909.

Fischer called attention, in his excellent paper, already mentioned, to the manner in which Flacherie can be artificially developed. He says that the disposition to the disease is secured by giving the caterpillars food which has been placed in water and renewed only every three or four days. This treatment apparently causes an injury to the leaf protoplasm, due to the presence of too much water, and there is a concomitant increase in the acidity of the leaves.[1] If, now, a caterpillar eats such leaves, the alkalinity of its digestive fluid, which is very strong in healthy individuals, decreases, and in this manner the first susceptibility to the disease is given. Before the visible outbreak of Flacherie, Fischer could recognize as an early symptom a characteristic sweet odor in the breeding cages, which could be compared best to that of somewhat withered lilac blossoms. Whenever this odor was noticeable Flacherie soon made its appearance, and as it progressed the odor increased proportionately. Fischer recommends the artificial production of Flacherie among the caterpillars of the "nun" ("die Nonne" of the Germans) by intentionally giving the larvæ this kind of food as soon as an abundance of the pest is noted in any particular locality.

Bearing in mind the close relationship existing between the "nun" and the gypsy moth, I attempted during the summer of 1909 to put Fischer's conclusions regarding the artificial production of the wilt to a practical test. These experiments were published in detail in the entomological journal "Psyche," Vol. XVI., No. 5, October, 1909. There appeared also a German translation of the paper in the "Societas Entomologica," Jahrgang XXIV., pp. 178–181, Zürich, Switzerland. The main facts in these experiments are here noted. Up to 70 per cent. of the caterpillars were killed by artificially produced

[1] See the experiments which Sasaki performed on mulberry trees in Japan, "Zeitschrift für Pflanzenkrankheiten," XII. Band, Jahrgang 1902, 4. Heft, pp. 203–226; 5. Heft, pp. 258–278.

Flacherie, while all caterpillars which were kept apart for control remained healthy. From these results I was therefore led to believe that the artificially produced Flacherie might be utilized as a valuable aid in the destruction of gypsy moth caterpillars. If the disease appears in nature during normal weather conditions, the caterpillars are in most cases almost full grown when attacked; but the farther the weather conditions of the year differ from the normal, the earlier in their life will the disease affect them. The fact that I succeeded in rendering the caterpillars susceptible to the wilt before the third molt suggested that this may be of importance in the practical use of the disease, since by artificially inducing Flacherie, relief might be had weeks sooner than happens in nature.

Better to understand the conclusions drawn from the last experiment, which was performed on trees on which a considerable number of gypsy moth caterpillars occurred naturally, the following account is given: A group of oak and another of willow trees were infested with about 5,000 caterpillars each. Shortly before their fourth molt, upon each of these two groups of trees 100 sick and 50 dead caterpillars were destributed. The disease spread with amazing rapidity, and even on the following day many freshly killed caterpillars could be counted. By the time of pupation about 4,000 caterpillars on each group of trees had succumbed to the disease. Two conditions which did not enter into my previous experiments united to cause this unusual result. In the first place, the two groups of trees had been badly infested and injured by gypsy moth caterpillars the previous season, as was evidenced by the unhealthiness of the leaves during the summer of 1909, and the caterpillars had probably become predisposed to the disease on account of the resulting decrease in the value of their food. As a second very important factor may be mentioned the dry weather, which by its desiccating effect upon the leaves served to render the food for the caterpillars still less nutritious. Hence, from the beginning there was a decreased vitality in the tissues, and digestion was early disturbed. In short, the caterpillars were already very susceptible to the disease at the time I introduced it

among them, and conditions were therefore most suitable for the spread of the wilt. Always in the places that have been injured by gypsy moth caterpillars in previous years, there is a predisposition on the part of caterpillars of the following year toward Flacherie. The heavy defoliation checks the normal metabolism of the attacked vegetation, which causes a weak and sickly development of the shoots, and these therefore do not furnish the caterpillars sufficiently wholesome nourishment. It should be remembered that these facts, in the long run, mean a self-protection of the vegetation. If at this time dead and sick material is introduced among the caterpillars in such a locality, the organisms of the disease will act readily upon the individuals present. Infection will take place even in cases where a locality is badly infested by the caterpillars for the first time, because one can always find a large number of weak and therefore susceptible specimens. Then, as the disease progresses, it acquires such virulence that even the previously healthy specimens become infected.

In the article mentioned I called attention to other ways in which the caterpillars advance the infection among themselves, that is, during the resting period, during the feeding time, etc., and how easily the disease may be carried over by the caterpillar to its pupal stage. The great probability of an economic value in Flacherie for destroying the gypsy moth was suggested, but it was thought that the experiments of only a single year had better not be taken as a comprehensive method for the practical use of the wilt, and that further experiments should be undertaken on a larger scale to substantiate the obtained results.

III. Flacherie Experiments in 1910.

A. General.

In the spring of 1910 the author was requested, by the State Forester of Massachusetts, to make similar experiments on a large scale in different parts of the State.[1] These experiments were undertaken with the help and kind encouragement of Prof. W. M. Wheeler. I would also express my indebtedness

[1] *Cf.:* "Sixth Annual Report of the State Forester of Massachusetts," 1909, p. 86.

to all those from whom I have received advice and actual assistance. My thanks are also due to State Forester Frank W. Rane and Assistant Forester L. H. Worthley for much help; and to their division agents, Norman Souther of Bridgewater, and Francis C. Worthen of Georgetown, and to Mr. H. P. Richardson, local moth superintendent of Concord, for their support in the field work. Last but not least, I owe, through correspondence, several valuable hints to Dr. E. Fischer, Zürich, Switzerland, who, through his investigations on insect diseases, is to be regarded the proper instigator of these experiments.

In the beginning of the work each of the division agents was asked by letter to suggest convenient localities in which to conduct the experiments. Three of the division agents stated that they had no suitable places in their districts. In the remaining divisions 29 places were chosen, but at the end of my investigations unfortunately 13 of these could not be used, since some of the local moth superintendents had not followed instructions, and other places had been sprayed with arsenate of lead. Isolated forest districts, varying from small areas to several acres, were chosen for the experiments. The isolation was for the purpose of making easier a control of the place, since in such a locality an eventual increase or decrease of the caterpillar mass by migration was less probable. The local superintendents of the different places were instructed not to use any artificial means for destroying caterpillars in the selected woods. I was, however, obliged to use some localities in which, during the preceding winter, some of the egg clusters had been killed by creosote. According to the size of the various places, the local superintendents were requested to collect a corresponding mass of gypsy moth caterpillars shortly before their second molt. These amounted to from 50 to 100 individuals per acre. Where many egg clusters were present but few caterpillars had to be collected, and *vice versa*. Hence, the number of caterpillars to be collected was decided in advance for each locality. The reason for this is that an infection spreads more easily and rapidly in a heavily infested district than in places less damaged by caterpillars. In a

badly infested forest of 10 acres or more the average number of caterpillars to be collected was placed at less than 50 specimens per acre, since the disease spreads best in such localities.

The local superintendents had been instructed to feed the collected caterpillars daily with oak leaves, or with apple leaves where oak leaves could not be secured. These leaves were not to be removed from the twigs, and were to be placed in water for at least four days before feeding. A special emphasis was laid on not giving as food leaves of trees which had been sprayed with arsenate of lead. As breeding cages common wooden boxes were used, to which the entry of air was provided for by means of gauze coverings. Further, the local superintendents, who were not familiar with the wilt, were taught the character of this disease and its manner of appearance, and were instructed to communicate with me at once on the first appearance of Flacherie in their breeding cages. The local superintendents were asked to attend to this part of the work, since at that time it was not convenient to rear several thousand gypsy moth caterpillars in one place, and also in order that their interest might be awakened in the experiments.

As soon as the wilt was determined to be present in a brood the whole material was transplanted upon the previously chosen places, with the help of the respective superintendents. This was done as follows: a piece of clean cloth, burlap, for instance, about 2 feet long by 1 foot wide, was hung in dense foliage between the limbs of a tree, or from one tree to another close by (Fig. 1). In this hammock-like bag were placed, besides the dead and still living caterpillars of the brood, also all food remaining in the breeding cage, since such remains might also be supposed to contain organisms of the disease. No means were used to prevent the escape of the sick but still crawling caterpillars, in order that they might disseminate the organisms.[1] Where possible, the bag with the material was hung about 6 feet or still higher from the ground, in order that the wind might aid in the spread of the disease. In planting the diseased material the direction of the prevailing wind of the

[1] That this is the case is proved by some experiments which I shall consider particularly later, where only sick caterpillars were transplanted, but no dead caterpillars.

season was taken into consideration. For instance, in localities which had prevailing east winds the infected material was exposed near the eastern border of the forest, but still inside of it, so that the wind, before reaching the larger part of the wood, was forced to strike first the center of the diseased area. It may be mentioned that in some cases, where no convenient cloth was at hand, the breeding cages themselves with the material, after the removal of the cover, were hung between limbs. No difference was observed in the results. The infected material was planted in most of the localities at a time when most of the caterpillars in the field were undergoing the

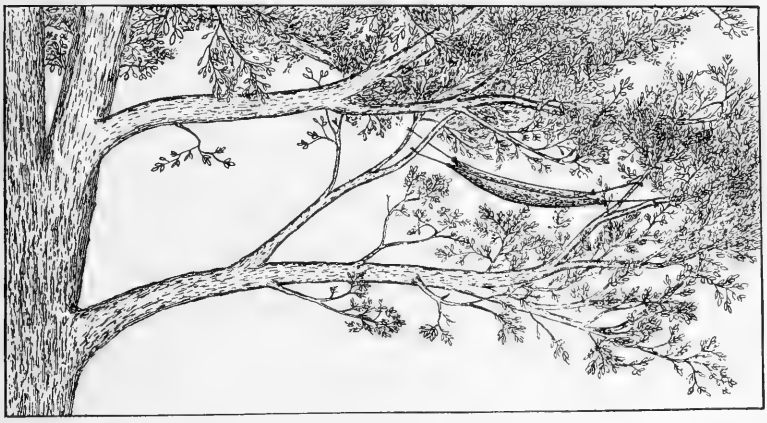

Fig. 1.—Method of hanging hammock in tree.

third molt. The respective ages of the caterpillars will be mentioned under each experiment.[1]

It was important to select places which gave the best guarantee for the health of the growing caterpillars; hence, special attention is called to the fact that in the experimental localities no disease is known to have occurred among the caterpillars of previous years.

[1] I had always planned to plant the disease as soon as it made its appearance in one or the other of the broods. This was, however, frustrated on several occasions by various circumstances. For instance, some local superintendents did not notice the Flacherie till after the disease had prevailed for several days. It was, further, not always possible for me to depart immediately upon receiving a communication concerning the outbreak of the disease. It was also almost impossible for one man to transplant the infected material to all the chosen places during the short time in which the gypsy moth caterpillars were in the third or beginning of the fourth stage. This is the reason why in some localities the disease was planted later, although the caterpillars were already beyond the third molt.

After the eggs were laid in the autumn of 1910 all localities were carefully inspected, and the number of the fresh clusters was determined as nearly as possible. For examination of the single eggs, five clusters, when possible, were collected from each locality. Five clusters from a place in the western part of Concord, Mass., served for control. These eggs must be considered as normal because they come from a place in which positively no disease whatever has occurred. In collecting clusters for examination the first five found were taken; and were not taken at random.

Every single egg of all these clusters was examined microscopically. This, it is true, required very much time, but it was nevertheless indispensable. The eggs were separated into three kinds: first, those that showed no signs of development of the embryo (empty or unfertilized eggs); second, those in which the more or less developed embryo had been killed before its complete development; and finally, those which showed a perfectly developed embryo (normal and supposedly living eggs). In every case in which the egg could not be absolutely assigned to the second series it was counted with the third series.[1]

In the details of all the work everything which seemed to suggest the economic value of the wilt has been purposely regarded from the most unfavorable standpoint, for the purpose of meeting any objections. When estimating the egg clusters from the selected localities there was always present either the division agent or the local superintendent, and at that time written notes were made of these estimates before the introduction of the disease. In the spring we made the lowest possible estimate on the number of clusters present, while with the second estimate in the autumn, after the disease had produced its effect, the fresh clusters were estimated as liberally as possible.

The average which resulted from the examination of the single clusters must not be taken as absolutely fixed, since the small number of the clusters examined admits of a variation

[1] The eggs of the control clusters could all be distributed with exactitude into the respective series.

from the mean in both directions. The main purpose of the experiments, however, was not to make mathematically exact calculations, but to find out in what manner and to what degree the gypsy moth may be infected by the wilt. For these purposes the calculations made should be sufficient, and the figures given will not be far from the real average.

As to the control experiment, the average of eggs in a normal cluster was found to be 437. I am not aware that the eggs of a large series of normal clusters have ever been counted in order to establish an accurate average. In published reports the average of eggs in a normal cluster is stated as "400 to 500."

Control Experiment, Concord, Mass.

Five clusters were taken in the western part of this locality, where there certainly did not occur any disease among the gypsy moth caterpillars. These clusters, therefore, must be regarded as normal. The microscopic examination of the eggs of these clusters gave the following results: —

Cluster 1.

Unfertilized eggs,	1	= .73 per cent., or about 1 per cent.
Eggs with dead embryos,	3	
Eggs apparently alive,	543	=99.27 per cent., or about 99 per cent.
Total,	547 eggs.	

Cluster 2.

Unfertilized eggs,	–	= .47 per cent., or about .5 per cent.
Eggs with dead embryos,	2	
Eggs apparently alive,	424	=99.53 per cent., or about 99.5 per cent.
Total,	426 eggs.	

Cluster 3.

Unfertilized eggs,	3	= 1.74 per cent., or about 2 per cent.
Eggs with dead embryos,	4	
Eggs apparently alive,	395	=98.26 per cent., or about 98 per cent.
Total,	402 eggs.	

Cluster 4.

Unfertilized eggs,	1	= .93 per cent., or about 1 per cent.
Eggs with dead embryos,	3	
Eggs apparently alive,	424	=99.07 per cent., or about 99 per cent.
Total,	428 eggs.	

Cluster 5.

Unfertilized eggs, . . .	–	
Eggs with dead embryos, .	3	= .79 per cent., or about 1 per cent.
Eggs apparently alive, . .	377	=99.21 per cent., or about 99 per cent.
Total, ...	380 eggs.	

The average of these 5 clusters is as follows: —

Dead eggs, ...	4	= .92 per cent., or about 1 per cent.
Eggs apparently alive, . .	433	=99.08 per cent., or about 99 per cent.
Total, ...	437 eggs.	

The results of this control experiment are used in estimating the departure from the normal of the egg masses in all the other experiments.

B. The Single Experiments.

Concord, Mass.

Division Agent, Chas. W. Minot; *Local Superintendent,* Henry P. Richardson.

As a suitable place for my experiments, I located, on May 20, 1910, an isolated forest of about 2¼ acres, belonging to the estate of Mr. William Brewster. This place is situated in the eastern part of Concord, about half a mile west of the West Bedford railroad station. The forest consists mainly of oaks about twenty years old and of a group of pines about fifty years old, all mixed with brush; and along the border, especially on the northern part, are birches about ten years old.

According to the local superintendent and to the owner, Mr. Brewster, the gypsy moth caterpillars were quite numerous during the summer of 1909. Both are certain that there was no disease among the caterpillars. We estimated this place to contain about 10,000 clusters of eggs in May, 1910.

On June 6 I received notice from the local superintendent that the wilt had appeared among the caterpillars which he had collected and fed according to instructions. Two days later I went to Concord, and found that some 10 caterpillars were already dead and the others were apparently very sick, as they remained motionless even when irritated. The superintendent had begun to feed the caterpillars on May 26, and had noticed the first dead specimen on June 5. Accordingly, he had succeeded in developing the wilt artificially in the course of eleven days.

With the assistance of the local superintendent the whole breeding material was immediately exposed in the western part of the selected forest. The distance from the ground to the material, which was hung between the limbs of a tree, was about 15 feet. The largest number of gypsy moth caterpillars in this locality were at this time in the third molt, or about to pass into this molt. The wilt soon spread over the whole forest, as was seen during occasional visits to the place by Mr. Richardson, Mr. Brewster and myself. On Sept. 7, 1910, the fresh egg clusters were estimated by the local superintendent and myself to amount to about 5,000. Often 4 or 5 of these clusters together would not make more than 1 normal cluster; the actual number of eggs was thus much less than would have been present in the same number of normal clusters.

The examination of 5 clusters which had been collected Sept. 7, 1910, on Brewster's estate showed the following counts: —

Cluster 1.

Unfertilized eggs,	3	= 9.66 per cent., or about 9.5 per cent.
Eggs with dead embryos,	11	
Eggs apparently alive,	131	=90.34 per cent., or about 90.5 per cent.
Total,	145 eggs.	

Cluster 2.

Unfertilized eggs,	2	=7.43 per cent., or about 7.5 per cent.
Eggs with dead embryos,	9	
Eggs apparently alive,	137	=92.57 per cent., or about 92.5 per cent.
Total,	148 eggs.	

Cluster 3.

Unfertilized eggs,	13	=48.06 per cent., or about 48 per cent.
Eggs with dead embryos,	49	
Eggs apparently alive,	67	=51.94 per cent., or about 52 per cent.
Total,	129 eggs.	

Cluster 4.

Unfertilized eggs,	1	= 8.64 per cent., or about 8.5 per cent.
Eggs with dead embryos,	6	
Eggs apparently alive,	74	=91.36 per cent., or about 91.5 per cent.
Total,	81 eggs.	

Cluster 5.

Unfertilized eggs, . . .	–	= 6.76 per cent., or about 6.5 per cent.
Eggs with dead embryos, .	5	
Eggs apparently alive, . .	69	=93.24 per cent., or about 93.5 per cent.
Total, ...	74 eggs.	

Averaging these 5 clusters we have: —

Dead eggs, ...	20	=17.24 per cent., or about 17 per cent.
Eggs apparently alive, . .	96	=82.76 per cent., or about 83 per cent.
Total, ...	116 eggs.	

A normal egg cluster contains on an average 433 eggs (p. 20) which are apparently alive. Since the infested locality averages only 96 eggs which are apparently alive per cluster, 4½ clusters are necessary to equal the size of a normal cluster. The number of the fresh clusters, estimated at 5,000, thus has to be reduced to about 1,100 clusters to compare with the 10,000 clusters present in the spring of 1910. The number of apparently vital eggs, therefore, is decreased to about 11 per cent. through the action of Flacherie.

The local superintendent informed me that the disease had also spread into the neighboring forest districts. By an extended walk through about 5 acres of these woods I learned that the wilt had operated in the same manner as in the first locality. He is of the opinion that the number of clusters in this 5 acres has been decreased to about 15 per cent. Adjoining these woods there are about 15 acres of forest, in which the local superintendent found that all egg clusters which had been laid in the summer of 1909, and which had been deposited 1 foot or more above the ground, had failed to produce caterpillars, that is, the eggs had remained unhatched; but the caterpillars had all emerged from those eggs in clusters placed less than 1 foot above the ground. I found that these statements corresponded very closely with the facts. Here and there I noticed a slight exception by occasionally finding either a high-placed cluster from which a few caterpillars had emerged, or I detected close to the ground a cluster from which only a portion of the caterpillars had emerged. These exceptions, however, were insignificant, for they represented in each case hardly more than 10 eggs. I am unable, so far, to find any explanation for this peculiar occurrence. At first I thought that an egg parasite might have exerted its helpful power, but the examination of eggs from several clusters which had remained unhatched showed that almost all eggs contained a fully developed dead embryo, and no signs of a parasite could be found. The moisture of the soil cannot be made responsible, for bor-

dering this forest there is another with exactly the same soil, the same kind of trees and of the same age as the other place, and although these forests are separated only by a very broad road, in the latter wood the caterpillars of almost all egg clusters of 1909 had emerged from clusters that had been placed at any height on the trunks of the trees. There were exceptional cases of clusters, sometimes on the upper, sometimes on the lower part of the trees, from which all caterpillars had not emerged, but there was no evidence of the peculiar condition that characterized the clusters in the place first mentioned. Whether any caterpillar disease has any effect in this occurrence, I cannot now say. The solution of this question may come in the future from careful observations at this particular locality.[1]

An extensive forest in the southwestern part of Concord was visited, in which, according to the information of the local superintendent, the wilt had broken out naturally. The peculiar conditions which we found here require a detailed description of the locality and of the manner in which the disease operated. The largest part of the forest, about 20 acres, is situated upon the ridge of a hill. On the east and west the hill slopes to wet meadows. On the north and south the hill gently passes over into level country, and it is bordered here by broad roads. The principal trees on the ridge of the hill are high pines about sixty to eighty years of age; brush is almost absent. The slopes are covered in large part with young oaks, which are much mixed with brush of different kinds. Now, while the forest of the whole ridge, including the northern and southern slopes, suffered considerably from injuries by gypsy moth caterpillars during the summer of 1910, the eastern and western slopes were exempt from this damage. Soon after the caterpillars had passed the third molt Flacherie made its appearance among those feeding on the pines upon the ridge of the hill. The disease developed here so rapidly that probably all caterpillars were killed, for we were unable, even by careful search in these 20 acres, on Sept. 7, 1910, to find a single fresh cluster. The statement, therefore, seems justified that all caterpillars, at least all the females (100 per cent.), were here killed by the wilt. This very high number, however, was restricted to the forest upon the ridge of the hill. On the first trees of the northern and southern slopes fresh egg clusters were found, and the number of these increased as we went toward the plain. But the inspection of such dead caterpillars as were observed showed that the wilt had also operated in the woods of these slopes. The local superintendent looked here for Flacherie, but it did not appear till the caterpillars were in their last stage. The reason for this behavior of the wilt might be that the ridge of the hill, with its high trees, was much exposed to the effect of the wind, and after Flacherie had once developed it could be spread very rapidly along the ridge. On the northern

[1] Similar observations, where eggs have not hatched, were made elsewhere by different persons connected with the moth work, but no definite observations, as at Concord, were reported.

and southern slopes, however, the wind could not strike so hard, and the spreading of Flacherie toward the plain, therefore, took place comparatively slowly. Upon the eastern and western slopes, on account of the lack of caterpillars, the conditions necessary for developing the wilt were not present.

A map of the place, sketched by Mr. Richardson (Fig. 2), which may aid in understanding the description, is given herewith.

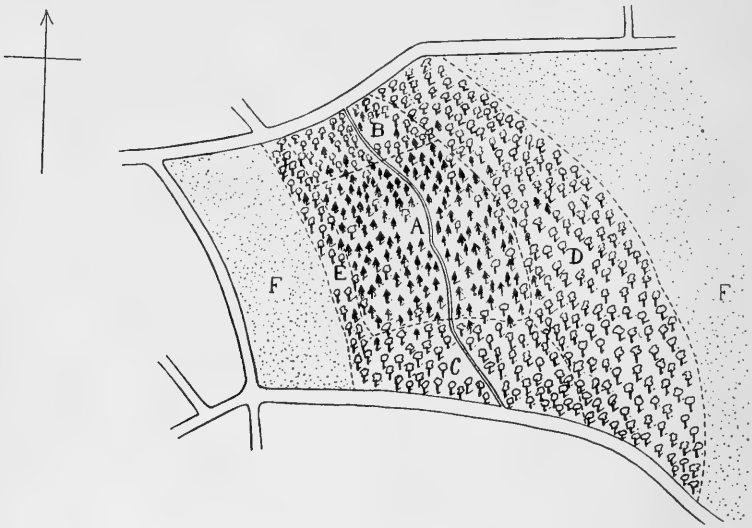

Fig. 2. — Experiment, Concord, Mass. A. Summit of hill, now cleared. B. Northern slope, infested. C. Southern slope, infested. D. Eastern slope, not eaten. E. Western slope, not eaten. F. Meadows.

Five clusters were examined for comparison from the localities in which Flacherie developed naturally. These were collected on a walk through the forest district at the southern end of the hill, and from different trees taken at random. The result was: —

Cluster 1.

Unfertilized eggs, . . .	4	} =12.59 per cent., or about 12.5 per cent.
Eggs with dead embryos, .	16	
Eggs apparently alive, . .	139	=87.41 per cent., or about 87.5 per cent.
Total, ...	159 eggs.	

Cluster 2.

Unfertilized eggs, . . .	2	} = 5.30 per cent., or about 5 per cent.
Eggs with dead embryos, .	6	
Eggs apparently alive, . .	143	=94.70 per cent., or about 95 per cent.
Total, ...	151 eggs.	

Cluster 3.

Unfertilized eggs,	1	= 2.14 per cent., or about 2 per cent.
Eggs with dead embryos,	4	
Eggs apparently alive,	229	= 97.86 per cent., or about 98 per cent.
Total,	234 eggs.	

Cluster 4.

Unfertilized eggs,	1	= 3.17 per cent., or about 3 per cent.
Eggs with dead embryos,	3	
Eggs apparently alive,	122	= 96.83 per cent., or about 97 per cent.
Total,	126 eggs.	

Cluster 5.

Unfertilized eggs,	6	= 12.93 per cent., or about 13 per cent.
Eggs with dead embryos,	32	
Eggs apparently alive,	256	= 87.07 per cent., or about 87 per cent.
Total,	294 eggs.	

Averaging these 5 clusters we get this result: —

Dead eggs,	15	= 7.77 per cent., or about 7.5 per cent.
Eggs apparently alive,	178	= 92.23 per cent., or about 92.5 per cent.
Total,	193 eggs.	

We notice also that the egg clusters from this place, where the wilt developed naturally, are considerably less than the normal size, about 2½ clusters being equal to 1 normal cluster. This, and the fact that only 7.5 per cent. of the eggs would fail to hatch, while in the experiment 17 per cent. were dead, is probably due to the fact that upon this southern slope Flacherie appeared late and spread but slowly.

North Carver, Mass.

Division Agent, John A. Farley; *Local Superintendent,* Herbert F. Atwood.

This locality was visited on May 9, 1910, with the inspector of the southern districts of the State of Massachusetts, Mr. Norman Souther of Bridgewater, to find suitable places for the intended experiments. The gypsy moth does not occur here in such enormous numbers as in the northern parts of the State, but I wished to have some experiments at places where the gypsy moth has but recently gained a foothold.

An isolated wood of about 2 acres, situated somewhat southwest from Makepeace's cranberry bog, was found to be a suitable place. It consists of pines about forty years old and of oaks about twenty to twenty-five years of age, with considerable brush.

The gypsy moth was discovered here for the first time during the winter of 1909–10, by finding egg clusters. Several of these clusters, unfortunately, had been already killed with creosote before my first visit, but there were present, according to Mr. Souther's and my estimation, about 25 clusters. Whether there was any disease among the caterpillars of the previous year could not be ascertained, but it is highly improbable, considering the youth of the colony and the large size of the clusters.

On June 14, 1910, the local superintendent sent me word that wilt had made its appearance among the caterpillars which he had collected and fed according to instructions. I therefore went to North Carver on June 16, and found that in Mr. Atwood's colony about 3 per cent. of the caterpillars had already died of Flacherie. Most of those still living were very sick. He therefore had developed the wilt artificially after a feeding of about fourteen days.

This same day, with the assistance of the local superintendent, a part of the breeding material was exposed on the western side of the selected place. The bag containing the material was fastened about 8 feet from the ground, between young oak trees. Most of the caterpillars of this locality had just passed the third molt.

On Oct. 7, 1910, an extended search was made by the local superintendent and myself, but only 4 fresh clusters could be found. The microscopic examination of these 4 clusters resulted as follows: —

Cluster 1.

Unfertilized eggs,	5	= 6.03 per cent., or about 6 per cent.
Eggs with dead embryos,	21	
Eggs apparently alive,	405	=93.97 per cent., or about 94 per cent.
Total,	431 eggs.	

Cluster 2.

Unfertilized eggs,	3	= 5.38 per cent., or about 5.5 per cent.
Eggs with dead embryos,	18	
Eggs apparently alive,	375	=94.62 per cent., or about 94.5 per cent.
Total,	396 eggs.	

Cluster 3.

Unfertilized eggs,	2	= 4.65 per cent., or about 4.5 per cent.
Eggs with dead embryos,	8	
Eggs apparently alive,	205	=95.35 per cent., or about 95.5 per cent.
Total,	215 eggs.	

Cluster 4.

Unfertilized eggs, . . .	3	=13.38 per cent., or about 13.5 per cent.
Eggs with dead embryos, .	18	
Eggs apparently alive, . .	136	=86.62 per cent., or about 86.5 per cent
Total, ...	157 eggs.	

Averaging these 4 clusters we get: —

Dead eggs, ...	20	= 6.67 per cent., or about 6.5 per cent.
Eggs apparently alive, . .	280	=93.33 per cent., or about 93.5 per cent.
Total, ...	300 eggs.	

Since, as we have seen, a normal cluster contains on the average 433 eggs with apparently living embryos, the living eggs of these 4 clusters, after the wilt did its work, amount to about 64.5 per cent. The egg clusters which were present in the spring of 1910 were estimated at about 25, while only 4 fresh clusters were found in the autumn of 1910. The total number of all apparently living eggs was decreased in this locality to about 13 per cent., as compared with the number present in the spring of 1910.

Another place for experiments, very similar to the last one, was selected in North Carver. This is a forest district of 3 acres, and is situated east of the cemetery on Wenham Street. The timber and brush here are the same as in the other locality, and the egg clusters of the gypsy moth were also first discovered here during the winter of 1909–10. Unfortunately, several clusters were killed with creosote before my first visit. The clusters still present were estimated by Mr. Souther and myself at about 600. On account of the young age of the colony and the considerable size of the clusters probably no disease had appeared among the caterpillars of the preceding year.

The remaining part of the wilt material was planted among the caterpillars of this locality on the same day and in the same manner as in the first colony. Here, also, most of the caterpillars at this time had just undergone the third molt.

The estimate of the fresh clusters, which was made by the local superintendent and myself Oct. 7, 1910, was about 400, from which the first 5 found were used for microscopical examinations. The result is as follows: —

Cluster 1.

Unfertilized eggs, . . .	–	= 4.11 per cent., or about 4 per cent.
Eggs with dead embryos, .	12	
Eggs apparently alive, . .	280	=95.89 per cent., or about 96 per cent.
Total, ...	292 eggs.	

Cluster 2.

Unfertilized eggs,	2	} =17.17 per cent., or about 17 per cent.
Eggs with dead embryos,	38	
Eggs apparently alive,	193	=82.83 per cent., or about 83 per cent.
Total,	233 eggs.	

Cluster 3.

Unfertilized eggs,	–	} = 7.38 per cent., or about 7 per cent.
Eggs with dead embryos,	9	
Eggs apparently alive,	113	=92.62 per cent., or about 93 per cent.
Total,	122 eggs.	

Cluster 4.

Unfertilized eggs,	1	} = 4.89 per cent., or about 5 per cent.
Eggs with dead embryos,	14	
Eggs apparently alive,	292	=95.11 per cent., or about 95 per cent.
Total,	307 eggs.	

Cluster 5.

Unfertilized eggs,	2	} = 2.95 per cent., or about 3 per cent.
Eggs with dead embryos,	9	
Eggs apparently alive,	362	=97.05 per cent., or about 97 per cent.
Total,	373 eggs.	

Averaging these 5 clusters we get: —

Dead eggs,	17	= 6.42 per cent., or about 6.5 per cent.
Eggs apparently alive,	248	=93.58 per cent., or about 93.5 per cent.
Total,	265 eggs.	

Since this place, after infection with Flacherie, contains on the average only 248 eggs with apparently living embryos per cluster, almost 2 clusters of this locality are necessary to equal a normal cluster. The number of the fresh clusters, estimated at about 400, thus has to be reduced to about 250. The number of apparently living eggs in this locality therefore decreased, after the wilt had operated, to about 42 per cent.[1]

[1] This forest was cut down by the owner in the beginning of the winter of 1910–11, and all egg clusters which the forest contained were collected by the local superintendent; 444 clusters were found. Our estimate of the clusters in the autumn, which was 400, therefore was nearly correct. The number of apparently living eggs which remained after Flacherie did its work has to be increased 3 per cent., that is to say, to 45 per cent.

Boxford, Mass.

Division Agent, Francis C. Worthen; *Assistant Local Superintendent,* Harry L. Cole.

Two places were selected in the West Boxford district for the intended experiments. The locality which we shall consider first is situated opposite the almshouse, near the Almshouse Road, and is only about a quarter of an acre in size. This small isolated wood is composed of oaks almost fifty to sixty years of age, and there is no brush. The gypsy moth caterpillars were numerous here in the summer of 1909. No disease had been noticed among them, according to Mr. Worthen and Mr. Cole, nor have any artificial means of destroying the gypsy moth been undertaken here. Mr. Worthen and I estimated the number of egg clusters at the time of my first visit, on May 6, 1910, at about 200.

Mr. Cole was intrusted with raising the caterpillars for the Boxford experiments. Having received no notice of the wilt making its appearance in the brood, on the 14th of June, 1910, I went to Boxford to inspect the material. It was found that Mr. Cole had reared the caterpillars in a very cold cellar, where they were eating but little and were retarded considerably in their development. He was instructed to place the caterpillars immediately in a warmer place in the open air. On June 19, 1910, a letter from him announced that Flacherie had broken out in his brood. On June 21 I went to Boxford to confirm his statement. About 5 per cent. of the caterpillars of this brood had already died of Flacherie, and most of the individuals still living showed all the signs of the disease.

One part of this brood was exposed, with the assistance of Mr. Cole, on the same day in the western part of the selected locality. The bag containing the material was fastened between twigs of oak trees, about 6 feet from the ground. Most of the caterpillars of this locality were at this time about ready for the fourth molt.

The fresh clusters at this place were estimated, on Aug. 26, 1910, by the division agent and myself, to be about 60. The first 5 clusters which were found were collected and examined. The examination resulted as follows: —

Cluster 1.

Unfertilized eggs, . . .	–	= 4.92 per cent., or about 5 per cent.
Eggs with dead embryos, .	6	
Eggs apparently alive, . .	116	= 95.08 per cent., or about 95 per cent.
Total, ...	122 eggs.	

Cluster 2.

Unfertilized eggs,	1	=10.16 per cent., or about 10 per cent.
Eggs with dead embryos,	12	
Eggs apparently alive,	115	=89.84 per cent., or about 90 per cent.
Total,	128 eggs.	

Cluster 3.

Unfertilized eggs,	3	= 7.14 per cent., or about 7 per cent.
Eggs with dead embryos,	4	
Eggs apparently alive,	91	=92.86 per cent., or about 93 per cent.
Total,	98 eggs.	

Cluster 4.

Unfertilized eggs,	8	=28.24 per cent., or about 28 per cent.
Eggs with dead embryos,	16	
Eggs apparently alive,	61	=71.76 per cent., or about 72 per cent.
Total,	85 eggs.	

Cluster 5.

Unfertilized eggs,	–	= 2.96 per cent., or about 3 per cent.
Eggs with dead embryos,	5	
Eggs apparently alive,	164	=97.04 per cent., or about 97 per cent.
Total,	169 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs,	11	= 9.17 per cent., or about 9 per cent.
Eggs apparently alive,	109	=90.83 per cent., or about 91 per cent.
Total,	120 eggs.	

Since this place, weakened by the wilt, contained only 109 eggs with apparently living embryos to the cluster, almost 4 clusters were necessary to equal the size of a normal cluster. The number of fresh egg clusters, which were estimated at 60, thus must be reduced to about 20 clusters. The number of apparently living eggs was therefore decreased, as the result of Flacherie, to about 10 per cent.

The second place which was selected in West Boxford for experiments with the disease consists of an isolated wood of about half an acre. Most of the trees are oaks about thirty years of age, mixed with underbrush. This locality is situated on Highland Street, between two apple orchards. In the summer of 1909 the gypsy moth caterpillars were relatively more numerous than at the first place. No dis-

ease was noticed among them by Messrs. Worthen and Cole, but it is nevertheless possible that the wilt might have made its appearance. No artificial means for destroying the gypsy moth had been undertaken here. The number of egg clusters present at the time of my first visit in the spring of 1910 was estimated by Mr. Worthen and myself at about 550.

Flacherie, which had been developed artificially by Mr. Cole, was planted in this locality June 21, 1910, in the same manner as in the place first described. The caterpillars were about ready for the fourth molt, as in the first experiment. With the assistance of the division agent the fresh clusters at this locality were estimated on Aug. 26, 1910, to be about 80. The microscopical examination of the first 5 clusters found shows: —

Cluster 1.

Unfertilized eggs, . . .	1	= 6.67 per cent., or about 6.5 per cent.
Eggs with dead embryos, .	10	
Eggs apparently alive, . .	154	=93.33 per cent., or about 93.5 per cent.
Total, ...	165 eggs.	

Cluster 2.

Unfertilized eggs, . . .	1	= 6.25 per cent., or about 6 per cent.
Eggs with dead embryos, .	5	
Eggs apparently alive, . .	90	=93.75 per cent., or about 94 per cent.
Total, ...	96 eggs.	

Cluster 3.

Unfertilized eggs, . . .	2	= 7.09 per cent., or about 7 per cent.
Eggs with dead embryos, .	7	
Eggs apparently alive, . .	118	=92.91 per cent., or about 93 per cent.
Total, ...	127 eggs.	

Cluster 4.

Unfertilized eggs, . . .	3	= 9.68 per cent., or about 9.5 per cent.
Eggs with dead embryos, .	12	
Eggs apparently alive, . .	140	=90.32 per cent., or about 90.5 per cent.
Total, ...	155 eggs.	

Cluster 5.

This cluster proved to be entirely without eggs, and it consisted only of a mass of wool of about 1 square centimeter in size. The female moth, which deposited this cluster, seems to have been absolutely sterile. It started mechanically, it is true, to lay eggs, but of course it could deposit nothing except the hairs from its abdomen.

The average of these clusters gives the following result: —

Dead eggs,	8	= 7.34 per cent., or about 7 per cent.
Eggs apparently alive,	101	=92.66 per cent., or about 93 per cent.
Total,	109 eggs.	

Since this locality, which had been infected with the wilt, showed only 101 eggs with apparently living embryos on the average per cluster, about 4 clusters would be equal to a normal one. The fresh egg clusters, which were estimated at about 80, thus have to be reduced to about 20. The number of apparently living eggs in this infested locality has thus decreased to about 4 per cent.

A third locality in which the wilt appeared naturally was somewhat closely inspected. A small isolated wood of about 3,000 square feet is situated on Main Street, about 500 yards south of Wood's Corner. The trees consist of oaks a hundred years or more of age, and the place is free from underbrush. The gypsy moth caterpillars were very numerous here in the summer of 1909, but no definite statement can be made as to whether or not there was disease among them. If the disease was present, it was doing little harm, as otherwise dead caterpillars in large numbers would have been noticed, without doubt, by the division agent or the local superintendent. Mr. Worthen estimated the number of clusters present in the spring of 1910 at about 400. No artificial means for destroying the gypsy moth were undertaken. Measured in a straight line this place is at least 1 mile from the nearest of the two localities previously mentioned. Flacherie was noticed here at a time when most caterpillars were in the fourth molt. Here, too, the disease worked considerably among the caterpillars. It was hard to find even 50 clusters when Mr. Worthen and I estimated the freshly laid ones, on Aug. 26, 1910. For comparison the first 5 clusters found were collected and examined. They gave the following results: —

Cluster 1.

Unfertilized eggs,	–	=11.27 per cent., or about 11 per cent.
Eggs with dead embryos,	8	
Eggs apparently alive,	63	=88.73 per cent., or about 89 per cent.
Total,	71 eggs.	

Cluster 2.

Unfertilized eggs,	1	=10.28 per cent., or about 10 per cent.
Eggs with dead embryos,	10	
Eggs apparently alive,	96	=89.72 per cent., or about 90 per cent.
Total,	107 eggs.	

Cluster 3.

Unfertilized eggs, . . .	2	= 6.94 per cent., or about 7 per cent.
Eggs with dead embryos, .	8	
Eggs apparently alive, . .	134	=93.06 per cent., or about 93 per cent.
Total, ...	144 eggs.	

Cluster 4.

Unfertilized eggs, . . .	–	= 4.26 per cent., or about 4 per cent.
Eggs with dead embryos, .	4	
Eggs apparently alive, . .	90	=95.74 per cent., or about 96 per cent.
Total, ...	94 eggs.	

Cluster 5.

Unfertilized eggs, . . .	2	= 8.59 per cent., or about 8.5 per cent.
Eggs with dead embryos, .	12	
Eggs apparently alive, . .	149	=91.41 per cent., or about 91.5 per cent.
Total, ...	163 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs, ...	9	= 7.08 per cent., or about 7 per cent.
Eggs apparently alive, . .	106	=92.92 per cent., or about 93 per cent.
Total, ...	115 eggs.	

Thus in this locality, also, in which the wilt appeared naturally, the egg clusters were far below the normal size. Examination showed that about 4 of these clusters would be necessary to equal a normal one in size. The estimated sum of 50 clusters, therefore, must be reduced to about 14. Hence, the apparently living eggs which remained amount to about 4 per cent.

Finally, a forest of about 30 acres was inspected. This is situated at an angle of 45°, and half a mile distant from the two first localities. In this forest, which consists mainly of large pines and oaks, the gypsy moth caterpillars had been present in considerable numbers during the summer of 1909, and were still more numerous during the first part of the summer of 1910. The owners of this place intended, according to the division agent, to cut down the forest, thus preventing a total stripping and decrease of the value of the wood. A powerful ally came to the support of the owners during the latter part of the summer of 1910, in the guise of Flacherie, which cleared up the caterpillars in a manner that left nothing to be desired. It cannot be determined whether the disease appeared naturally or was spread to this

forest from the two localities in which the experiments were performed. However this may be, the wilt had acted at any rate in such a virulent manner that in all these 30 acres of forest not a single fresh egg cluster could be found, notwithstanding the most painstaking search on the part of Mr. Worthen and myself.

Mr. Worthen also undertook, on his own behalf, the breeding of several hundred caterpillars, feeding them according to my instructions. The disease could be noticed in this brood as early as June 14, 1910. Most of these caterpillars had just passed the third molt. Three days later he exposed all the material among the caterpillars of a forest near his home. Soon he observed the "dying off" of the caterpillars which were there present. The number of the dead ones grew astonishingly, but the final result cannot be stated, since, unfortunately, the trees were later sprayed with arsenate of lead.

West Bedford, Mass.

The division agent and the local superintendent in this locality were not requested to perform the experiments. My friend, Mr. L. W. Swett, the well-known specialist in Geometridæ, asked me in the spring of 1910 to undertake an experiment with the wilt upon his estate on Davis Street, northeast of the railroad station, in West Bedford. We inspected the place for this purpose on May 29, and the locality appeared to be a very suitable one for the work. It consists of two isolated strips of wood, which meet at a right angle. One strip comprises oaks about fifty years of age, mixed with some brush; while the other consists of dense birch brush about six years old. The whole locality comprises about three-quarters of an acre. The gypsy moth was first discovered here in 1908, and the place since that time has been under continuous observation by Mr. Swett. He assured me that there were positively no signs of a disease among the caterpillars. During the summer of 1909 the caterpillars were quite numerous. Part of the egg clusters, which were laid in the autumn of 1909, were killed with creosote, but there were still present, according to Mr. Swett's and my estimation at the time of my first visit, about 400 clusters on the oaks and about 100 clusters on the birches.

The caterpillars for this experiment were raised by the author at Forest Hills. They began to die from Flacherie after a continuous feeding of fourteen days, and just as they had passed the third molt. This material was planted, June 22, 1910, in the birch brush, and the bag was fastened about 6 feet from the ground. Most of the caterpillars of this locality were at that time half way between the third and fourth molt. The place was visited again on July 18, 1910, to determine the progress of the disease. Mr. Swett and I found that the caterpillars were dying in considerable numbers, and the percentage of dead individuals was greatest on the shortest brush, and decreased

gradually the higher the vegetation grew. For instance, all the caterpillars which had been feeding on the small willow brushes were already dead. This brush, hardly 3 feet high, occurs here and there in front of the two rows of woods. The dead caterpillars were readily seen, as they were hanging all over the brush. Many of the caterpillars on the birches were dying, but a considerable number of living individuals was still present. In the colony of the high oaks, however, the wilt had

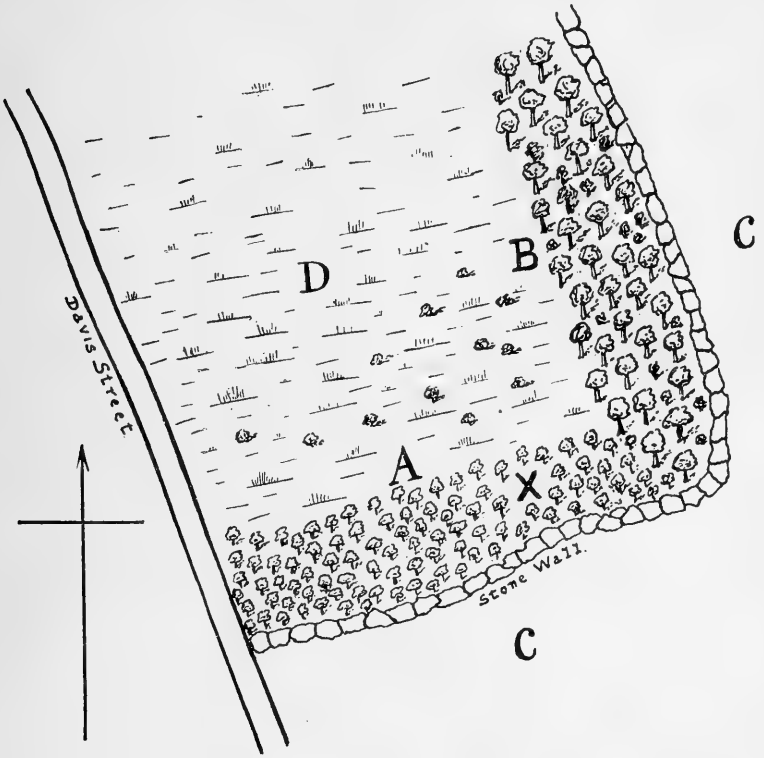

Fig. 3.—Experiment, West Bedford, Mass. A. Dense birches. X. Exposure of disease. B. Oaks and underwood. C. Field. D. Marshy meadow with a few scattered willows.

not spread so much, although dead individuals were found in considerable numbers.

On Sept. 23, 1910, the freshly laid egg clusters were estimated. We made the interesting discovery that there existed no fresh clusters in the row overgrown with birch. Thus, all the caterpillars, at least the females, had been killed by Flacherie. To be certain of this fact the crevices of the bordering stone wall were carefully examined, since the gypsy moth female selects with preference such hidden places for oviposition. But no fresh clusters could be found here. The other row with the high oaks, however, proved to have a relatively large number

of fresh clusters, which were estimated at about 150. Mr. Swett later made an examination and confirmed these facts. There is no sufficient explanation so far for the peculiar behavior of the wilt in this locality. Apparently the wind here played a special rôle. The difference in the vegetation may also have had some influence. Does the eating of birch foliage hasten the production of the disposition to Flacherie among the caterpillars?

The accompanying map will complete the description of the West Bedford locality (Fig. 3).

The microscopic examination of the 5 first egg clusters, found on the oaks, gave the following result: —

Cluster 1.

Unfertilized eggs,	–	= 2.69 per cent., or about 2.5 per cent.
Eggs with dead embryos,	5	
Eggs apparently alive,	181	=97.31 per cent., or about 97.5 per cent.
Total,	186 eggs.	

Cluster 2.

Unfertilized eggs,	2	= 2.67 per cent., or about 2.5 per cent.
Eggs with dead embryos,	7	
Eggs apparently alive,	328	=97.33 per cent., or about 97.5 per cent.
Total,	337 eggs.	

Cluster 3.

Unfertilized eggs,	1	= 3.25 per cent., or about 3 per cent.
Eggs with dead embryos,	4	
Eggs apparently alive,	149	=96.75 per cent., or about 97 per cent.
Total,	154 eggs.	

Cluster 4.

Unfertilized eggs,	12	=20.65 per cent., or about 20.5 per cent.
Eggs with dead embryos,	58	
Eggs apparently alive,	269	=79.35 per cent., or about 79.5 per cent.
Total,	339 eggs.	

Cluster 5.

Unfertilized eggs,	1	= 3.19 per cent., or about 3 per cent.
Eggs with dead embryos,	9	
Eggs apparently alive,	303	=96.81 per cent., or about 97 per cent.
Total,	313 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs, ...	20	= 7.52 per cent., or about 7.5 per cent.
Eggs apparently alive, . .	246	=92.48 per cent., or about 92.5 per cent.
Total, ...	266 eggs.	

Since this locality, in which the wilt has worked, contained only 246 eggs with apparently living embryos in average per cluster, nearly 2 clusters were necessary to equal a single normal cluster. The number of fresh clusters, which were estimated at about 150, must therefore be reduced to about 90. The number of apparently living eggs of that part of this locality which bears the oaks was therefore decreased to about 22.5 per cent. after the wilt had worked, while, as already mentioned, the part with the birches contained probably no living eggs.

Haverhill, Mass.

Division Agent, H. F. Armstrong; *Local Superintendent*, G. F. Moore.

With the assistance of the local superintendent a place was selected for the experiment in East Parish, Haverhill; it is situated west of East Broadway and northeast of Millway Pond, and on the Old Country Road. This locality represents almost 50 acres of isolated forest, in which oaks about thirty years old, mixed with underbrush, prevail. Only about 12 acres of this forest are infested with the gypsy moth. The caterpillars were numerous here during the summer of 1909, but no disease was present, according to the local superintendent. On May 18, 1910, our joint estimation gave 1,000 clusters per acre, *i.e.*, altogether about 12,000 clusters. No artificial means of destroying the gypsy moth had been undertaken.

Mr. Moore, owing to lack of time, could not raise caterpillars for the experiment, and he had no reliable man to whom he could entrust the work. Upon the recommendation of Mr. Fitzgerald, the field inspector of the northern divisions, the brother of the local superintendent of Methuen, Mass., Mr. Wagland, was intrusted with the raising of the caterpillars. As no communication was received from Mr. Walter Wagland by June 21, 1910, that his caterpillars showed signs of Flacherie, I went on this day to Methuen, to convince myself of the condition of the insects. The local superintendent, A. H. Wagland, Mr. Walter Wagland's brother, was with me, and we found that all the caterpillars were sick and that several had already died. The reason why I had received no word from Mr. Walter Wagland was that he did not recognize the disease. The planting of the material in the selected place in Haverhill was accomplished the next day. All the material was exposed in a pasteboard box in the western part of the forest, about 6 feet from the ground and between limbs of oak trees.

Most of the caterpillars of this locality were at this time about half way between the third and fourth molts.

The place was visited again Aug. 30, 1910, with the local superintendent of Haverhill, to see how the wilt had operated, and how many fresh egg clusters were present. First it was noticed that the infested portion of the forest was not uniformly infected with Flacherie. While the periphery of the infested area (about 8 to 9 acres) showed a very considerable decrease of the egg clusters in comparison with those of the spring of 1910, the real center of the colony, which covered 3 to 4 acres, had been more resistant to the disease, although here also the number of the fresh clusters had decreased considerably in comparison with the clusters of the previous year. Altogether the number of fresh clusters of the whole colony was estimated by us to be about 3,500. The 5 clusters which served for examination proved to be as follows: —

Cluster 1.

Unfertilized eggs,	8	
Eggs with dead embryos,	28	=28.57 per cent., or about 28.5 per cent.
Eggs apparently alive,	90	=71.43 per cent., or about 71.5 per cent.
Total,	126 eggs.	

Cluster 2.

Unfertilized eggs,	–	
Eggs with dead embryos,	5	= 3.31 per cent., or about 3 per cent.
Eggs apparently alive,	146	=96.69 per cent., or about 97 per cent.
Total,	151 eggs.	

Cluster 3.

Unfertilized eggs,	4	
Eggs with dead embryos,	13	= 5.63 per cent., or about 5.5 per cent.
Eggs apparently alive,	285	=94.37 per cent., or about 94.5 per cent.
Total,	302 eggs.	

Cluster 4.

Unfertilized eggs,	7	
Eggs with dead embryos,	25	=12.36 per cent., or about 12 per cent.
Eggs apparently alive,	227	=87.64 per cent., or about 88 per cent.
Total,	259 eggs.	

Cluster 5.

Unfertilized eggs,	–	
Eggs with dead embryos,	6	= 1.95 per cent., or about 2 per cent.
Eggs apparently alive,	302	=98.05 per cent., or about 98 per cent.
Total,	308 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs,	19	= 8.30 per cent., or about 8 per cent.
Eggs apparently alive,	210	= 91.70 per cent., or about 92 per cent.
Total,	229 eggs.	

Since a normal cluster contains, on the average, 433 eggs with apparently living embryos, and this locality in which Flacherie had prevailed contained only 210 eggs with apparently living embryos on the average per cluster, 2 clusters were necessary to equal a normal one. The number of fresh clusters, which were estimated to be about 3,500, must therefore be reduced to about 1,750. The number of apparently living eggs had decreased in this locality, after the wilt had operated, to about 14.5 per cent.

Marshfield, Mass.

Division Agent, JOHN A. FARLEY; *Local Superintendent,* P. R. LIVERMORE.

I did not visit this locality, but the experiment was undertaken by the local superintendent with the assistance of Mr. Joseph Shermann of Marshfield, who raised the caterpillars according to my instructions. On visiting Marshfield on June 24, 1910, it was found that Mr. Shermann's caterpillars, most of which were ready to undergo the fourth molt, were sick with Flacherie. He was instructed to expose the material, with the assistance of the local superintendent, in a forest infested with the gypsy moth. This was done on June 26, 1910, in a forest of 10 acres. On Oct. 25, 1910, the local superintendent sent, upon my request, a number of fresh egg clusters from the locality where the disease had been planted, and he remarked that the number of egg clusters were considerably decreased in comparison with those present in the spring of 1910. Unfortunately, further detailed communications regarding this locality were not received. The first 5 clusters, which were taken from the top of the shipment, were examined microscopically. The result was as follows: —

Cluster 1.

Unfertilized eggs,	1	= 4.26 per cent., or about 4 per cent.
Eggs with dead embryos,	10	
Eggs apparently alive,	247	= 95.74 per cent., or about 96 per cent.
Total,	258 eggs.	

Cluster 2.

Unfertilized eggs,	8	= 13.47 per cent., or about 13.5 per cent.
Eggs with dead embryos,	65	
Eggs apparently alive,	469	= 86.53 per cent., or about 86.5 per cent.
Total,	542 eggs.	

Cluster 3.

Unfertilized eggs,	2	} =10.59 per cent., or about 10.5 per cent.
Eggs with dead embryos,	41	
Eggs apparently alive,	363	=89.41 per cent., or about 89.5 per cent.
Total,	406 eggs.	

Cluster 4.

Unfertilized eggs,	1	} = 5.28 per cent., or about 5 per cent.
Eggs with dead embryos,	14	
Eggs apparently alive,	269	=94.72 per cent., or about 95 per cent.
Total,	284 eggs.	

Cluster 5.

Unfertilized eggs,	4	} = 6.64 per cent., or about 6.5 per cent.
Eggs with dead embryos,	9	
Eggs apparently alive,	181	=93.36 per cent., or about 93.5 per cent.
Total,	194 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs,	31	= 9.20 per cent., or about 9 per cent.
Eggs apparently alive,	306	=90.80 per cent., or about 91 per cent.
Total,	337 eggs.	

After the wilt had operated in this locality the size of the egg clusters was not up to the average size of the normal cluster, and the percentage of dead eggs was very high.

Kingston, Mass.

Division Agent, John A. Farley; *Local Superintendent,* C. C. Faunce.

With the help of the field inspector, Mr. Norman Souther of Bridgewater, two places were selected for the intended experiments. The locality which we will first consider is an isolated part of the so-called "Rocky Nook," and is situated about 1 mile east of the Kingston-Plymouth car line. This place is about a quarter of an acre in size and mainly overgrown with oaks about twenty-five years of age. The gypsy moths were discovered here in the autumn of 1909 by finding egg clusters. The youth of the colony made it seem improbable that there was any disease among the caterpillars of 1909, and, moreover, the egg clusters had a considerable size. Several of the clusters found had been killed with creosote, but there were still left about 60 clusters, according to Mr. Souther's and my estimate.

The local superintendent was intrusted by Mr. Souther with the breeding of caterpillars. On June 24, 1910, I found the wilt in this brood. The same day, with the assistance of the local superintendent, one part of the material was exposed in the locality mentioned. This brood was thoroughly sick, but the "dying off" of the caterpillars had not begun. The bag containing the material was fastened between twigs about 7 feet from the ground. The caterpillars in this locality were at this time half way between the third and fourth molt.[1]

On Oct. 25, 1910, the fresh egg clusters of this locality were estimated by the local superintendent and myself. We found that the place contained almost the same numbers of clusters as in the spring of 1910, with the difference, however, that many clusters had the hairy covering only in part. Several clusters completely lacked this covering. It seems that the disease spread very slowly, and that it did not kill many caterpillars but had merely given them a mild form of the disease, which manifested itself later in the manner mentioned, when the females laid their eggs. The 5 clusters which were first found were examined, like those of other localities. The examination gave the following interesting results: —

Cluster 1.

Unfertilized eggs, . . .	2	= 3.97 per cent., or about 4 per cent.
Eggs with dead embryos, .	13	
Eggs apparently alive, . .	363	=96.03 per cent., or about 96 per cent.
Total, ...	378 eggs.	

Cluster 2.

Unfertilized eggs, . . .	6	=18.85 per cent., or about 19 per cent.
Eggs with dead embryos, .	92	
Eggs apparently alive, . .	422	=81.15 per cent., or about 81 per cent.
Total, ...	520 eggs.	

Cluster 3.

Unfertilized eggs, . . .	2	=13.48 per cent., or about 13.5 per cent.
Eggs with dead embryos, .	58	
Eggs apparently alive, . .	385	=86.52 per cent., or about 86.5 per cent.
Total, ...	445 eggs.	

Cluster 4.

Unfertilized eggs, . . .	1	=20.98 per cent., or about 21 per cent.
Eggs with dead embryos, .	123	
Eggs apparently alive, . .	467	=79.02 per cent., or about 79 per cent.
Total, ...	591 eggs.	

[1] This experiment was intentionally undertaken with sick caterpillars only, and no dead ones, in order to see what effect the exposure of only sick individuals might have upon the healthy caterpillars in the field.

Cluster 5.

Unfertilized eggs, . . .	–	= 6.06 per cent., or about 6 per cent.
Eggs with dead embryos, .	2	
Eggs apparently alive, . .	31	= 93.94 per cent., or about 94 per cent.
Total, ...	33 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs, ...	60	= 15.23 per cent., or about 15 per cent.
Eggs apparently alive, . .	334	= 84.77 per cent., or about 85 per cent.
Total, ...	394 eggs.	

Since this place, in which Flacherie had operated, contained on the average only 334 eggs with apparently living embryos per cluster, the size of these clusters was about one-quarter less than normal. The fresh clusters, which were estimated to be about 60, *i.e.*, the same number which was found in the spring, thus must be reduced to about 45. The number of apparently living eggs of this locality therefore was decreased, after the wilt had worked, to about 77 per cent.

This experiment also shows that the exposure of sick instead of dead caterpillars contributes to the spread of the wilt. As in such cases, however, the disease spreads slowly, the caterpillars, it is true, will not be killed in large numbers, but they will be infected more or less lightly. The result is that a high percentage of the eggs deposited by the females will fail to hatch.

The second place which was selected in Kingston for an experiment is situated on the eastern side of Jones River, opposite the poor farm. This is an isolated wood of about one-eighth of an acre in size, which contains several large oaks and underbrush. The gypsy moth was discovered here also by the finding of egg clusters first in the autumn of 1909. It cannot be stated whether disease was present among the caterpillars of the summer of 1909, but this seems improbable, owing to the youth of the colony. Several of the clusters were killed with creosote, but there were still left, according to Mr. Souther's estimate, about 50 clusters.

The planting of the sick material was accomplished on the same day and in the same manner as in the first locality. Estimating the fresh clusters on Oct. 25, 1910, unfortunately I found that most of these fresh clusters (about 25) had been already killed with creosote by the men working under the local superintendent. Even with the assistance of the local superintendent, only 2 untouched egg clusters could be found. Only 1 of these could be collected, since the second was out of reach. Although, therefore, we are unable to draw any

complete and final conclusions in regard to the work of the wilt in this locality, nevertheless the result of the examination of the single cluster which could be secured may be given: —

Unfertilized eggs, . . .	1	= 3.52 per cent., or about 3.5 per cent.
Eggs with dead embryos, .	12	
Eggs apparently alive, . .	356	= 96.48 per cent., or about 96.5 per cent.
Total, ...	369 eggs.	

All we can say concerning this locality is that through the operation of Flacherie, which was introduced by sick material only, the number of fresh clusters seems to have been reduced in comparison with that of the previous year.

Brockton, Mass.

Division Agent, L. W. Hodgkins; *Local Superintendent,* E. Moltan.

The place which, with the assistance of the inspector, Mr. Norman Souther of Bridgewater, was selected for an experiment, is situated near Oak Street, northwest of Brockton Center and east of the Dutchland Farm. The place, of about half an acre, consists of a growth of oaks about forty to fifty years of age; no brush is present. The caterpillars of the gypsy moth were abundant here in the summer of 1909, but no disease was noticed among them. Several of the clusters were killed with creosote during the winter of 1909–10. The clusters which were left were estimated by Mr. Souther and myself to be about 40.

The raising of caterpillars for the intended experiment Mr. Souther intrusted to Mr. Rudolph Marshall, 218 Battle Street, Brockton. On June 24, 1910, the brood was inspected. Several caterpillars had already died from the wilt and the others were found to be sick. This same day the whole material was exposed in the selected place. The bag was fastened between oak limbs, about 8 feet from the ground. Most of the caterpillars of this locality were at this time about half way between the third and fourth molt.

This place was visited again on Oct. 7, 1910, with Mr. Souther, to determine the number of fresh clusters. But in spite of the most strenuous search there were found but 4 clusters; these were collected for examination. They resulted as follows: —

Cluster 1.

Unfertilized eggs, . . .	2	= 2.99 per cent., or about 3 per cent.
Eggs with dead embryos, .	10	
Eggs apparently alive, . .	389	= 97.01 per cent., or about 97 per cent.
Total, ...	401 eggs.	

Cluster 2.

Unfertilized eggs,	13	=11.71 per cent., or about 11.5 per cent.
Eggs with dead embryos,	22	
Eggs apparently alive,	264	=88.29 per cent., or about 88.5 per cent.
Total,	299 eggs.	

Cluster 3.

Unfertilized eggs,	3	= 5.47 per cent., or about 5.5 per cent.
Eggs with dead embryos,	14	
Eggs apparently alive,	294	=94.53 per cent., or about 94.5 per cent.
Total,	311 eggs.	

Cluster 4.

Unfertilized eggs,	2	= 4.81 per cent., or about 5 per cent.
Eggs with dead embryos,	18	
Eggs apparently alive,	396	=95.19 per cent., or about 95 per cent.
Total,	416 eggs.	

The average of these 4 clusters gives the following result: —

Dead eggs,	21	= 5.88 per cent., or about 6 per cent.
Eggs apparently alive,	336	=94.12 per cent., or about 94 per cent.
Total,	357 eggs.	

Since this place, in which the wilt had operated, contained only 336 eggs with apparently living embryos on the average per cluster, the size of these clusters was about one-fourth less than normal. The number of the fresh clusters, which were found to be 4, must thus be reduced to 3. The number of apparently living eggs of this locality therefore was decreased, after Flacherie had worked, to about 7.5 per cent.

Beverly, Mass.

Division Agent, Saul Phillips; *Assistant,* W. F. Holmes.

With the help of the assistant of the division agent two places were selected for the experiments. The place which we will first consider is situated near Hart Street, north of Greenwood Avenue, Beverly Farms. It is an isolated wood of about 1 acre, mainly overgrown with maple about fifty to sixty years of age, and yellow birch, and has dense underbrush. The gypsy moth caterpillars were very numerous here during the summer of 1909, but no disease was noticed among them. A small percentage of egg clusters was killed with creosote during the

winter of 1909–10. A joint estimate of the egg clusters in this locality made with the assistant of the division agent in the spring of 1910 resulted in finding about 500 clusters.

The rearing of caterpillars was undertaken by Mr. Phillips's assistant. On June 20, 1910, he noticed the first dead individuals in the brood. Three days after the receipt of this communication I went to Beverly to inspect the material. Many of the caterpillars had already died from the wilt. This same day (June 25), with the help of the assistant, one part of the material was exposed in the western portion of the locality mentioned. The bag containing the material was fastened about 6 feet from the ground, between limbs with dense foliage. Most of the caterpillars of this locality had at this time just passed the third molt.

After the wilt had operated all through the summer among the caterpillars of this locality, the place was visited again on Sept. 13, 1910, together with Mr. Phillips's assistant. We estimated the number of fresh clusters present to be about 250. The decrease in the size of the clusters compared with those of the previous year was very striking. The examination of the first 5 clusters which were found gave the following result: —

Cluster 1.

Unfertilized eggs,	5	
Eggs with dead embryos,	12	= 13.60 per cent., or about 13.5 per cent.
Eggs apparently alive,	108	= 86.40 per cent., or about 86.5 per cent.
Total,	125 eggs.	

Cluster 2.

Unfertilized eggs,	2	
Eggs with dead embryos,	8	= 5.92 per cent., or about 6 per cent.
Eggs apparently alive,	159	= 94.08 per cent., or about 94 per cent.
Total,	169 eggs.	

Cluster 3.

Unfertilized eggs,	1	
Eggs with dead embryos,	6	= 7.37 per cent., or about 7 per cent.
Eggs apparently alive,	88	= 92.63 per cent., or about 93 per cent.
Total,	95 eggs.	

Cluster 4.

Unfertilized eggs,	1	
Eggs with dead embryos,	7	= 5.76 per cent., or about 5.5 per cent.
Eggs apparently alive,	131	= 94.24 per cent., or about 94.5 per cent.
Total,	139 eggs.	

Cluster 5.

Unfertilized eggs,	–	= 6.45 per cent., or about 6.5 per cent.
Eggs with dead embryos,	4	
Eggs apparently alive,	58	=93.55 per cent., or about 93.5 per cent.
Total,	62 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs,	9	= 7.63 per cent., or about 7.5 per cent.
Eggs apparently alive,	109	=92.37 per cent., or about 92.5 per cent.
Total,	118 eggs.	

Since a normal cluster contains on the average 433 eggs with apparently living embryos, and this place, in which Flacherie had operated, contained only 109 eggs with apparently living embryos on the average per cluster, about 4 clusters were necessary to equal the size of a normal one. The number of fresh clusters, which were estimated to be about 250, thus must be reduced to about 65. The number of apparently living eggs of this locality therefore was decreased, after the wilt had worked, to about 15 per cent.

For the second experiment a small isolated group of oaks, about eighty years of age, was selected. This place is situated near the railroad station, Beverly Farms, between the railroad track and the ocean. The caterpillars of the gypsy moth have always appeared here only in small numbers, and there were hardly more than one dozen clusters in the spring of 1910, according to our estimate. It must be mentioned, especially, that this locality is always exposed to very strong winds.

Flacherie, artificially developed by the assistant of the division agent, was planted among the caterpillars at this place on June 25, 1910, in the same manner as in the first locality. Considering the heavy breeze the material was placed in a wooden box, which was then fastened between limbs; thus the wind was not able to carry off the whole material. Most of the caterpillars of this place were about ready at this time to undergo the third molt.

On Sept. 13, 1910, this locality was visited again. The wilt had done very considerable damage to the caterpillars. Although the place was carefully searched with Mr. Holmes's assistance, we could find but 2 fresh clusters. One of these is especially remarkable, as it lacks completely the protecting covering. The microscopic examination of both clusters gave the following results: —

Cluster 1.

Unfertilized eggs,	3	= 9.17 per cent., or about 9 per cent.
Eggs with dead embryos,	8	
Eggs apparently alive,	109	= 90.83 per cent., or about 91 per cent.
Total,	120 eggs.	

Cluster 2.[1]

Unfertilized eggs,	38	= 87.50 per cent., or about 87.5 per cent.
Eggs with dead embryos,	116	
Eggs apparently alive,	22	= 12.50 per cent., or about 12.5 per cent.
Total,	176 eggs.	

The average of these 2 clusters gives the following: —

Dead eggs,	83	= 55.70 per cent., or about 55.5 per cent.
Eggs apparently alive,	66	= 44.30 per cent., or about 44.5 per cent.
Total,	149 eggs.	

Since this place, in which Flacherie had operated, contained only 66 eggs with apparently living embryos on the average per cluster, the size of these clusters was about five-sixths less than normal. The number of fresh clusters, which were found to be 2, thus equal together only one-third of a normal one. The number of apparently living eggs of this locality therefore had decreased, after the wilt had worked, to about 3 per cent.

Cohasset, Mass.

Division Agent, F. A. Bates; *Local Superintendent,* J. E. Grassie.

An island, known as Barron's Island, which is situated southeast of Cohasset in the headpart of Bailey's Creek, was selected for the experiment. This island has an area of about 10 acres, and is densely overgrown, mostly with oaks about twenty-five years of age and with underbrush. The gypsy moth was quite numerous here in 1909, but there was no disease among the caterpillars, according to Mr. Grassie's statement. Our joint estimate of the clusters which were present in the spring of 1910 was about 2,000. No artificial means of destroying the gypsy moth had been undertaken here.

Mr. Grassie, who was intrusted with the breeding of the caterpillars, noticed the wilt in this brood after a feeding of about sixteen days. On June 27, 1910, the caterpillars were inspected, and there were found

[1] Without the protecting cover.

about 70 per cent. individuals already dead from the disease.[1] The same day all the material was exposed, with the assistance of Mr. Grassie, in the western part of the selected place, and about 6 feet from the ground. Most of the caterpillars of this locality were at this time about ready to undergo the fourth molt.

On Sept. 26, 1910, the island was visited again, in company of the local superintendent, to determine in what manner the wilt had operated among the caterpillars. An especially considerable reduction of the number of the fresh egg clusters, compared with those of the previous year, had not occurred. According to our estimate there were about 1,500 fresh clusters. The size of each of these clusters, compared with the clusters found in the spring of 1910, was diminished in such a degree, however, that the clusters were often no larger than a bean. The eggs also were often only covered in part with hair. This, as well as the comparatively small mortality and the smallness of the fresh clusters, may be perhaps a consequence of the late planting of the disease. It is true that a number of caterpillars were killed, but most of them only grew slightly sick, the disease again expressing itself at the time of oviposition. The fresh clusters of this locality were also of an abnormally light yellowish color, which was noticed nowhere else.

The examination of the first 5 clusters found gave the following result: —

Cluster 1.

Unfertilized eggs, . . .	4	= 6.36 per cent., or about 6 per cent.
Eggs with dead embryos, .	7	
Eggs apparently alive, . .	162	=93.64 per cent., or about 94 per cent.
Total, ...	173 eggs.	

Cluster 2.

Unfertilized eggs, . . .	3	=23.68 per cent., or about 23.5 per cent.
Eggs with dead embryos, .	15	
Eggs apparently alive, . .	58	=76.32 per cent., or about 76.5 per cent.
Total, ...	76 eggs.	

Cluster 3.

Unfertilized eggs, . . .	1	=12.28 per cent., or about 12 per cent.
Eggs with dead embryos, .	6	
Eggs apparently alive, . .	50	=87.72 per cent., or about 88 per cent.
Total, ...	57 eggs.	

[1] It should be mentioned that Mr. Grassie sent a telephone communication on June 12, 1910, that the wilt had made its appearance among his caterpillars, but by a mistake I did not receive this notice until June 23.

Cluster 4.

Unfertilized eggs,	5	=18.31 per cent., or about 18 per cent.
Eggs with dead embryos,	21	
Eggs apparently alive,	116	=81.69 per cent., or about 82 per cent.
Total,	142 eggs.	

Cluster 5.

Unfertilized eggs,	8	=39.15 per cent., or about 39 per cent.
Eggs with dead embryos,	66	
Eggs apparently alive,	115	=60.85 per cent., or about 61 per cent.
Total,	189 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs,	27	=21.26 per cent., or about 21 per cent.
Eggs apparently alive,	100	=78.74 per cent., or about 79 per cent.
Total,	127 eggs.	

Since this place, in which Flacherie had worked, contained only 100 eggs with apparently living embryos on the average per cluster, more than 4 clusters were necessary to equal a normal cluster. Thus the number of fresh clusters must be reduced to about 370. The number of apparently living eggs of this locality therefore had decreased, after the wilt had operated, to about 18 per cent.

Hingham, Mass.

Division Agent, F. A. Bates; *Local Superintendent,* A. W. Young.

For the experiment an island of about 1 acre was selected, very densely overgrown with low wood. This island is situated east of Water Street and south of the railroad track in the so-called Millpond. The wood consists mainly of oaks and birches of five to six years of age, and of underbrush. The gypsy moth was quite numerous here in the summer of 1909, but there was no disease among the caterpillars, according to the statements of the division agent and the local superintendent. Several of the clusters were killed with creosote during the winter of 1909–10. The number of the clusters which still remained was estimated by Mr. Young and myself to be about 100.

The breeding of a series of caterpillars was accomplished exactly according to my instructions by the local superintendent, but unfortunately he omitted to send word when the wilt made its appearance, since he had understood that he was to notify me only after all the caterpillars of the brood had died. To convince myself about the con-

dition of the brood, I inspected the caterpillars July 1, 1910, and found that about 60 per cent. of them had succumbed to Flacherie. The first dead caterpillars were noticed by Mr. Young about fifteen days before. On the same day the whole of the material was exposed, with Mr. Young's assistance, in the southwestern part of the island, about 5 feet from the ground. Most of the caterpillars of this locality had at this time just undergone the fourth molt.

On Sept. 26, 1910, this island was visited, again in company with the local superintendent. We could see that the wilt had done very considerable damage to the caterpillars, for there were only a few scattered clusters. According to our estimate there were hardly 15 fresh clusters present; these, moreover, were much smaller in size than those of the previous year. It was also noticed that the clusters were often only partly covered with hair. All these conditions may well be attributed to Flacherie. The almost full-grown caterpillars had contracted the disease, and the females which then emerged from pupæ produced by these caterpillars were unable to oviposit like healthy moths.

The examination of the first 5 clusters found gave the following result: —

Cluster 1.

Unfertilized eggs, . . .	3	
Eggs with dead embryos, .	10	= 9.56 per cent., or about 9.5 per cent.
Eggs apparently alive, . .	123	=90.44 per cent., or about 90.5 per cent.
Total, ...	136 eggs.	

Cluster 2.

Unfertilized eggs, . . .	3	
Eggs with dead embryos, .	12	= 8.82 per cent., or about 9 per cent.
Eggs apparently alive, . .	155	=91.18 per cent., or about 91 per cent.
Total, ...	170 eggs.	

Cluster 3.

Unfertilized eggs, . . .	1	
Eggs with dead embryos, .	7	= 4.73 per cent., or about 4.5 per cent.
Eggs apparently alive, . .	161	=95.27 per cent., or about 95.5 per cent.
Total, ...	169 eggs.	

Cluster 4.

Unfertilized eggs, . . .	2	
Eggs with dead embryos, .	5	=10.77 per cent., or about 10.5 per cent.
Eggs apparently alive, . .	58	=89.23 per cent., or about 89.5 per cent.
Total, ...	65 eggs.	

Cluster 5.

Unfertilized eggs, . . .	4	= 9.22 per cent., or about 9 per cent.
Eggs with dead embryos, .	9	
Eggs apparently alive, . .	128	=90.78 per cent., or about 91 per cent.
Total, ...	141 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs, ...	11	= 8.09 per cent., or about 8 per cent.
Eggs apparently alive, . .	125	=91.91 per cent., or about 92 per cent.
Total, ...	136 eggs.	

Since this place, in which Flacherie had operated, contained only 125 eggs with apparently living embryos on the average per cluster, almost 4 clusters were necessary to equal a normal one. The number of the fresh clusters thus must be reduced to about 5. The number of apparently living eggs of this locality therefore had decreased, after the wilt had worked, to about 5 per cent.

Byfield, Mass.

On June 30, 1910, a letter was received from Mr. James O. Hale of Byfield, in which he stated that he had heard of my Flacherie experiments of 1909, and asked for aid in diminishing the gypsy moth caterpillars by using Flacherie. I therefore visited the locality on July 5, 1910, and took with me sick and dead caterpillars which had been raised at Forest Hills. The forest in question is about 4 to 5 acres in size, and consists mainly of oaks of different ages and some underbrush. It is situated on the border between Rowley and Newbury. It is not isolated, but connected with woods which belong to other persons. At the time of my arrival most of the caterpillars had already undergone the fifth molt, so that it seemed questionable whether the disease would be able to show much success this year. The infected material was exposed in the southwestern part of the forest, about 7 feet from the ground. It proved to be impossible to secure a correct estimate of the caterpillars which were present; all that could be stated was that the caterpillars were quite plentiful.

This locality was visited again with Mr. Hale on Sept. 16, 1910, to determine the results. Mr. Hale gave his opinion that there was, at the least, no increase in the number of egg clusters compared with that of the previous year, although there was no visible decrease in the number of the fresh clusters. However, these fresh clusters were considerably smaller than those of the preceding year.

The first 5 clusters collected gave the following counts: —

Cluster 1.

Unfertilized eggs,	2	
Eggs with dead embryos,	6	= 8.33 per cent., or about 8 per cent.
Eggs apparently alive,	88	=91.67 per cent., or about 92 per cent.
Total,	96 eggs.	

Cluster 2.

Unfertilized eggs,	1	
Eggs with dead embryos,	4	= 3.76 per cent., or about 3.5 per cent.
Eggs apparently alive,	128	=96.24 per cent., or about 96.5 per cent.
Total,	133 eggs.	

Cluster 3.

Unfertilized eggs,	1	
Eggs with dead embryos,	5	= 2.75 per cent., or about 2.5 per cent.
Eggs apparently alive,	212	=97.25 per cent., or about 97.5 per cent.
Total,	218 eggs.	

Cluster 4.

Unfertilized eggs,	2	
Eggs with dead embryos,	4	= 4.72 per cent., or about 4.5 per cent.
Eggs apparently alive,	121	=95.28 per cent., or about 95.5 per cent.
Total,	127 eggs.	

Cluster 5.

Unfertilized eggs,	3	
Eggs with dead embryos,	6	= 5.59 per cent., or about 5.5 per cent.
Eggs apparently alive,	152	=94.41 per cent., or about 94.5 per cent.
Total,	161 eggs.	

The average of these 5 clusters gives the following result: —

Dead eggs,	7	= 4.76 per cent., or about 4.5 per cent.
Eggs apparently alive,	140	=95.24 per cent., or about 95.5 per cent.
Total,	147 eggs.	

We notice that the clusters of this locality in which the wilt had operated are far smaller than normal ones, since about 3 clusters are necessary to equal the size of a normal one. The percentage of dead eggs, however, does not attain that of other localities.

IV. Summary.

The artificially developed Flacherie was planted, after the "dying off" of the breeding material had begun, among the caterpillars of the gypsy moth in the following localities, the de-

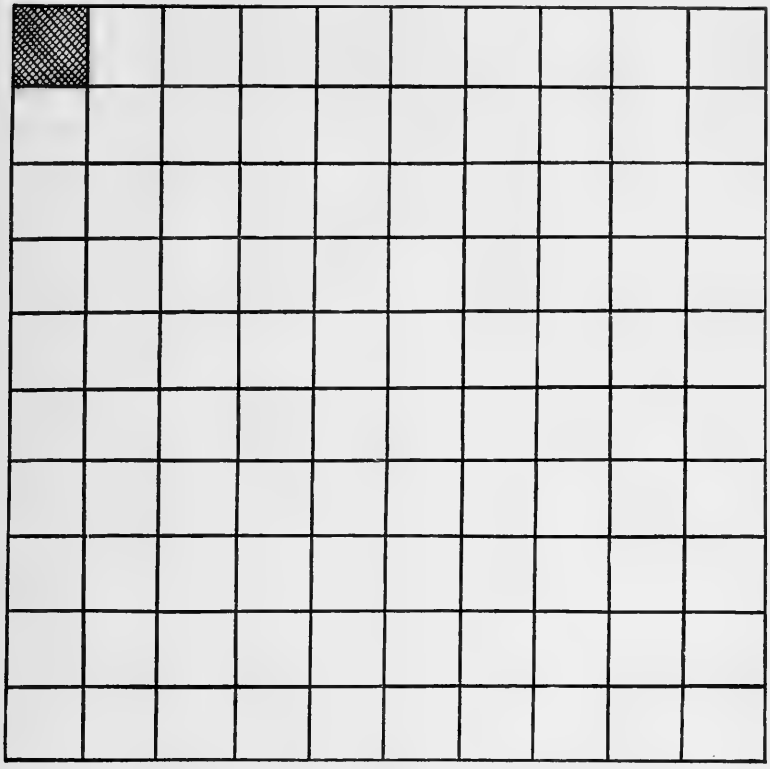

Fig. 4. — Diagram showing percentage of living eggs in healthy colonies.

tails in regard to these experiments being given in the preceding pages. The number of apparently living eggs was reduced to the following percentages: —

	Per Cent.
Concord, Mass. (Brewster's estate),	11
Carver, Mass. (southwest of Makepeace's cranberry bog),	13
Carver, Mass. (on Wenham Street),	45
Boxford, Mass. (near the almshouse),	10
Boxford, Mass. (on Highland Street),	4
West Bedford, Mass. (Swett's estate), 0 per cent. + 22½ per cent. =	11½
Haverhill, Mass. (west of East Broadway),	14½

	Per Cent.
Brockton, Mass. (on Oak Street),	7½
Beverly, Mass. (on Hart Street),	15
Beverly, Mass. (beside railroad track),	3
Cohasset, Mass. (Barron's Island),	18
Hingham, Mass. (island in the millpond),	5

Taking the average of these results, we see that the total number of apparently living eggs has been decreased by introduction of the artificially developed Flacherie to about *14* per cent. This result is shown graphically in Figs. 4 and 5, where

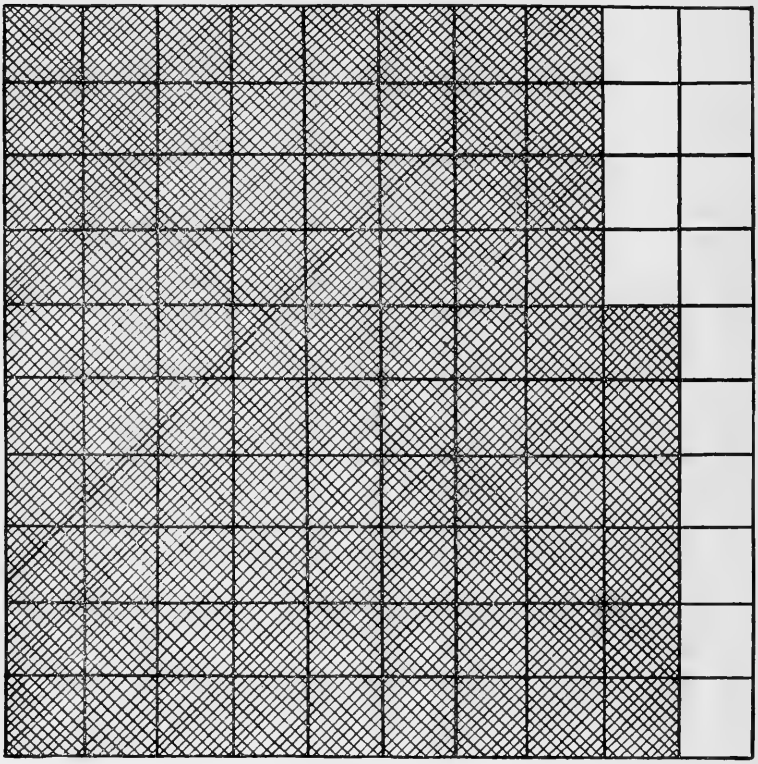

Fig. 5. — Diagram showing average percentage of living eggs after introduction of the disease.

1 per cent. is equal to 1 square, the cross-lined spaces representing the percentage of *dead* eggs.

Only those localities have here been tabulated on which we had complete data from the beginning to the end of the experiment.

V. Final Conclusions.

The foregoing experiments prove conclusively that Flacherie has an injurious influence upon the prosperity of the gypsy moth caterpillars, this influence varying according to the manner and time of the appearance of the disease. There was no difference noticed in the progress of the wilt which broke out naturally and that of the artificially developed Flacherie. The latter, however, is probably the more important factor, for with its help we may be able to introduce the disease among caterpillars of localities in which the wilt, perhaps, would not make its appearance naturally. The infection of a place with *sick* material only seems to be, as regards the " dying off " of the caterpillars, less favorable for the spread of Flacherie than with material which already contains a number of *dead* individuals. In selecting the localities in which the disease is to be introduced, it is unimportant whether the caterpillars of the gypsy moth are present in large or small numbers. It is true the wilt will get a stronger foothold and attain a greater virulence the larger the number of caterpillars. In places, however, which are not badly infested, the disease will also spread to the healthy caterpillars, as was shown by several of the experiments. According to the observations, we are almost inclined to believe that the direction of the wind plays an important rôle in spreading the disease. This opinion is strengthened especially by the observations made in Concord and West Bedford.

Wherever the naturally as well as the artificially developed Flacherie occurs the female caterpillars will always succumb to it more readily than the male. This may perhaps be due to the fact that they require a longer time to mature than the male caterpillars. If, at the flying period of the moth, we visit such a diseased locality, — one in which during the summer the caterpillars were quite plentiful, — we find ourselves surrounded by male moths, which to the superficial observer would indicate that the wilt had caused no considerable diminution. As soon, however, as we begin to search for adult females, we discover that they are present in a decided minority, and

that they are by no means in the same large proportion to the male moths as in localities where the disease has not occurred among the caterpillars. The effective result, then, will be shown at the time of oviposition, in the decrease of the number and size of the fresh clusters, compared with those of the previous year. To be sure, this will not always be the case; for instance, in localities in which Flacherie appears very late. However, places infected early enough, always show as a result a diminution in the number of the fresh clusters, sometimes to 100 per cent. The reduced average size of the clusters also has a close connection with the wilt. Heretofore it has often, but erroneously, been supposed that small clusters were deposited by small female moths, which suffered during their caterpillar stages from lack of food. Certainly such cases are not rare, but the origin of small clusters is capable of yet another explanation. For instance, in localities in which there are few gypsy moth caterpillars, and where there is no lack of food, but where the wilt has worked, egg clusters are found which are no larger than a pea or a bean. Such clusters contain from 4 to 12 eggs, with embryos which are usually incompletely or not at all developed. In such localities it may often be recognized, from the volume of the abdomen, even of the freshly emerged female moths, which were little below the normal size, that the body contained only a small number of eggs. Also, in several cases the interior of the body was examined, and then it was found that the cause of the small circumference of the body was that the ovary was small. Females which had already oviposited and died were examined to see whether they contained more eggs in their bodies. Eggs were always found in females that had laid egg clusters which were only partly, or not at all, covered with hair. But there were sometimes found undeposited eggs in females which had completely covered the cluster with their abdominal hairs. All this must be taken in connection with the wilt, for female moths from healthy colonies deposit all the eggs they contain, as long as they are not interrupted at the time of egg laying, and it does not matter whether the individuals are large or small.

The most important point to be noticed is the fact that the

clusters which are found in localities in which Flacherie operates among the caterpillars contain, on the average, a comparatively high percentage of dead eggs. Hence, Flacherie has a direct effect even upon the next generation. If, however, the number and the quality of the eggs in the female adult are affected by the wilt, is it not then possible that the disease goes directly over to the eggs? Certainly we have no direct proof of this at the present time, but we do know that Flacherie can be carried over from the caterpillar to the pupa, and from the pupa to the adult, and we have seen that the eggs in the ovary of females which come from infected colonies are influenced by the disease in regard to their number and vitality. In spite of the many investigations which have been made by celebrated bacteriologists in both the old and the new world, the carriers of the disease have not yet been determined. This shows what a difficult problem science has before it to solve. Although several scientists accept neither the heredity of the disease, nor believe that it can be carried over to the next generation, there are others (Pasteur, Fischer) who believe in its transmissibility. Perhaps the disease is carried over to the following generation through the adult female only, in a similar manner to the pébrine. Perhaps, moreover, the name Flacherie covers several diseases, which, it is true, make their appearance in the same manner in the infected individuals, but nevertheless are specifically distinct. One of these diseases may be restricted, indeed, to caterpillar and pupa only, while the other disease is carried over to the adult, and might possibly be inherited through the female organism by the descendants. It may be possible to throw some light on these complicated questions by breeding experiments, but only the investigations of the bacteriologist and pathologist can secure the final proof. It would be of the highest importance for the economic value of Flacherie if the inheritance of the disease could be definitely proved. If the wilt proves to be the direct cause for the " dying off " of many embryos of eggs from infected localities, death would be caused by the organisms of the disease themselves, and probably not be a result of the weak constitution of the female moth. The still living embryos of the same cluster will

then contain, without doubt, at least partially, the carriers of the disease, which, according to their number and to the constitution of the embryo, will kill, early or late, the larva after it has hatched. Thus Flacherie will be carried again through the whole ontogeny of the descendants of those individuals which were originally infected by the disease. In this case the wilt would be hereditary, and it would have by far the greatest possible economic value and benefit. If, however, the "dying off" of several of the embryos is only a consequence of the weak condition of the female adult, which perhaps was slightly infected during the caterpillar stage, then of course the guaranty for the wilt is not yet given for the next generation. Among the hatching caterpillars there will always be a considerable percentage of weak individuals which thus possess from the beginning the necessary predisposition to the disease. If, then, the climatic conditions develop favorably for the disease, these weak caterpillars will be attacked first by the wilt, but as it increases in virulence it will attack the stronger and healthier individuals. If the climatic conditions are less favorable for the natural appearance of Flacherie, we hope the introduction of the artificially developed Flacherie in the respective localities will transmit the disease to the weak caterpillars. Then the disease will operate as though it had appeared naturally.

The existence of the wilt does not depend upon climatic conditions as soon as the disease is once established. It is true weather conditions will often be of great advantage in spreading the disease, but not likely to be of considerable harm. Hence, Flacherie, even if its nonheredity should be proved, is a factor of great importance to economic entomology. It will be advisable to work with the wilt against the gypsy moth in large wooded areas of all kinds, and it has the great advantage of cheapness, while the spraying with arsenate of lead or with other poisons is expensive. A very good scheme would be to furnish as many trees as possible with rings of tanglefoot in heavily infested forest districts, and not to kill the caterpillars after they are gathered together under the rings, but to assist in this manner the more rapid spread of the wilt, since the sick and weak individuals thus have a greater possibility of coming

in contact with healthy caterpillars. The effect of this method was observed in one case during the summer of 1910. In company with the division agent, Mr. Worthen, I came in touch with a locality in Boxford where gypsy moth caterpillars were gathered together in considerable numbers under tanglefoot rings. It had been decided to kill the caterpillars with burning oil, but I dissuaded the men from doing this by giving as my opinion that the wilt would make its appearance in all probability in a few days. This assumption was right, for there was seen, after three days, the first signs of the disease, which then spread so quickly that in a few more days the caterpillars had succumbed.

Perhaps it might be worth while to work with the wilt in different ways from those in the experiments described. There is, for instance, the recapitulation of the experiments of 1909 on a large scale. Caterpillars which had been killed by Flacherie were mixed with water in different ways, and the mixture was then either sprayed upon trees or was painted as rings around the trunks. One or the other of these methods may prove to be valuable, but the expense will be quite high, while the use of the simple exposure method incurs but small expense. There might be mentioned still another point; Dr. E. Fischer of Zürich, the discoverer of the predisposition of caterpillars towards Flacherie, wrote me some time ago the following directions for developing Flacherie artificially in the field: cut some of the larger roots of a tree that is infested with a sufficient number of caterpillars, water frequently the ground around the cut surfaces and put into the trunk as much water as possible through a hole bored at an angle of about 45° to the base of the tree. By these means the same unhealthy food is produced on the tree as is otherwise obtained by the placing of twigs in water. It is certain that the wilt can be developed artificially in the manner just described, but such an experiment needs constant attention, and trees thus treated are, of course, destroyed.

I doubt whether the gypsy moth will ever become extinct in America, but the wilt will probably produce, first, a considerable reduction of the mass, and then it is to be hoped that the

insect parasites and other natural enemies will contribute in diminishing the pest to a minimum. I am quite convinced that we can apply the wilt in a systematic manner to the benefit of our forests, and that in so doing we shall come considerably nearer to a solution of the problem of destroying the gypsy moth. In wooded areas mainly much more attention should be given in future to the wilt as an aid in combating the insect, while for street trees, garden trees, etc., which are more easily managed, the eggs and caterpillars of the gypsy moth may be removed according to established methods. The wilt should eventually reduce the pest to a condition in which it can be easily kept in check, and prevent serious outbreaks and damage.

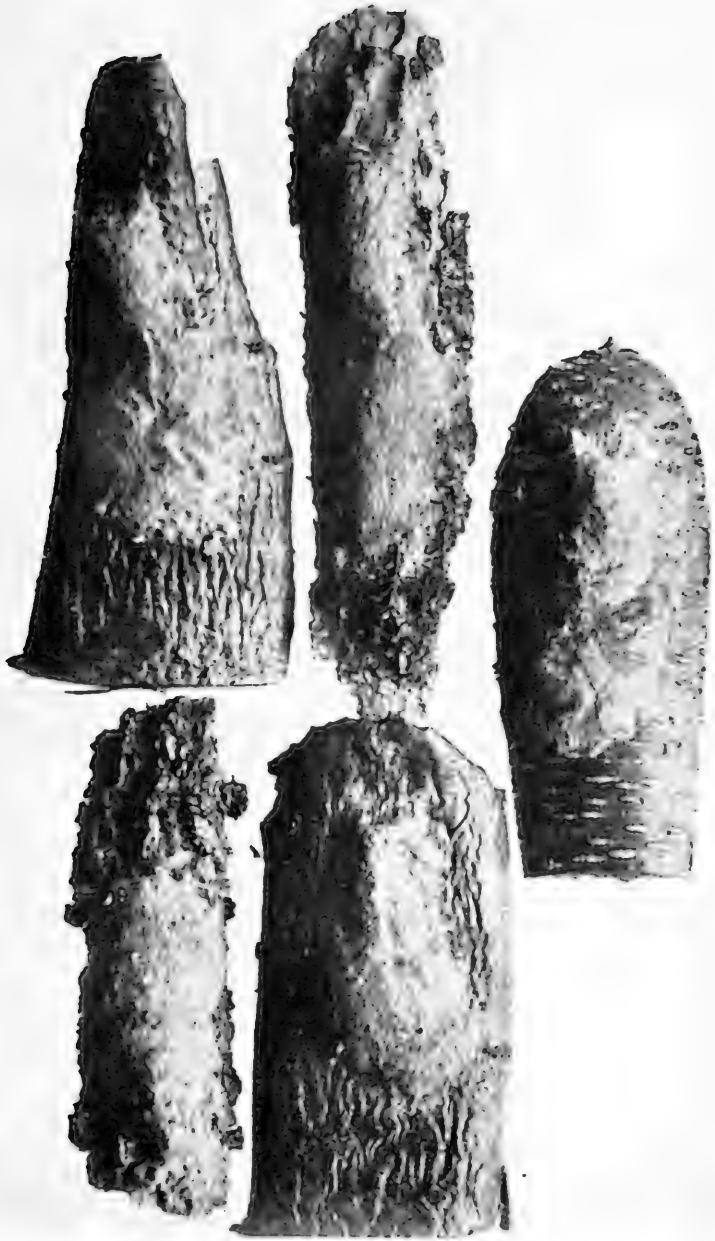

PLATE I. — Egg clusters from a healthy colony.

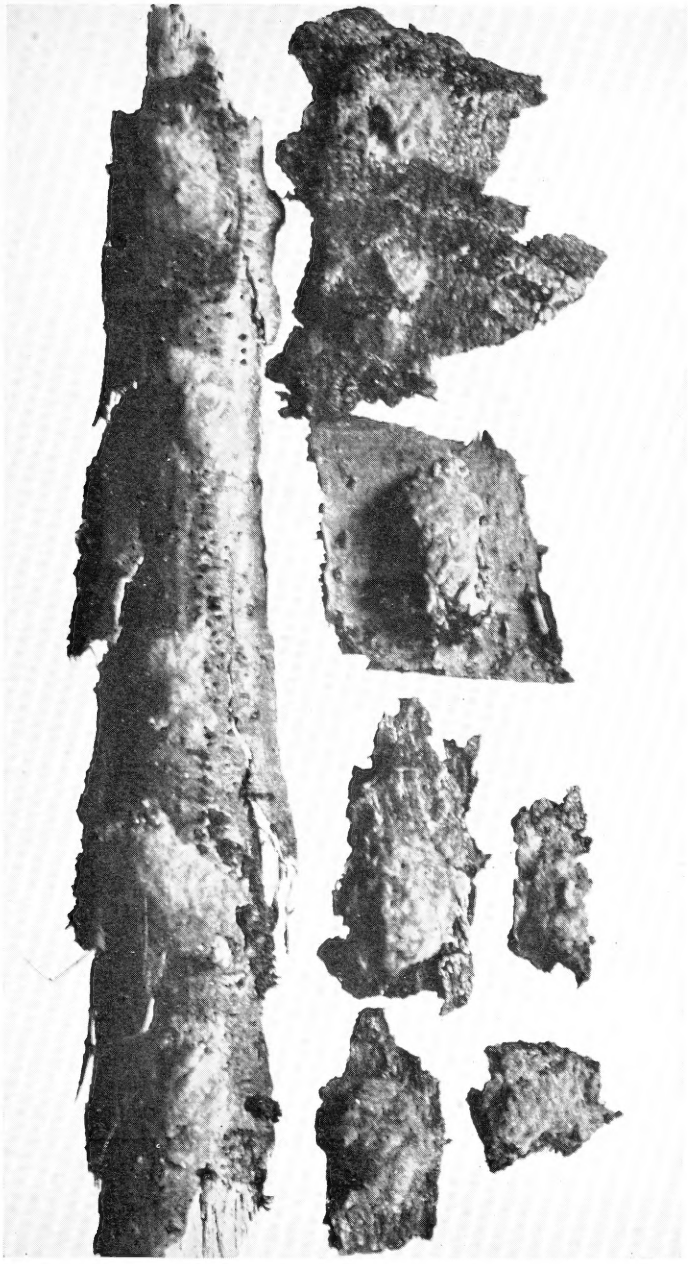

PLATE II.—Egg clusters from a colony where disease was introduced.